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Rogun HPP ESIA

ОЭСВ РОГУНСКОЙ ГЭС

Environmental and Social Impact Assessment for Rogun Hydro Power Plant

Оценка экологического и социального воздействия для Рогунской ГЭС

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Report prepared by/ Отчет подготовлен:

Contact:

Dr. Robert Zwahlen
Environment and Social Development Specialist
Pöyry Energy Ltd.
Hardturmstrasse 161, P.O. Box
CH-8037 Zurich/Switzerland
Tel. +41 44 355 55 54
Mobile +41 76 356 21 13
Fax +41 44 355 55 56
e-mail robert.zwahlen@poyry.com
http://www.poyry.com

Контактные лица:

Dr. Роберт Звален
Специалист по окружающей среде и социальному развитию
«Pöyry Energy Ltd.»
Hardturmstrasse 161, P.O. Box
CH-8037 Zurich/Switzerland
Тел. +41 44 355 55 54
Моб. +41 76 356 21 13
Факс +41 44 355 55 56
е-мейл robert.zwahlen@poyry.com
http://www.poyry.com

Picture on front page: View of the construction site of Rogun HPP; picture taken 2013-08-25

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LIST OF ACRONYMS AND ABBREVIATIONS

ATD	Afghan-Tajik depression
BHR	Bureau of Human Rights and Rule Of Law
BP	Before Present
BT	Barki Tojik
BVO	Basin Water Organisation (Basseynoe Vodnoe Obedinenie)
CASAREM	Central Asia/South Asia Regional Electricity Market
CC	Climate Change
CIS	Commonwealth of Independent States
CITES	Convention on International Trade with Endangered Species
CR	Critically endangered
d/s	downstream
DSR	Dam Safety Report
EFR	Environmental Flow Regulation
EHS	Environment, Health and Safety
EIA	Environmental Impact Assessment
ELOHA	Ecological Limits of Hydrologic Alteration
EMMP	Environmental Monitoring and Management Plan
EMP	Environmental Management Plan
EN	Endangered
ESIA	Environmental and Social Impact Assessment
ESMP	Environmental and Social Management Plan
ET	Evapotranspiration
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
FGD	Focus Group Discussion
FSL	Full Supply Level
GBAO	Gorno Badakhshan Autonomos Oblast
GCM	Global Climate Models
GCMP	Global Climate Model Projection
GHG	Greenhouse Gas
GLIMS	Global Land Ice Measurements from Space
GLOF	Glacier lake outbreak flood
GOT	Government of Tajikistan
GPS	Global Positioning System
GWh	Gigawatt-hours
HC	Health Center
HDI	Human Development Index

HH	Household
HPP	Hydropower Project
HRU	Hydrological Response Unit
HSMP	Health and Safety Management Plan
ICAS	Interstate Council on the Aral Sea Problems
ICOLD	International Commission on Large Dams
ICWC	International Coordination Water Commission
IESS	Initial Environmental and Social Screening
IFAS	International Fund for the Aral Sea
IHA	International Hydropower Association
IHA:	International Hydropower Association
InSAR	Interferometric synthetic aperture radar
IPCC	Intergovernmental Panel on Climate Change
IUCN	International Union of Conservation of Nature
LC	Least concern
LCR	Local Consultation Representatives
m asl	meters above sea level
MAF	Mean Annual Flow
MCE	Maximum credible earthquake
MOL	Minimum Operational Level
MSK-64	Medvedev–Sponheuer–Karnik macroseismic intensity scale
MWh	Megawatt-hours
NT	Near threatened
OCS	Open Stock Company
PAP	Project Affected Person
PMF	Probable Maximum Flood
PMP	Pasture Management Plan
PoE	Panel of Experts
PPCR	Pilot Programme for Climate Resilience
PPE	Personal Protective Equipment
PRA	Participatory Rural Appraisal
RAP	Resettlement Action Plan
RBT	Red Book of Tajikistan
RCM	Regional Climate Models
ROR	Run-of-River
RT	Republic of Tajikistan
RU	Resettlement Unit
SADC	Southern African Development Community
SEA	Strategic Environmental Assessment
SIA	Social Impact Assessment

S-MMP	Sub-Monitoring and Management Plan
SSR	Socialist Soviet Republic
TEAS	Techno-Economical Assessment Study
TJS	Tajik Somoni
TKM	Turkmenistan
TOR	Terms of Reference
TPP	Thermal Power Plant
TWh	Terawatt-hours
u/s	upstream
USD	United States Dollar
USSR	Union of Socialist Soviet Republics
UZB	Uzbekistan
VU	Vulnerable
WB	Word Bank
WCD	World Commission on Dams
WGI	World Glacier Inventory
WWF	World Wide Fund for Nature

EXECUTIVE SUMMARY

Background and Introduction

Tajikistan suffers from a critical need for winter electricity, with demand exceeding supply by up to 25 percent at present. Demand-side changes such as improvements in energy efficiency are needed as part of the solution, but the shortfall can only be overcome in the mid- and long term with additional generation capacity. Rogun HPP has been identified as part of the long-term solution.

The Rogun Hydropower Project (Rogun HPP) was first conceived in the Soviet Union in the 1950s and 1960s as part of the regional development of what are now several independent states. The original purpose of the Rogun project has evolved from supporting regional irrigation and hydropower generation, to the present plan, which calls for Rogun to serve as a multi-purpose project providing power, flow regulation, flood control and sediment retention.

The Rogun HPP site lies about 110 km east of Dushanbe (Figure 0-1), and the HPP would become the uppermost of a planned and partly built hydropower cascade on the Vakhsh river. Of most importance is Nurek HPP, 70 km downstream from Rogun, which has operated since the 1980. The Nurek HPP includes a high dam – at 300 meters the highest in the world -- and a reservoir with a storage capacity of 10.5 km^3. Nurek is operated in such a way as to shift about 4.2 km^3 of water from summer to winter to meet Tajikistan’s electricity demand in the cold season. The other HPPs in the cascade are run-of-river (ROR) schemes with little or no storage capacity.

Figure 0-1: Map of Tajikistan indicating Rogun dam site

Construction of Rogun HPP began in 1982 and was then interrupted by political changes resulting from the independence of Tajikistan and the other Central Asia countries. Construction began again in 2008, but since 2012 only care and maintenance activities have been carried out pending finalisation of the technical, economic, environmental and social studies.

The World Bank in 2011 provided funding to the Government of Tajikistan to conduct a Technical and Economic Assessment Study (TEAS) and an Environmental and Social Impact Assessment (ESIA) for Rogun HPP. The objectives of TEAS were to evaluate the technical and economic feasibility of different operational regimes and project configurations. The two studies have been carried out in parallel and with extensive cooperation between the study teams.

TEAS studies demonstrate that it is technically possible and economically feasible to operate Rogun and the cascade within existing water management agreements and practices, and recommend the preferred alternative (the FSL 1290 alternative described below).

This is the Executive Summary of the draft Environmental and Social Impact Assessment (ESIA), which includes three volumes: this Executive Summary and the main text in Volume I, annexes in Volume II, and a preliminary draft Environmental and Social Management Plan in Volume III.

The Project (ESIA Chapter 3)

The Rogun configuration recommended by TEAS is an earth core rock-filled dam that would rise 335 meters to a crest elevation of 1300 meters above sea level (m asl), with the reservoir at a full supply level (FSL) of 1290 m asl. Alternative configurations that called for slightly lower dams to achieve FSLs of 1255 and 1220 m asl were also considered by TEAS and compared in ESIA Chapter 22. The table below gives key elements of the options.

Table 0-1: Rogun dam alernatives studied by TEAS

Alternative	**FSL 1290**	**FSL 1255**	**FSL 1220**
Dam height	335 m	300 m	265 m
Total reservoir capacity	13.3 km^3	8.55 km^3	5.22 km^3
Reservoir active storage	10.3 km^3	6.45 km^3	3.93 km^3
Reservoir area	170 km^2	114 km^2	68 km^2

The powerhouse and related infrastructure will be in caverns that have been partially excavated but that require further work to overcome deformation and other issues emerging over time caused by floods ,and geological conditions. Other works include diversion tunnels and spillways to carry normal flows and floodwaters (up to the Probable Maximum Flood), multi-level intakes, access tunnels, and temporary works to handle river flows during construction. To the extent possible, excavated spoil is to be stored and used in dam construction.

The dam would be raised in two stages. Stage 1 would take about three years to reach an elevation of 1110 m asl, at which time electricity production could begin, although at only a fraction of output to be achieved later. During Stage 2, as the dam rises and the reservoir fills over a period of about 13 more years (for the FSL 1290 alternative), electricity generation capacity would progressively increase to its maximum of 3'200 MW.

The construction site occupies an area of about 20 km^2 up-and downstream of the dam site near Rogun town. Construction site facilities are already present, as they have been used since construction began in the 1980s. The site contains office buildings for contractors, workers’ quarters, health posts, fueling station, water distribution system, spoil storage areas, quarries and borrow sites, workshops, and other necessary works. Facilities would include a new wastewater treatment plant and other improvements before new construction begins. Figure 3-6 in Chapter 3 illustrates the site as of 2011. As noted, only safety and maintenance activities, including work to improve some past practices, are being carried out at present.

Transmission lines and other grid infrastructure needed to take power from the powerhouse to the national grid are yet to be designed and would be evaluated in a future environmental and social impact assessment. Several area roads would be submerged by the reservoir and are being relocated.

At present, Nurek HPP is operated so as to retain up to 4.2 km^3 of water that fill its reservoir in summer until it can be used for electricity generation in winter. Thus, the water level in Nurek reservoir rises and falls over 50 meters over the course of the year. With Rogun HPP in place, however, the Nurek reservoir is intended to be maintained at a constant level, while the Rogun reservoir would be used for water regulation, with its reservoir water level varying by about 30 meters. Thus, the seasonal flow pattern established by Nurek would remain unchanged, since Nurek would effectively become a run-of-river operation. In effect, the same water that is now used once to generate winter electricity at Nurek would in future be used twice, once in Rogun and then again in Nurek, without changing the downstream flow pattern (that is, without shifting water flows from summer to winter more than is the case now at Nurek). TEAS studies that simulate reservoir operations and electricity generation show that this is a technically and economically feasible operating regime for Rogun HPP and the cascade.

Project Purpose (ESIA Section 3.2)

The primary purpose of the Rogun HPP is to generate electricity to help Tajikistan overcome critical shortages of electricity in winter and meet future demand, while respecting the water needs of downstream riparian countries. In addition, the project can provide other significant benefits, including:

- *Downstream flow regulation potential:* the added storage capacity provided by Rogun could help overcome shortages that are now felt in downstream areas in dry years.
- *Electricity production for export:* Rogun HPP would allow power sales to neighbouring countries, including in particular Pakistan and Afghanistan.
- *Flood routing:* today’s Vakhsh cascade, including Nurek dam, is not designed to handle the Probable Maximum Flood (PMF). The construction of Rogun HPP would provide flood routing capacity and protect Nurek and the lower cascade.

- *Retention of sediments:* by retaining the high sediment load which otherwise would reach and fill Nurek reservoir, Rogun would effectively extend the life of Nurek HPP and the Vakhsh cascade by over 100 years.

The Study Area (ESIA Chapter 4)

The project could have local, national, and international impacts, so the study area was not confined to the immediate vicinity of the dam and reservoir. The project area of influence comprises the following: (i) dam and reservoir impoundment areas, (ii) sites of construction and civil works: (iii) downstream areas that could be affected by operations of the Vakhsh cascade, including the Aral Sea, (iv) resettlement sites, including host communities, (v) areas affected by induced development or other indirect effects, and (vi) communities, households, and industries that benefit from assured electricity supply and other benefits provided by the project.

The most direct effects, both environmental and social, would be in the area where the dam and reservoir will be located, and where some impacts have been felt since the 1980s. Outside this immediate area, indirect social effects could be felt in nearby villages and population centers that will not be relocated, but whose people and institutions could be affected by the project. The project would generate electricity to benefit all of Tajikistan, including in particular rural people in winter. Finally, the project could have effects downstream of Nurek, including effects on the Tigrovaya Balka protected area on the downstream Vakhsh river in Tajikistan; on those who use water for irrigation in Afghanistan, Turkmenistan, and Uzbekistan; and on the Aral Sea.

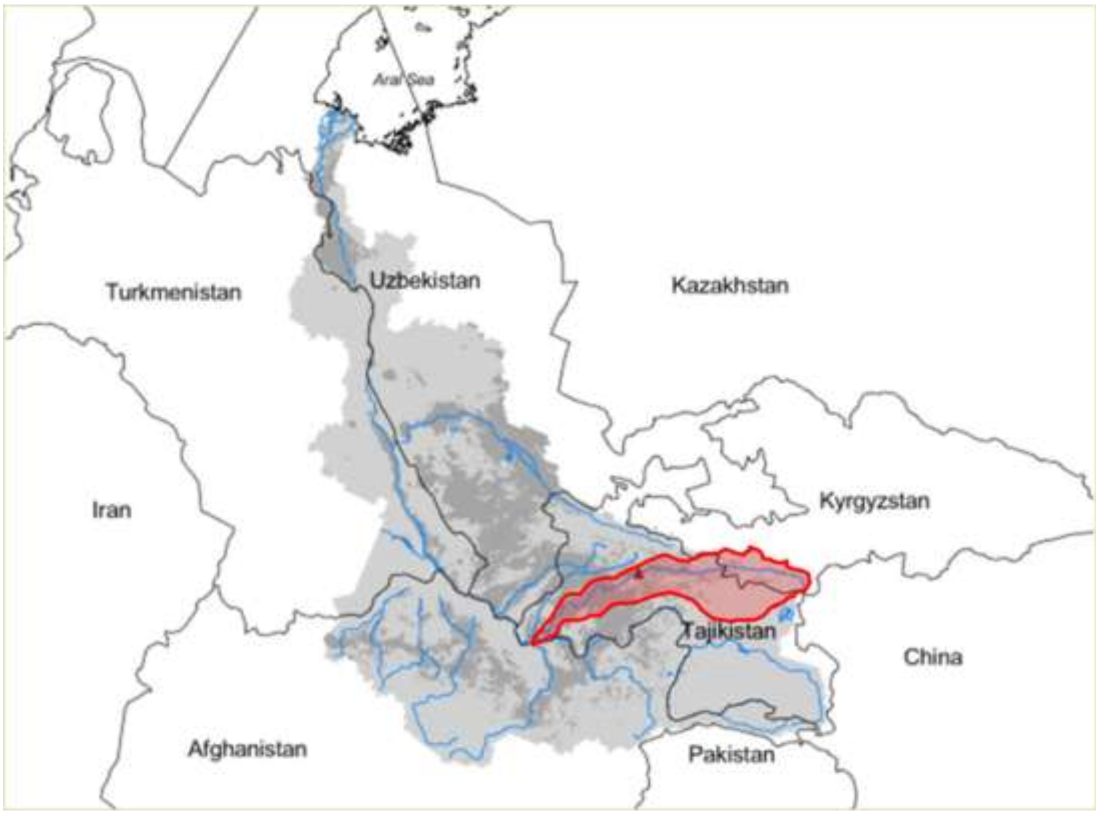


Figure 0-2: The Amu Darya basin (grey) and Vakhsh subbasin (red)

Source of map: www.cawater-info.net/**amudarya**/geo_e.htm

Institutional and Legal Framework (ESIA Chapters 2, 8)

Environmental and Social *(ESIA Chapter 2)****.*** This ESIA has been prepared to meet Tajikistan's requirements for impact assessment and of World Bank Operational Policy (OP) 4.01 “Environmental Assessment.” The recommendations in the ESIA are intended to ensure the project meets national legal requirements, World Bank policies, international treaties and conventions to which Tajikistan is a party, and good international practice. The specific laws, policies, conventions, and practices are identified in Chapter 2. Of particular importance are institutions, laws, and agreements in the two main areas of potential impact and concern, resettlement and water use.

Resettlement *(ESIA Chapter 2)* Tajikistan has two key bylaws that apply to resettlement, one dealing with (voluntary) internal migration and the other specifically with resettlement of people affected by Rogun HPP. These laws establish the authorities and activities that would guide (and are guiding) resettlement planning and implementation. World Bank policy (OP 4.12) establishes the broad goals that must be met when people have to be relocated by projects.

Water Use and Allocation *(ESIA Chapters 2, 8)****.*** Management of the Amu Darya and Vakhsh river, one of its major tributaries, is guided by an agreement initially reached within the Soviet Union and supplemented since that time with additional agreements between the newly independent states. Key agreements among riparian countries - Kyrgyz Republic, Tajikistan, Turkmenistan, and Uzbekistan - include those reached in 1987 (Protocol 566--principles of water sharing), 1991 (declaration of intention to continue cooperation), 1992 (establishment of Interstate Commission for Water Management Coordination - ICWC - to coordinate transboundary water management), and Nukus Declaration of 1995 (recognition of previous agreements)[1]. Afghanistan is not a party to these agreements.

These agreements form the basis for the current practice of water allocation among the Central Asian states (Kyrgyzstan, Tajikistan, Uzbekistan and Turkmenistan for the Amu Darya basin). The BVO Amu Darya (Basseynovoe Vodnoe Obedinenie, or Basin Water Organization) is the operating branch of the ICWC for the Amu Darya.

Environmental and Social Conditions and Potential Impacts

Seismicity and Geology (ESIA Chapter 6)

Seismicity. To protect against seismic events, the dam is designed to withstand the Maximum Credible Earthquake. To reduce the risk of reservoir-triggered seismic events, which is in general higher when filling is done quickly and stresses change more quickly, the Rogun reservoir would be filled slowly, over a period of 16 years; at that rate, the maximum reservoir-triggered earthquake would be relatively minor. To further characterize background seismicity, monitoring networks for strong-motion and microseismic events are recommended before dam construction.

[1] It is important to note that the technical studies and the ESIA assumed that the practices used to date would continue to serve as the basis for future water allocations. This, in turn, established the rationale for the reservoir operations scenario used for the assessment of downstream risks and impacts.

Geology. The Ionakhsh Fault cuts across the dam site, and is bordered with salt in the form of a "wedge" that widens at depth and is slowly being extruded upward. Dissolution of the salt due to contact with water must be avoided. TEAS technical studies concluded that a combination of grouting and a hydraulic barrier would reduce risk to an acceptable level. To ensure effectiveness, a micro-gravity monitoring system is recommended to allow timely intervention if required.

In addition, design measures have been proposed to ensure underground structures are not adversely affected by geologic conditions.

Landslides. The region is somewhat erosion-prone, a situation made worse by local deforestation caused by logging, agriculture and grazing. Oscillations in reservoir water levels may increase the risk of landslide and erosion. Investigations identified no large landslide blocks whose failure could cause damaging waves in the reservoir, although recommended preventive measures would be needed at settlements which are near these features -- monitoring, reforestation, and other recommended measures should prevent significant adverse effects.

Climate (ESIA Chapters 7 and 20)

The climate of the project area is characterised by hot dry summers and cool winters, with the majority of precipitation falling as snow, especially on the high mountains where tributaries to the Vakhsh river originate. River flows are highly seasonal, with low flows in winter and high flows in summer since most of the water originates from snow and glacier melt.

The Rogun HPP reservoir would be too small to have a significant effect on local or regional climate, although temperature moderation may lead to a few more frost-free days in some years.

Previous studies of climate change in the region predict two main trends on a regional scale: a general increase in temperature and no major change in overall precipitation, although there may be seasonal changes as more precipitation falls as rain and less as snow, and increasing variability from year to year. These changes can lead to earlier peaks in Vakhsh flows and overall increased flows for at least several decades while glaciers recede. In the longer term, flows could decrease due to reduced glaciation. In general, the additional storage capacity of Rogun could help buffer increased variability in inter-annual precipitation.

Greenhouse gas emissions from the reservoir would not be significant. To the extent that electricity generated by Rogun substitutes for power generated by carbon based fuels, there would be reductions in greenhouse gas emissions.

Water (Hydrology) (ESIA Chapters 8, 21)

The Amu Darya is the largest river of Central Asia, and one of the two main tributaries of the Aral Sea. The river is formed by the confluence of its two most important tributaries, the Pyanj and Vakhsh rivers. The Vakhsh contributes an average of about 26 percent of the annual Amu Darya flow, and the Pyanj about 40 percent. In the Amu Darya as in the Vakhsh, the flow pattern is highly seasonal, with high flows in summer due to snow and glacier melt in the mountains, and low flow in winter since most of the precipitation in the catchment area falls as snow. Both the Vakhsh and Pyanj carry high sediment loads, in the case of the Vakhsh in the range of 60-100 million m^3 per year at the Rogun site.

Water Allocation and Use with Rogun HPP. In practice, water allocations among riparian countries are calculated seasonally by BVO Amu Darya based on the countries' requests and forecasts for the coming season. BVO presents these to ICWC members for approval. Seasonal adjustments may be made by ICWC when uncertainty or inaccuracies in initial estimates and allocations lead to issues regarding allocations. To date, Tajikistan has not used its full allocated water share from the Amu Darya (particularly from the Vakhsh river). Between 2005 and 2011 the average annual unused Tajik share from the Vakhsh river was 1.2 km^3. In future, Tajikistan intends to use its full water share of Vakhsh, respecting the downstream water requirements as allocated by ICWC, with or without the Rogun project.

Reservoir Filling and Operations. The Government's intent is to fill the Rogun reservoir using part of the share allocated to Tajikistan under current agreements and practices. Assuming that this situation would continue to prevail until the end of the reservoir filling period, this hitherto unused share would be sufficient to fill the reservoir. As per the TEAS report, reservoir filling is expected to take 16 years.

For the operational phase of the Rogun project, it is the Government's intent to limit the transfer of water from the vegetative season inflows at Rogun to the non-vegetative season releases downstream of Nurek to 4.2 km^3, which is the quantity currently transferred by the operation of the Nurek reservoir utilizing its present live storage capacity. The TEAS simulations are based upon this operating regime, which would not change the current downstream flow pattern.

The technical and environmental studies demonstrate that it is possible to operate the Vakhsh cascade with Rogun in a way that the river flow pattern downstream of the cascade will remain unchanged. For the initial filling of the Rogun reservoir, Tajikistan will use its unutilised share of water allocated to it by ICWC, remaining in compliance with Nukus Declaration, Protocol 566 and the average limits set by the ICWC. Tajikistan has indicated that it intends to operate the cascade in this way. Under these assumptions, building and operating Rogun HPP will not reduce water shares allocated to downstream riparians.

To evaluate risks and opportunities that could arise from reservoir operation, the ESIA examined a number of scenarios, including the possibility of maximising winter energy. These analyses show that the best option for operating the reservoirs would be the intended operation pattern, both for Tajik interests as well as the interest of downstream countries. By contrast, Rogun HPP could benefit all downstream water users in the Amu Darya basin by providing additional water for irrigation in exceptionally dry years. Modifications of existing agreements and practices would allow for such an improvement of the situation. All scenarios are described in Chapter 21.

Flood control. The Nurek HPP is not designed to handle the Probable Maximum Flood, and this places both the facility and downstream areas at some risk. Rogun, on the other hand, is so designed, and its storage capacity and water regulation capability would allow it to control flows so as to protect Nurek and the downstream cascade[2]. Even so,

[2] FSL 1290 and FSL 1255 alternatives could manage the PMF, but not FSL 1220. Without Rogun or with FSL 1220, it would be possible to adapt the cascade to handle PMF, but only with additional investments of at least several hundred million dollars.

dam break scenarios and wave propagation studies would need to be undertaken and emergency preparedness and response plans developed prior to reservoir filling.

Aral Sea. The Aral Sea has suffered greatly due to massive irrigation schemes which were built in the 1960s, and which led to a very severe reduction of water inflow, to less than 10% of natural inflows. It has been shrinking very considerably, and salinity has increased. Today, the southern part, also called "Large Aral Sea", which is alimented by the Amu Darya, is significantly degraded, with no identified solution for recovery in the foreseeable future. Rogun HPP will not cause any change in the situation of the Aral Sea.

Biodiversity and Protected Areas (ESIA Chapters 9, 10, 11, 12)

Terrestrial flora and fauna. Available documentation and fieldwork carried out as part of the ESIA verified that flora and fauna in the project area are strongly influenced and degraded by human interference, primarily logging in the past and overgrazing in the present. The area previously supported native forest, but only very limited areas now support even isolated and often stunted trees.

Surveys concluded that habitats and biodiversity in the reservoir area were not unique or even rare in Tajikistan. Although this area is within the range of some protected or sensitive species of flora and fauna, these species are relatively widespread. Similarly, there are no habitats that are not found widely in the country. Although not rare, two riparian areas in the floodplain would qualify as “natural habitats” (although not “critical natural habitats”) under World Bank Operational Policy 4.04. Additional surveys would need to be conducted to document the biodiversity value of these riparian areas to serve as the basis for defining the specific measures that would be required to offset their loss (see below).

Protected areas. The Rogun HPP would not have significant adverse effects on any protected area if the cascade is operated as intended. The Tigrovaya Balka State National Reserve lies on the Vakhsh river downstream of the Rogun site near Vakhsh’s confluence with Pyanj river. This area is one of the few remaining Tugai riparian habitats. Tigrovaya Balka has suffered from flow changes caused by Nurek HPP, in particular the reduction in summer flows and floods. The intended operating regime for Rogun HPP is not expected to cause any further effects on Tigrovaya Balka, and could even provide the opportunity for some improvements if planned floods were carefully managed to avoid downstream damage.

The recommended option for mitigation for the conversion of the two areas of natural habitat (*not* Tugai) described above would be to provide support to one or more programs of maintenance and improvements of Tigrovaya Balka. If this is the choice of offset, a detailed plan would need to be developed and put in place prior to filling of the Rogun reservoir.

Other protected areas, including one near the Nurek reservoir and additional Tugai habitat areas in downstream countries, would not be affected.

Aquatic biodiversity. A total of about 85 km of the Vakhsh river would be directly affected by Rogun. The 15-kilometer reach immediately downstream of Rogun but above Nurek reservoir would have its flow pattern fundamentally changed, and would become similar to the current flow pattern downstream of Nurek (since Rogun’s operating regime is intended to approximate the current Nurek pattern and Nurek would become essentially run-of-river with a full reservoir at all times). At no time would this 15-kilometer reach be dewatered, and it is recommended that a minimum residual flow of at least 10 m³/s be maintained at all times.

Upstream of the Rogun dam, approximately 70 km of the free-flowing river would become a lake, with consequent changes in biodiversity. There are no important fisheries on the Vakhsh -- fish fauna are relatively impoverished and Nurek has already interrupted all long-distance fish migration. Thus, adverse impacts are not considered significant.

As noted previously, Rogun would be managed for flow regulation and management of the downstream Vakhsh. As a result, the reservoir water level would not be constant, but rather would be subject to drawdowns of up to 30 meters by late winter and then filling by early autumn. This oscillation is likely to limit the development of a significant lacustrine fishery in Rogun reservoir, although this would be evaluated and confirmed in future studies. The reduction in Nurek reservoir oscillation by conversion to a static reservoir, on the other hand, could enhance the possibility of fishery development there, and this would also be evaluated and followed up as appropriate.

Socioeconomic Conditions, Resettlement and other Impacts (Chapters 13 and 19)

The economic situation in the project area is very difficult, as it is in much of rural Tajikistan. Unemployment is very high, there is widespread poverty, and most families are involved to some degree with subsistence-level agriculture and animal husbandry. The only major employer in the area in recent decades has been development works related to Rogun HPP, and that has been significantly reduced by the recent hiatus in construction work. The primary alternative is seeking work as migrant labour, mainly in Russia. In the future, up to 13000 people may be employed in construction, with significant employment for most of the 16 years of construction.

For the purposes of the ESIA, the Rogun HPP “social area of influence” comprises communities, households and individuals that: (i) are living within the reservoir area that will need to be physically relocated; (ii) are directly affected by the construction of civil works, presence of work camps and influx of workers; (iii) will act as host communities for resettled households; (iv) that may be affected by the long–term operations of the Vakhsh cascade principally by changes to water availability downstream of the dam(s); (v) may be indirectly affected by economic development triggered by Rogun HPP; (vi) will receive the direct benefit of assured electricity supply after the project is completed.

The ESIA identifies social risks associated with the project mainly as a result of involuntary resettlement and the influx of workers from outside the project area. Mitigating impacts on household income and livelihoods and identifying strategies to ensure that incomes are restored require further examinations of needs and potential solutions. The expected influx of non-local workers and others would exert pressure on existing institutions and infrastructure. These impacts need to be better understood, and required actions to minimize the impacts need to be designed and implemented.

However, Rogun HPP has been identified as the best way for closing the gap in winter energy supply in Tajikistan. This is the major benefit from the project, which will contribute to improving the living and socio-economic conditions of the population of the entire country including jobs and economic stimulation resulting from large scale works and infrastructure.

The reservoir (FSL 1290 alternative) would cover an area of 170 km^2 where over 42'000 people live in 77 villages. These people would have to be relocated. Resettlement would be carried out in two stages corresponding to dam construction and reservoir filling: of the 42'000 people to be relocated, approximately 2'000 (7 villages) are affected by past construction and the initial phase of reservoir filling. These are Stage 1, villages with the remaining 70 villages in Stage 2. All are in the three districts Rogun, Nurobod and Rasht.

Resettlement began in the 1980s when construction of Rogun HPP started. Presently, some resettlement is ongoing under Stage 1. The process is being and would continue to be implemented by a Resettlement Unit which started to work in 2011.

A Resettlement Action Plan (RAP) for Stage 1, which would apply to all who have been or would be affected by Phase 1 construction, will be completed and disclosed soon. Stage 2 resettlement will be guided by a Resettlement Policy Framework (RPF). The overall goal of the resettlement process is to restore or improve the socioeconomic status of affected people. This has to be accomplished in consultation with those affected people. A partial audit of past resettlement activities is being completed and results are allowing fine-tuning of ongoing efforts and informing the finalization of the Stage 1 RAP and RPF and provide for retroactive measures for people already resettled..

Cultural Heritage (Chapter 14)

The project area has been inhabited for millennia, since at least the Neolithic period. Most archaeological sites in the area are related to a branch of the Silk Road that passed through Vakhsh valley. With one exception, known archaeological sites in the area to be affected by the project were partly or entirely destroyed in the past by road construction and other activities. However, the ancient fortresses at Navdonak, are believed to be relatively intact although they have not been investigated so far. An archaeological investigation of this site would be completed prior to impoundment.

In addition, some local villages that would be submerged and whose populations would be resettled are quite old. In order to document local culture and oral traditions, an ethnographic survey of the area would be carried out before impoundment.

Analysis of Alternatives (ESIA Chapter 22)

Strategic Alternatives for Electricity Generation. Tajikistan suffers from a critical need for winter electricity, with demand exceeding supply by about 25 percent at present. Thus, urgent action is needed. Demand-side changes such as improvements in energy efficiency are needed as part of the solution, but the shortfall can only be overcome in the mid- and long term with additional generation capacity. This could come from burning fossil fuels (coal or natural gas), hydropower, or alternative renewable sources such as wind or solar.

Tajikistan has limited fossil fuel resources, and importing enough for significant generation would be unaffordable even if supplies could be found. Wind and solar are also very expensive, and cannot generate electricity on a full-time basis.

By contrast, Tajikistan has plentiful hydropower resources that have yet to be developed. Hydro-power development is considered to be essential to meet Tajikistan’s long-term strategic energy needs in a sustainable manner ensuring energy self-sufficiency and security.

***Alternative Hydropower Projects*.** Hydropower resources consist of storage and run-of-river opportunities. TEAS analysis established that the benefits of Rogun exceed those of other feasible HPPs and thermal plants. This is in part because run-of-river plants have lower generation capacity in winter due to low river flows. On the other hand, storage-type HPPs (that is, those with reservoirs) can store summer water for use in winter, but can have major impacts on downstream water flows and users. Only if they are upstream of and operate as a cascade with one or more existing storage HPPs can significant benefits be achieved without such changes in downstream flows. The only suitable location for such a new HPP would be upstream of Nurek on the Vakhsh river. Thus, Rogun HPP has been identified as the most preferable project site.

Evaluation of Alternative Rogun Configurations. The TEAS studies considered a number of scenarios and options, most notably three different dam heights (FSL 1220, FSL 1255 and FSL 1290). TEAS studies found all three dam heights to be economically feasible. However, based on economic and technical considerations, TEAS recommended to take the FSL 1290 alternative forward for further detailed consideration.

The ESIA was undertaken for the TEAS recommended alternative of FSL 1290 and an installed capacity of 3200MW. However, comparisons are made with the two other alternatives (FSL 1255 and FSL 1220) and a “no Rogun” case.

The FSL 1220 alternative has a reduced energy output, a relatively short life span and it does not mitigate the Vakhsh cascade’s inability of handling PMF. Thus it offers no comparable advantages to the two higher dam alternatives. For this reason, it was eliminated from further consideration.

FSL 1290 and FSL 1255 alternatives differ in their main environmental and social impacts and risks. In addition to the best economic results, the longer life span and the better flood and drought mitigation potential are strong arguments in favour of the FSL 1290 alternative. On the other hand, the lower potential for adversely influencing the downstream flow conditions, and mainly the fact that resettlement would be reduced by more than half are similarly strong arguments for the FSL 1255 alternative (see Table below).

Given the considerably longer life span of the FSL 1290 alternative, the higher electricity production and that the incremental environmental and social impacts can be appropriately mitigated, the ESIA consultant recommends to take the FSL 1290 alternative forward for detailed consideration.

Conclusions

Based on the analyses presented in this ESIA, the Consultant confirms the recommendation of the TEAS that Rogun HPP FSL 1290 alternative be taken forward for detailed consideration.

From an environmental and social point of view, there are two main categories of significant potential effects: resettlement and social impacts on local communities, and changes in downstream flows in summer.

The resettlement process is intended to minimize potential negative impacts of relocation and effects on people’s livelihoods. Resettlement planning is designed to ensure there is fair and adequate compensation of all losses caused to the affected population by the project, with the result that the status of affected people is restored or improved, and that they are consulted throughout the process. Resettlement and associated livelihood restoration issues are being dealt with in two stages. The institutional arrangements for accomplishing this are in place, with an active Resettlement Unit proceeding with Stage 1 and planning for Stage 2. The project would involve large scale resettlement which must be suitably planned, resourced and supported including work to strengthen the aspect of livelihood restoration.

Tajikistan intends to maintain the current seasonal pattern of flows in the Vakhsh river by converting Nurek to a run-of-river HPP and using Rogun HPP to regulate the cascade and downstream water flows. Technical studies show this is technically and economically feasible, within existing agreements and practices, including Tajikistan utilizing its allocated share. Rogun would also contribute to flood control benefits by adding the ability to manage the Probable Maximum Flood and by reducing risks of floods of lower magnitudes but higher probability of occurrence. Rogun could also be operated to partly overcome downstream water shortages during dry years. Rogun HPP would provide significant extension of the lifespan of Nurek and the Vakhsh hydropower cascade, due to sediment retention.

The recommended mitigation, management, and monitoring measures should be sufficient to manage the principal project risks while allowing the project to achieve its primary aim of generating power to help overcome critical shortages in winter. The ESMP and RAP provide for robust programs of adaptive management that would allow continuous adjustments as needed to minimize environmental and social impacts.

1 INTRODUCTION

This is the Main Report for the Environmental Impact Assessment for the Rogun Hydropower Plant.

There are two studies being carried out in parallel, namely:

- TEAS (Technical and Economical Assessment Study) and
- ESIA (Environmental and Social Impact Assessment).

These two studies are carried out by different consultants (referred to in this report as the TEAS Consultant and the ESIA Consultant). The TOR of both studies specify the requirements for coordination between the two groups, and this was also an important topic of discussion during the meetings with World Bank and the POE.

The ESIA Report is subdivided in three main parts as follows:

A Project and Legal Framework: this first part describes the legal and administrative framework to be followed, provides a description of the project and the definition of the study area.

B **Sectoral Studies**: in this part, the different topics to be dealt with are described in detail. This Part is again subdivided in three, namely:

   i. the physical environment (geology and soils, climate, water);
   ii. the biological environment (vegetation, terrestrial and aquatic fauna, protected areas);
   iii. the human environment (local population and socio-economy, cultural resources).

   As far as possible, the chapters in this part follow a common structure which covers a description of the present situation, an analysis of impacts caused by the Project, and proposed mitigation measures.

C **Synopsis**: this part contains a synthetic analysis of impacts and measures:

   i. Classification of impacts
   ii. Impacts and mitigation
   iii. Environmental and social management plan
   iv. Construction site audit
   v. Resettlement planning
   vi. Climate change and its effect on Rogun HPP
   vii. Effects on riparian countries
   viii. Analysis of alternatives
   ix. Public participation
   x. Environmental and social monitoring

The report ends with a short chapter providing the main recommendations.

Annexes are provided in a separate volume (Volume II); basically, there is one Annex for each main Chapter of the Report.

For practical reasons - i.e. because of the size of the report, it was also decided to prepare a separate Volume III which contains the preliminary ESMP and related issues (construction site management, site rehabilitation, monitoring and instrumentation, etc.).

It should be noted that the RAP for Stage 1 is also dealt with in a separate report.

PART A PROJECT AND LEGAL FRAMEWORK

This first part describes the legal and administrative framework to be followed, provides a description of the project and the definition of the study area.

2 LEGAL AND ADMINISTRATIVE FRAMEWORK

2.1 Key Messages

The ESIA for Rogun HPP had to be carried out according to the following legal and administrative conditions:

- National legislation on environmental protection and ESIA procedures, including conditions for resettlement caused by the project.
- World Bank environmental and social safeguards, given the participation of World Bank in the project assessment studies.

These conditions and requirements are described in this chapter.

2.2 National Laws

2.2.1 Environmental Protection

Annex 2.1 provides a list of the relevant laws on protection of the environment. This list is provided in the following Table, with some indications on objectives and relevance for different activities.

Table 2-1: National legislation on protection of the environment

Name	Objective	Of relevance for
Water Codex of the Republic of Tajikistan (news of Majlisi Oli of the Republic of Tajikistan 2000, № 11, art. 510; 2006, № 3, art. 164)	The Water Code contains provisions for particular uses of water for which there is a charge and for compensation of damage to water sources. The procedures for calculating the charges are described in Directive Document RD-01-93.	Aspects related to water and use of the resource (mainly Chapter 8).
Law of the Republic of Tajikistan on Fauna (news of Majlisi Oli of the Republic of Tajikistan, 2008, № 1 part 2, art 19)	Protection of fauna.	Terrestrial fauna (Chapters 10) and aquatic fauna (Chapter 11)
Law of the Republic of Tajikistan On waste production and consumption (news of Majlisi Oli of the Republic of Tajikistan 2002, , №4, part-1,art 287,2005, №7 art 409)	The Law on Production and Consumption Waste states that payments for waste disposal depend on the volume of waste and its toxicity. The procedures for calculating the charges are described in Directive Document RD-01-93.	Basis for developing the required waste management plans (see sections on waste management in Vol. III, ESMP).
Law of the Republic of Tajikistan On Environmental Protection (Gazette of the Supreme Soviet of the Republic of Tajikistan 1994, № 2, art 36, news of Majlisi Oli of the Republic of Tajikistan 1996, № 3,art 48, 1997, № 23-24, art 333, 2002, № 4, part-1, art 245, 2002, № 11, art 708, 2004, № 7 art 465,c2007, №c6,artc440)	Conditions for environmental protection.	Applicable for the environmental management of the construction site (see Vol. III, ESMP)
Law of the Republic of Tajikistan On Ecological Expertise (news of Majlisi Oli	Procedure for preparing environmental impact assessments.	ESIA preparation (see also

Name	Objective	Of relevance for
of the republic of Tajikistan 2003, № 4, art. 150, 2005, № 12, art. 638, 2007, № 7 art. 690).		following Section).
Law of the Republic of Tajikistan On Specially Nature Territories and Objects (news of Majlisi Oli of the Republic of Tajikistan 1996, № 23,art 353,1998, №10, art125, 2002, № 4 part -1, art272)	Protected areas	Protected Areas (Chapter 12)
Law of the Republic of Tajikistan On Air Protection (news of Majlisi Oli of the Republic of Tajikistan 1996, №3,art53,1997, № 23-24,art333,2007, №5 art 370)	The Law on Air Protection defines the economic mechanism for air protection, including its objectives, sources of financing for air protection measures and payments for air pollution (within and beyond established limits).	Applicable on the construction site (air quality management, see Vol. III, ESMP)
Law of the Republic of Tajikistan On Protection and Using of Flora (news of Majlisi Oli of the Republic of Tajikistan 2004, №5,art342,2007, №7,art 691,2008, №1 part2 art 18) http://cis-legislation.com/document.fwx?rgn=8246	This Law defines principles of the state policy in the field of protection and rational use of flora, determines the legal, economic and social basis in this area and is directed on preserving and reproduction of resources of flora.	Vegetation (Chapter 9)
Forest Codex of the Republic of Tajikistan (Gazette of the supreme soviet of the Republic of Tajikistan.1993 , № 13 art. 243, news of Majlisi Oli of the Republic of Tajikistan 1997, № 9 art 117)	The Code regulates forestry and is directed at creating conditions for the rational use of forests, their safe keeping and protection, conservation and improvement of the natural environment, production of timber and agricultural products.	Vegetation (Chapter 9)
Law of the Republic of Tajikistan On Hydrometeorological Activity Dushanbe 2002 http://cis-legislation.com/document.fwx?rgn=5870	This Law sets the legal basis of activities in the field of hydrometeorology. Its aim is directing on support of needs of the state, physical persons and legal entities in providing hydrometeorological as well as environmental information.	Climate (Chapter 20) and hydrology (Chapter 8).
Resolution of the Republic of Tajikistan from 30.12.2010 №702 Dushanbe.	About occupational diseases, list of hazardous substances and production factors.	EH&S on the construction site: occupational health. See Vol. III, ESMP, sections on workers' health.

2.2.2 ESIA Procedure

The ESIA procedure is defined by the Procedure of Environmental Impact Assessment (No. 464, approved October 3, 2006). This text contains a detailed description of the procedure to be followed for the preparation of impact assessment studies. Its Appendix 1 defines the projects for which an EIA is required, and point No. 1 in this list is “Hydropower, thermal power plant and other facilities with thermal output of 300 Megawatt”.

Appendix 4 of the Procedure provides a flow chart of EIA procedure (see Figure 2-1).

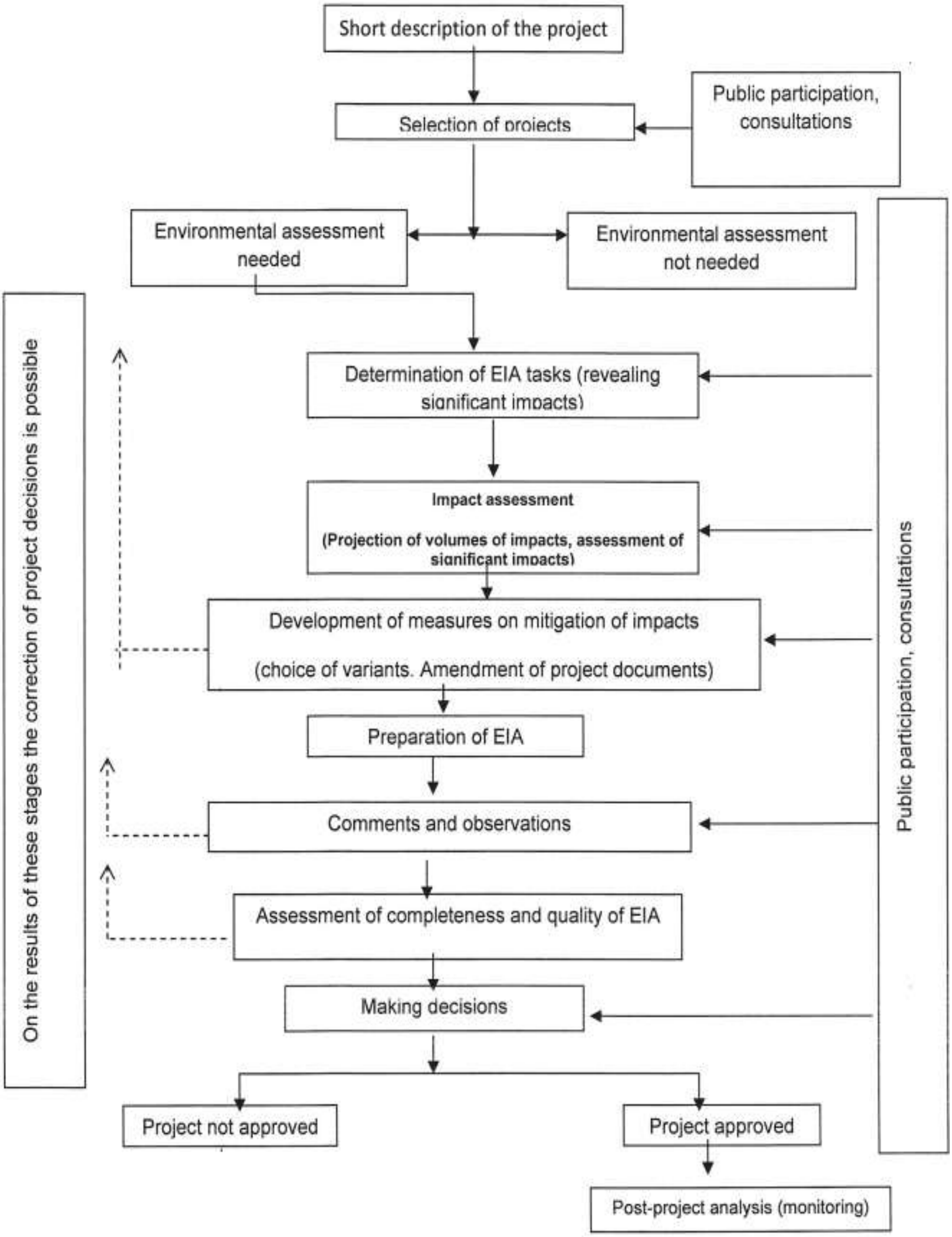


Figure 2-1: EIA procedure

2.2.3 Resettlement

Resettlement in Tajikistan in general, and Rogun HPP specifically, is guided by two texts, namely:

- **Regulations on Domestic Migration Procedure in the Republic of Tajikistan**

  (Resolution No. 467 of Oct. 1, 2008; see Annex 13.4.2).

- **Resettlement of the Population of Rogun Town and Nurobod Rayon from Zones of Submersion of Rogun Hydropower Plan**

  Resolution No. 47 of January 20, 2009: see Annex 13.4.1).

2.3 International Standards

2.3.1 World Bank Safeguards

The main applicable international standards for the Rogun HPP ESIA are the Safeguards (Operational Policies, OPs) of the World Bank (WB). The following Table lists these standards and comments on whether or not they are applicable in the present case.

Table 2-2: Applicable World Bank Operational Policies (OPs)

OP No.	Title	Dated	Comments
4.01	Environmental Assessment	Jan. 1999	Applicable. The project is clearly of a type and size (Category A Project) which requires a full environmental assessment.
4.04	Natural Habitats	Jun. 2001	Applicable. Some natural habitats are affected directly (by submersion at filling of reservoir) and indirectly (by change in river discharge conditions).
4.09	Pest Management	Dec. 1998	Not applicable.
4.10	Indigenous Peoples	Jan. 2005	Not applicable. The population of the project area is not considered - and does not understand itself - as an ethnic minority.
4.11	Physical Cultural Resources	Jan. 2006	Applicable. A number of cultural (historical, archaeological) sites are known to exist in the project area.
4.12	Involuntary Resettlement	Dec. 2001	Applicable. A total of 77 villages with a total of approximately 42'000 inhabitants have to be resettled due to the project.
4.36	Forests	Nov. 2002	Not applicable. No forest areas are affected by the project.
4.37	Safety of Dams	Oct. 2001	Applicable. It is a project of a high dam in a seismic active area. Dam safety must have a high priority in this project (aspect to be covered mainly in the technical assessment and design).
7.50	Projects on International Waterways	June 2001	Applicable. The river to be used for the project, Vakhsh, is a main tributary of Amu Darya, whose water is essential for irrigation and water supply in riparian countries (mainly Uzbekistan and Turkmenistan). Amu Darya is one of the two tributaries of Aral Sea.

2.4 Additional Rules and Guidelines

2.4.1 World Commission on Dams Report

The WCD Report,

World Commission on Dams (WCD), 2000: Dams and Development: a New Framework for Decision-Making. Earthscan Publications Limited, London and Sterling, VA, 404 pp.

in an attempt to bring together representatives of all stakeholders involved in or concerned by the construction of large dams, has developed recommendations and guidelines to be applied in the development of dam projects in order to ensure sustainability, of the projects as well as of the use of the resource which are at the basis of such projects. WCD formulated a set of seven Strategic Priorities as listed below. These can be taken as recommendations or guidelines, however, they do not have any binding character. Comments related to compliance of the project with these principles are provided in Vol. II (Annex 25).

2.4.2 IHA Sustainability Protocol

The Hydropower Sustainability Assessment Protocol is an enhanced sustainability assessment tool used to measure and guide performance in the hydropower sector.

The Protocol assesses the four main stages of hydropower development: Early Stage, Preparation, Implementation and Operation. Assessments rely on objective evidence to create a sustainability profile against some 20 topics depending on the relevant stage, covering all aspects of sustainability. for additional information see http://www.hydrosustainability.org/Protocol.aspx .

Like the WCD guidelines, this protocol has no binding character. However, given the size and complexity of Rogun HPP, it is recommended to use this Protocol as a tool for addressing all environmental, social and sustainability issues related to it.

2.4.3 IFC EHS Guidelines

As international standards for the Rogun HPP, the IFC EH&S Guidelines have been used. Table 3 of ESIA Vol. III lists the topics which are covered by the IFC Guidelines and the Management Plans which will have to be implemented by Rogun HPP.

2.5 International conventions and Treaties

2.5.1 Aarhus Convention

The UNECE Convention on Access to Information, Public Participation in Decision-making and Access to Justice in Environmental Matters was adopted on 25th June 1998 in the Danish city of Aarhus at the Fourth Ministerial Conference in the 'Environment for Europe' process. Tajikistan has ratified the convention on 17.07.2001.

The Aarhus Convention is a new kind of environmental agreement. The Convention:

- Links environmental rights and human rights
- Acknowledges that we owe an obligation to future generations

- Establishes that sustainable development can be achieved only through the involvement of all stakeholders
- Links government accountability and environmental protection
- Focuses on interactions between the public and public authorities in a democratic context.

The subject of the Convention goes to the heart of the relationship between people and governments. The Convention is not only an environmental agreement, it is also a Convention about government accountability, transparency and responsiveness.

The Aarhus Convention grants the public rights and imposes on Parties and public authorities obligations regarding access to information and public participation and access to justice.

The Aarhus Convention is also forging a new process for public participation in the negotiation and implementation of international agreements. For additional information see http://www.unece.org/env/pp/introduction.html.

2.5.2 Other International Treaties

Other international treaties and conventions are listed below, and their relevance for Rogun HPP is mentioned.

Table 2-3: International treaties

Name	Objective	Relevance for Rogun HPP
Convention on Wetlands of International Importance (Ramsar, Iran, 1971) -- called the "Ramsar Convention" http://www.ramsar.org	The Convention's mission is "the conservation and wise use of all wetlands through local and national actions and international cooperation, as a contribution towards achieving sustainable development throughout the world".	The Convention on Wetlands came into force for Tajikistan on 18 November 2001. Tajikistan presently has 5 sites designated as Wetlands of International Importance, with a surface area of 94,600 hectares. None of these sites will be affected by Rogun HPP.
CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora) http://www.cites.org/	International agreement between governments. Its aim is to ensure that international trade in specimens of wild animals and plants does not threaten their survival.	Tajikistan is not a contracting party. Not of relevance for Rogun HPP
Berne Convention (Convention on the Conservation of European Wildlife and Natural Habitats; in force since 1 March 2002) http://www.coe.int/t/dg4/cultureheritage/nature/bern	Its aims are to conserve wild flora and fauna and their natural habitats, especially those species and habitats whose conservation requires the cooperation of several states. Particular emphasis is given to endangered and vulnerable species, including endangered and vulnerable migratory species (Convention, Chapter 1, Article 1).	Tajikistan is not a contracting party. Not of relevance for Rogun HPP
Convention on the Conservation of Migratory Species of Wild Animals (also known as CMS or Bonn Convention; in force since 1979) http://www.cms.int/en/country/tajikistan	The Convention aims to conserve terrestrial, aquatic and avian migratory species throughout their range. It is an intergovernmental treaty concerned with the conservation of wildlife and habitats on a global scale.	The Convention on the Conservation of Migratory Species of Wild Animals came into force for Tajikistan on February 2001. Not of relevance for Rogun

		HPP
UN Convention on Biodiversity (part of the Rio Convention) http://www.cbd.int/countries/default.shtml?country=tj	The objectives of this Convention are the conservation of biological diversity, the sustainable use of its components and the fair and equitable sharing of the benefits arising out of the utilization of genetic resources, including by appropriate access to genetic resources and by appropriate transfer of relevant technologies, taking into account all rights over those resources and to technologies, and by appropriate funding (Convention, Article 1 Objectives).	The Convention on Biological Diversity came into force for Tajikistan on 29 October 1997. Not of relevance for Rogun HPP
Convention on Environmental Impact Assessment in a Transboundary Context, signed in Espoo, Finland in1991, entered into force in 1997 http://www.unece.org/fileadmin/DAM/env/eia/subregions/central_asia.htm	The Espoo is a United Nations Economic Commission for Europe (UNECE). It sets out the obligations of Parties (contracting States) to carry out an environmental impact assessment of certain activities at an early stage of planning. It also lays down the general obligation of states to notify and consult each other on all major projects under consideration that are likely to have a significant adverse environmental impact across boundaries.	Tajikistan is not a contracting party. However, the spirit of the convention is being applied by the riparian consultation for Rogun Project.
World Heritage Convention (WHC), into force on December 1975 http://whc.unesco.org/en/list	Convention concerning the Protection of the World's Cultural and Natural Heritage.	Tajikistan presently has 2 properties designated as World Heritage site (cultural: Proto-urban Site of Sarazm; natural: Tajik National Park (Mountains of the Pamirs)). None of these sites will be affected by Rogun HPP.
The UN Framework Convention on Climate Change (part of the Rio Convention, into force on 21 March 1994) https://unfccc.int	The convention is an international environmental treaty; legally non-binding. Its objective is to "stabilize greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system".	Accession of Tajikistan on 7 January 1998 Climate (Chapter 9)
UN Convention to Combat Desertification (part of the Rio Convention, into force on December 1996) www.unccd.int	The Convention is “the first and only internationally legally binding framework set up to address the problem of desertification. The Convention is based on the principles of participation, partnership and decentralization”.	Accession of Tajikistan on 16 July 1997 Not of relevance for Rogun HPP

2.6 International Water Laws

Two conventions on use of international waters could provide guidance in the important issues of sharing water among riparian states related to the project, namely:

- UN Convention on the Law of the Non-Navigational uses of International Watercourses; and
- UNEC Convention on the Protection and Use of Transboundary Watercourses and International Lakes.

They are discussed in the following Sections.

2.6.1 Definition of International River

In its Operational Policy on Projects on International Waterways, the World Bank provides the following definition:

(a) any river, canal, lake, or similar body of water that forms a boundary between, or any river or body of surface water that flows through, two or more states;

(b) any tributary or other body of surface water that is a component of any waterway described in (a).

Source: WB OP 7.50, Projects on International Waterways, 2013

Vakhsh has to be considered as being an international waterway according to this definition.

2.6.2 Rules for the Use of International Rivers

According to ICOLD (2007:21), “When a river passes from one state (country, region) to another, the sharing is not on equal basis. In principle, every country has the right to use the water on the basis of international agreements and principles (...). The out-flowing water from a state should be of acceptable quality for subsequent downstream use.”

Several international conventions (UN Convention, Helsinki Rules of the International Law Association and revised SADC Protocols) specify criteria for equitable and reasonable utilisation of transboundary rivers, such as:

- Natural factors as hydrology, climate
- Social and economic needs
- Population dependent on watercourse
- Effects on uses in other watercourse states
- Existing and potential uses
- Conservation, protection, development and economy of use and the costs of measures
- Availability of alternatives of comparable value.

Again according to ICOLD (2007:37), “Watercourse states are obliged not to cause significant harm to other co-basin States and should take all appropriate mitigation measures. Provision could be made for compensation in certain instances.”

“Best mechanism of sharing water is by application of Article 6 of the **UN Convention on the Law of the Non-Navigational uses of international watercourses**" (ICOLD 2007:71).

Table 2-4: Articles 5 and 6. UN Convention on International Waters

Article 5: Equitable and Reasonable Utilization and Participation
1. Watercourse States shall in their respective territories utilize an international watercourse in an equitable and reasonable manner. In particular, an international watercourse shall be used and developed by watercourse States with a view to attaining optimal and sustainable utilization thereof and benefits therefrom, taking into account the interests of the watercourse States concerned, consistent with adequate protection of the watercourse.
2. Watercourse States shall participate in the use, development and protection of an international watercourse in an equitable and reasonable manner. Such participation includes both the right to utilize the watercourse and the duty to cooperate in the protection and development thereof, as provided in the present Convention.

Article 6: Factors Relevant to Equitable and Reasonable Utilization

1. Utilization of an international watercourse in an equitable and reasonable manner within the meaning of article 5 requires taking into account all relevant factors and circumstances, including:

Geographic, hydrographic, hydrological, climatic, ecological and other factors of a natural character;

The social and economic needs of the watercourse States concerned;

The population dependent on the watercourse in each watercourse State;

The effects of the use or uses of the watercourses in one watercourse State on other watercourse States;

Existing and potential uses of the watercourse;

Conservation, protection, development and economy of use of the water resources of the watercourse and the costs of measures taken to that effect;

The availability of alternatives, of comparable value, to a particular planned or existing use.

2. In the application of article 5 or paragraph 1 of this article, watercourse States concerned shall, when the need arises, enter into consultations in a spirit of cooperation.

3. The weight to be given to each factor is to be determined by its importance in comparison with that of other relevant factors. In determining what is a reasonable and equitable use, all relevant factors are to be considered together and a conclusion reached on the basis of the whole.

Статья 5: Справедливое и разумное использование и участие

1. Государства водотока используют в пределах своей соответствующей территории международный водоток справедливым и разумным образом. В частности, международный водоток используется и осваивается государствами водотока с целью достижения его оптимального и устойчивого использования и получения связанных с этим выгод, с учетом интересов соответствующих государств водотока, при надлежащей защите водотока.

2. Государства водотока участвуют в использовании, освоении и защите международного водотока справедливым и разумным образом. Такое участие включает как право использовать водоток, так и обязанность сотрудничать в его защите и освоении, как это предусмотрено в настоящей Конвенции.

Статья 6: Факторы, относящиеся к справедливому и разумному использованию

1. Использование международного водотока справедливым и разумным образом по смыслу статьи 5 требует учета всех соответствующих факторов и обстоятельств, включая:

географические, гидрографические, гидрологические, климатические, экологические и другие факторы природного характера;

социально-экономические потребности соответствующих государств водотока;

зависимость населения от водотока в каждом государстве водотока;

воздействие одного или нескольких видов использования водотока в одном государстве водотока на другие государства водотока;

существующие и потенциальные виды использования водотока;

сохранение, защиту, освоение и экономичность использования водных ресурсов водотока и затраты на принятие мер в этих целях;

наличие альтернатив данному запланированному или существующему виду использования, имеющих сопоставимую ценность.

2. При применении статьи 5 или пункта 1 настоящей статьи соответствующие государства водотока, в случае возникновения необходимости, вступают в консультации в духе сотрудничества.

3. Значение, которое должно быть придано каждому фактору, подлежит определению в зависимости от его важности по сравнению с другими соответствующими факторами. При определении того, что является разумным и справедливым использованием, все соответствующие факторы должны рассматриваться совместно и заключение должно выноситься на основе всех факторов.

Source:
UN Convention on the Law of the Non-navigational Uses of International Watercourses
КОНВЕНЦИЯ О ПРАВЕ НЕСУДОХОДНЫХ ВИДОВ ИСПОЛЬЗОВАНИЯ МЕЖДУНАРОДНЫХ ВОДОТОКОВ
http://internationalwaterlaw.org/documents/intldocs/watercourse_conv.html

The UN Water Convention will enter into force on August 17, 2014. The UNECE Water Convention (Helsinki 1992) entered into force as of October 1996. Tajikistan has not ratified either of the conventions.

This **Convention on the Protection and Use of Transboundary Watercourses and International Lakes** (Water Convention) is intended to strengthen national measures for the protection and ecologically sound management of transboundary surface waters and groundwaters.

The Convention obliges Parties to prevent, control and reduce transboundary impact, use transboundary waters in a reasonable and equitable way and ensure their sustainable management. Parties bordering the same transboundary waters shall cooperate by entering into specific agreements and establishing joint bodies. The Convention includes provisions on monitoring, research and development, consultations, warning and alarm systems, mutual assistance, and exchange of information, as well as access to information by the public.

Initially negotiated as a regional instrument, the Convention was amended in 2003 to allow accession by all the United Nations Member States. The amendments entered into force on 6 February 2013, after its ratification by two thirds of the parties, and it is expected that non-ECE countries will be able to join the Convention in the near future (source: http://www.unece.org/env/water/).

Kazakhstan in 2001, Uzbekistan in 2007 and Turkmenistan in 2012 have acceded and are parties to the Convention. The Secretariat of the UNECE Water Convention has been optimistic and active in Central Asia, advocating the countries to build regional water cooperation based on the principles of the Convention. The Convention permits accession by non-UNECE states, which would include Afghanistan in Central Asia.

However, in the context of the issues at hand in relation with Rogun HPP and irrigation in the Amu Darya basin, it has to be pointed out that the focus of this convention is on water pollution and its prevention, not on flow distributions and consumptive uses of water. Specific rules might have to be developed in this respect. Still, even so central points of this convention would certainly by applicable here, as e.g. Article 2, Point 6 (see following Table).

Table 2-5: UNECE Water Convention, Art.2.6

Article 2 6. The Riparian Parties shall cooperate on the basis of equality and reciprocity, in particular through bilateral and multilateral agreements, in order to develop harmonized policies, programmes and strategies covering the relevant catchment areas, or parts thereof, aimed at the prevention, control and reduction of transboundary impact and aimed at the protection of the environment of transboundary waters or the environment influenced by such waters, including the marine environment.
Статья 2 6. Прибрежные Стороны осуществляют сотрудничество на основе равенства и взаимности, в частности, путем заключения двусторонних и многосторонних соглашений с целью выработки согласованной политики, программ и стратегий, охватывающих соответствующие водосборы или их части, для обеспечения предотвращения, ограничения и сокращения трансграничного воздействия и с целью охраны окружающей среды трансграничных вод или окружающей среды, находящейся под воздействием таких вод, включая морскую среду.

Source: http://www.unece.org/fileadmin/DAM/env/water/pdf/waterconr.pdf

2.7 Central Asia Water Management Agreements

Water management among Central Asian States is guided by agreements dating in part back to Soviet times, and additional agreements between the newly independent states reached since then. These instruments include:

- Protocol 566 of September 10, 1987
- October 12, 1991 Declaration
- February 18, 1992 Agreement "On Cooperation in the Field of Joint Water Resources Management and Conservation of Interstate Sources
- Nukus Declaration of September 20, 1995.

A more complete list of agreements can be accessed on ICWC's website (http://www.icwc-aral.uz/legal_framework.htm).

These agreements form the basis for the current practice of water allocation among the Central Asian states (Kyrgyzstan, Tajikistan, Uzbekistan and Turkmenistan for the Amu Darya basin). The following institutions are in charge of water allocation:

- Two Basin Water Organisations (BVO, Basseynoe Vodnoe Obedinenie) were created still during Soviet times, one for the Amu Darya, and one for the Syr Darya).
- The 1992 agreement led to the foundation of the Interstate Commission for Water Coordination (ICWC).

ICWC is the institution in charge of water allocation; the two BVOs are the operative branches of ICWC (see NeWater 2005). The agreements and the role of the institutions are discussed in detail in Section 8.5.

3 THE PROJECT

3.1 Key Messages

This chapter briefly describes the Rogun project:

- The primary purpose of the Rogun HPP is to generate electricity to help Tajikistan overcome critical shortages of electricity in winter and meet future demand, while respecting the water needs of downstream riparian countries.
- The studies on the Rogun project were initiated in 1963. Main construction started in 1982, but partially stopped in 1990.
- The techno-economic assessment study of various project alternatives, including environmental and social impact costs, has led to the TEAS recommended alternative (“recommended alternative”), assessed in the ESIA.
- **TEAS studies recommend a 335 m high earth core rock filled dam with its Full Supply Level (FSL) at 1290 m asl, with an installed capacity of 3200 MW be taken forward for detailed consideration.**
- Rogun HPP will with its average annual electricity production of 14.4 TWh contribute to approximately 30% of the Tajik demand between 2020 and 2050 and thus significantly enhance supply security in the country.
- Nurek will be operated as a run-of-river HPP, whereas all regulation will be done by Rogun HPP, the Vakhsh river flow pattern downstream of the cascade remaining unchanged.
- The economic viability of the Rogun design under the range of assumptions could be demonstrated by TEAS.
- Further information is given about the location and history, the technical and economic main characteristics as well as the existing construction site of the Rogun project.

Throughout the report, "recommended alternative" will be understood as "alternative recommended by TEAS".

3.2 The Aim of the Project

The main purpose of Rogun Hydropower Project (HPP) is the generation of electricity to reduce winter shortages and meet growing peak demand in Tajikistan, while respecting the water needs of downstream riparian countries.; this is important since the majority of Tajik people suffers from extensive shortages of electricity in winter. The project has several additional potential benefits:

- **Electricity production for export**: Rogun HPP will allow power trading with neighbouring countries, especially Pakistan and Afghanistan. For export of surplus electricity in summer, the planned transmission lines need to be built and a regional trading market has to be set up.
- **Flood management**: today’s Vakhsh cascade, including Nurek dam, is not designed to handle high floods, as e.g. Probable Maximum Flood (PMF). The construction of Rogun reservoir will improve flood routing capacity.

- **Downstream flow regulation potential**: additional water could be provided to the downstream area in especially dry years. However, it is not foreseen to provide water directly from Rogun for additional irrigation.
- **Retention of sediments**: Rogun reservoir will be able to retain large quantities of sediment which otherwise would reach Nurek reservoir. Sediment retention in Rogun will increase the life span of Nurek.

3.3 Project Location and Context

Rogun HPP is located on the Vakhsh river about 70 km upstream of the Nurek dam and in a distance of approximately 110 km east of the Tajik capital Dushanbe. One of the tributaries of Vakhsh river, the Kizil-Su, originates in Kyrgyzstan, flows through the Pamir-Alai mountains of Tajikistan and joins the Muk-Su, forming the Surkhob river. Vakhsh river is formed by the confluence of Surkhob with Obihingou; it then joins the Pyanj river after 520 km to form Amu Darya; Pyanj and Amu Darya lie on the border of Tajikistan and Afghanistan. The drainage area of the Vakhsh river in Tajikistan is 31’200 km^2. Most of the river runs through very mountainous territory. At the dam site, about 340 km upstream of the confluence with the Pyanj river, the river flows through a narrow, 400 to 500 m deep V-shaped gorge with gradients of the valley sides up to 50°.

Figure 3-1: Map of Tajikistan indicating Rogun dam site

Rogun dam site (38°40’34 N; 69°46’23 E) is located in the Rasht region, which is divided into seven districts (rayons), namely Fayzabad, Rogun, Nurobod, Rasht, Tavildara, Tojikobod and Jirgital. The construction site and the future reservoir directly affect Rogun, Nurobod and Rasht districts.

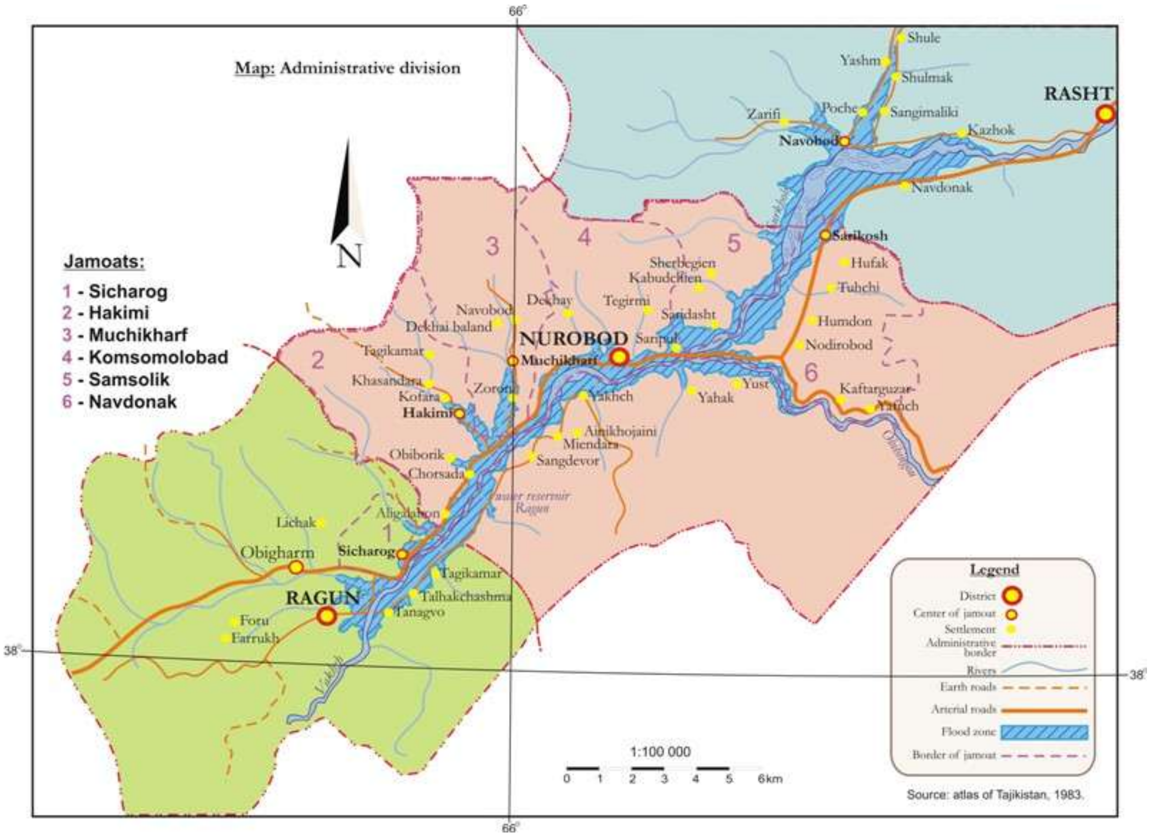


Figure 3-2: Outline of Rogun reservoir with affected districts

Rogun HPP is the uppermost of a planned - and partly built – hydropower cascade on the Vakhsh river. Five of the plants are already operating, Rogun HPP and Sangtuda 1 and 2 HPPs are under construction, and Shurob HPP is under planning (see Figure 4-2).

The Nurek storage hydropower scheme, with its 300 m high dam and its reservoir of 10.5 km^3 total storage capacity, is in operation since about 30 years. Nurek is operated to shift 4.2 km^3 of water from summer to winter to meet the peak electricity demand in the cold season. The other existing HPPs are run-of-river (ROR) schemes with no or very small storage capacity, and therefore with no effect on seasonal flow distribution.

3.4 Project History and Scope

The studies on the Rogun project were initiated in 1963, completed in 1978, and revised in 1981, when Nurek started operation. The main goals of the initial project with a 335 m high embankment dam were water regulation for irrigation in Uzbekistan and Turkmenistan as well as power supply for Soviet Central Asian countries. The final approval for Rogun HPP was given in 1980 and main construction started in 1982.

Main parts of the underground works and a 45 m high cofferdam were constructed until 1990 when the realization came to halt due to political changes resulting in the independence of Tajikistan. In 1993 a flood occurred, during which the diversion tunnels were clogged and the cofferdam overtopped and destroyed. Further damage was caused by an earthquake in 1995. In 2009, Hydroproject Institute of Moscow (HPI) was mandated to study the completion of Rogun project.

In response to a request by the Government of Tajikistan, the World Bank is supporting two studies to evaluate the viability of the proposed Rogun HPP according to international standards:

- Techno-Economic Assessment Study (TEAS)
- Environmental and Social Impact Assessment (ESIA)

The Assessment Studies aim to examine the potential benefits and risks of the proposed Rogun HPP and comprehensively evaluate its technical, economic, social, and environmental viability based on international standards and practices. The Studies will provide the Government of Tajikistan, the World Bank, the other Central Asian countries and the international community with information about key elements associated with the proposed Rogun HPP, such as the project’s technical soundness and safety, economic viability and compliance with all relevant environmental and social safeguards. To achieve these goals, the following scope was agreed:

- Techno-economic assessment and comparison of various project alternatives including environmental and social impact costs,

  leading to the alternative recommended by TEAS (“recommended alternative”);

- Environmental and social impact assessment of the recommended alternative, including an overall analysis of alternative concepts,

  leading to the alternative recommended by ESIA.

3.5 TEAS Recommended Alternative

3.5.1 Comparison of Alternatives

TEAS studies (Phase II Report – Volume 1: Summary – Chapter 3.2: Selection of Site, Powerhouse, Dam Type and Alternative, April 2014) propose an earth fill dam with a central impervious core at the dam site considered by HPI in 2009. Thus TEAS has undertaken a techno-economic assessment of three different dam heights and three different installed capacities for each of them:

Table 3-1: Alernatives for Rogun HPP studied by TEAS

Alternative	FSL 1290	FSL 1255	FSL 1220
Dam crest level	1300 m asl	1265 m asl	1230 m asl
Dam height	335 m	300 m	265 m
Total reservoir capacity	13’300 hm^3	8’550 hm^3	5’220 hm^3
Reservoir active storage	10’300 hm^3	6’450 hm^3	3’930 hm^3
Investigated installed capacities	2800 MW 3200 MW 3600 MW	2400 MW 2800 MW 3200 MW	2000 MW 2400 MW 2800 MW

TEAS studies have further investigated the nine alternatives considering a high number of design criteria. The main characteristics of the assessed alternatives are given in detail in Chapter 22. The following Figure shows the reservoirs of the three alternatives.

The Figure also includes Stage 1, when the dam will reach a height of 140 m and impoundment will start up to a level of 1100 m asl (for the FSL 1290 alternative). This will allow starting the electricity production. Stage 1 will be maintained for about three years, being especially relevant for resettlement issues. Construction of the dam will continue until it reaches its final height. The reservoir will be filled gradually until it reaches its final FSL. From this moment onwards the power plant will be operated at full capacity according to an operating regime defined by TEAS.

Potential future risks of all alternatives have been studied and addressed by TEAS. All projects generate the risks, to be mitigated by adequate measures according to the indicated quality, safety, performance and sustainability requirements.

Considering the results of the techno-economic assessments, TEAS recommends FSL 1290 alternative with an installed capacity of 3200 MW be taken forward for detailed consideration.

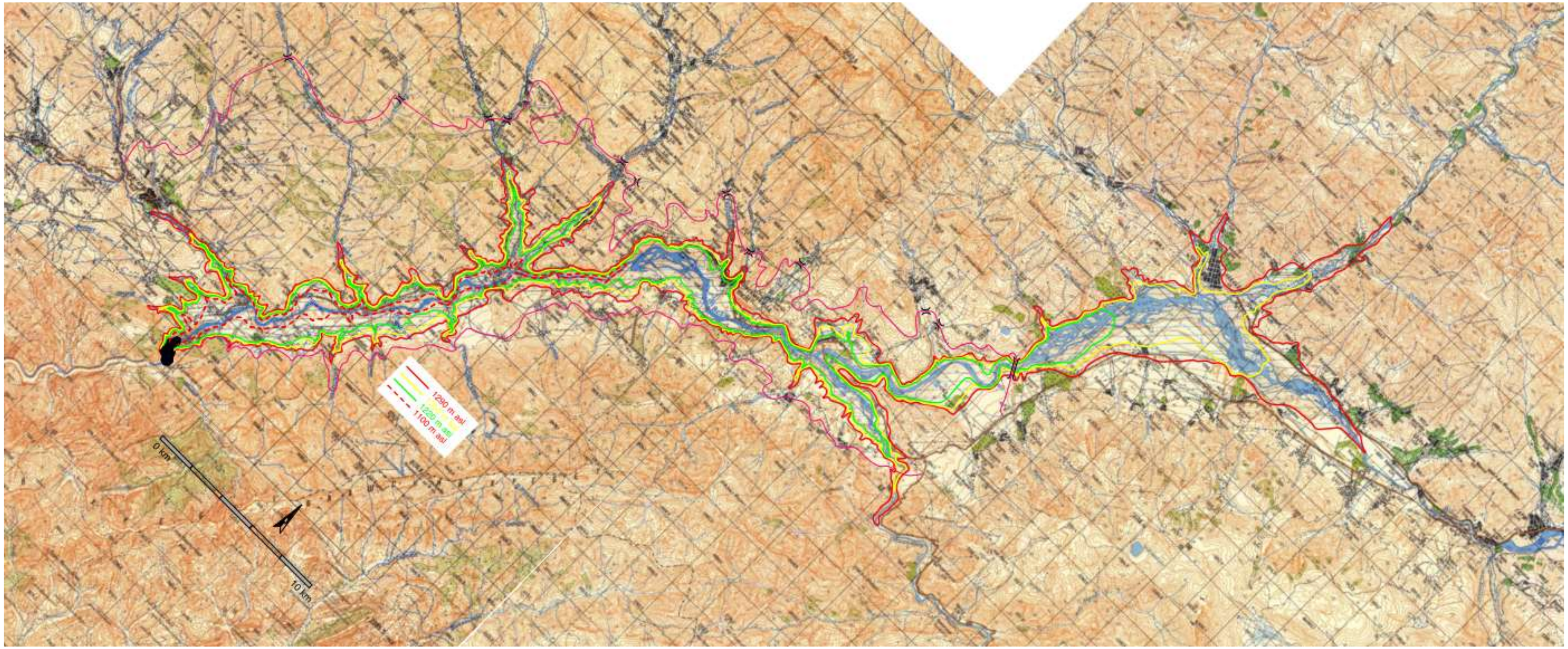


Figure 3-3: Project area map showing the reservoirs of the tree alternatives

As mentioned in the Table above, Stage 1 is shown only as a reference, and is not considered as alternative

3.5.2 Main Characteristics of the Recommended Rogun HPP

3.5.2.1 Dam and Reservoir

The Rogun site is tight and the layout of the dam is imposed because of mainly geological constraints as well as the existing assets. The proposed earth core rock filled dam has the following main characteristics:

- Dam crest: 1300 m asl
- Full Supply Level (FSL): 1290 m asl
- Minimum Operation Level (MOL): 1185 m asl
- Foundation level: 965 m asl
- Dam height: 335 m
- Crest length: 660 m

A 70 km long reservoir will form behind the Rogun dam:

- Reservoir active storage: 10’300 hm^3
- Total reservoir capacity: 13’300 hm^3
- Reservoir surface area at FSL: 170 km^2
- Reservoir surface area at MOL: 51 km^2

The construction of Rogun dam requires a number of intermediate facilities:

- Cofferdam: Crest elevation 1050 m asl Volume 2.3 Mm^3
- Stage 1 dam: Crest elevation 1110 m asl
- Main dam: Crest elevation 1300 m asl Volume 74 Mm^3

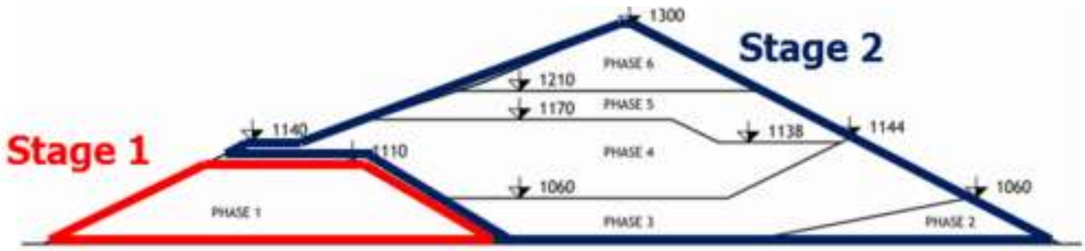


Figure 3-4: Longitudinal cross section with construction stages 1 and 2

Source: TEAS Phase II Report – Volume 1: Summary – April 2014

3.5.2.2 Powerhouse and Transformer Caverns

An underground powerhouse is set within the left bank. The transformer cavern is of similar shape and located parallel to the powerhouse cavern. The powerhouse cavern has already been partly built. The powerhouse and transformer caverns have the following main characteristics:

- Powerhouse cavern: (L x W x H): 220 x 20 x70 m
- Transformer cavern: (L x W x H): 220 x 20 x40 m
- Total installed capacity: 3200 MW
- Number of Francis units: 6

- Maximum head: 320 m
- Minimum head: 185 m
- Rated head: 285 m

The project will also include measures to increase stability of the cavern excavation that has been completed to date.

The switchyard will be an open air type switchyard.

As soon as the reservoir will reach a level of 1100 m asl, the units 5 and 6 in their first step arrangement will start producing electricity. However, due to the low head at that time their capacity will be limited. This Stage 1 will be kept for approximately 3 years, then the reservoir level will start to rise again continuously for finally reaching its FSL at 1290 m asl.

3.5.2.3 Spillways and Intakes

Rogun dam provides several flow regulation facilities. Flood management has been addressed by TEAS for both construction and operation phase of Rogun. Studied concepts are discussed in TEAS Chapter 3.3 (Alternatives design) in the appendices 3 (Flood Management during Construction), 4 (Hydraulics of the Project Components) and 5 (PMF Management). The various facilities on different levels are designed according to high safety standards, taking into account construction progress, operation head as well as sediment issues, and operated by redundant control-command systems. The planned facilities consist in:

- **Diversion tunnels 1, 2 and 3** for flood evacuation during construction; the diversion tunnels 1 and 2 will be used as tailrace tunnels of the powerhouse during operation;
- **Middle level outlets 1 and 2** for dam protection during construction;
- **High level tunnel spillways 1 and 2** for flood evacuation after dam completion;
- **Surface spillway** with a capacity equal to PMF peak flow of 8160 m^3/s once the reservoir is filled up with sediment;
- **Multi-level intakes** to mitigate the sedimentation effect with relatively low cost.

The surface spillways have to replace the other flood evacuation organs once the sediment in the reservoir prevents their use or reduces their discharge capacities.

3.5.2.4 Access and Power Tunnels

Given the situation at site, many of the power facilities are underground, needing access tunnels:

- **Diversion tunnels** have been excavated at the left bank, crossing the valley under the dam area and continuing at the right bank. The downstream part will be used as tailrace tunnels during operation.
- **Six independent headrace tunnels and penstocks** will guide the water from the intakes to the powerhouse at the left bank.
- **Several access tunnels** to the powerhouse as well as transformer caverns, gate chambers etc. are needed.

3.5.2.5 Roads

Access to the site is provided by existing roads, first the main road from Dushanbe to Obi Garm and onwards (M41), then a road leaving the main road shortly before reaching Obi Garm, leading to Rogun town and the construction site. This latter part of the road is presently being upgraded.

However, the creation of a new major reservoir has consequences for the existing road network in the area. For one, the main road M41 will be interrupted shortly after Obi Garm; short stretches of this road will already be submerged in Stage 1 and major parts of it, including the only bridge suitable for heavy traffic crossing the river, will disappear at later stages of impoundment. The same will happen to the small bridges which now allow access to the villages on the left bank of Vakhsh River and to a number of local roads in the upper part of the reservoir.

The main road needs to be replaced, and where required access to villages which will not be relocated will have to be granted. For this, a road project was prepared, with the following main components, shown in Figure 3-5:

- **# 1: main road on the right bank in the lower part of the reservoir:** the relocation of this international road started in the 1980s, when a considerable part of it could be finalised. Like for Rogun itself, construction stopped shortly after independence, and the structures already built have degraded for the last 20 years. Recently, the Research and Design Institute in Dushanbe, the state agency responsible for planning and construction of roads, prepared a project for finalising this road, which also includes rehabilitation of the damaged assets.
- **# 2: main bridge over the reservoir:** the relocation of the international road also includes a major bridge with a span of 786 m.
- **# 3: main road on the left bank in the upper part of the reservoir:** only a small section of the international road needs to be replaced.
- **# 4: new access road on the right bank in the upper part of the reservoir:** an access road needs to be built because of the HPP in quite difficult terrain.
- **# 5: new access road on the left bank in the lower part of the reservoir:** an access road needs to be built because of the reservoir in easy terrain.

Sections # 1, 2 and 3 are part of the national and international road (Dushanbe) - Vakhdat - Jirgital - (Kyrgyzstan) and are therefore not considered as part of Rogun project.

An EIA was prepared for this project in the 1980s, along with the technical project, and during 2005-2011, within the project of rehabilitation and renovation of the international highway Vakhdat - Jirgital, an additional assessment of environmental impacts was carried out. For this reason, environmental impacts of these sections are not included in the ESIA for Rogun.

Sections # 4 and 5, for which so far there is only a project at the pre-feasibility level, will only be built alongside and because of Rogun HPP. Thus they are considered as part of the project, and environmental impacts are taken into consideration in the Rogun ESIA.

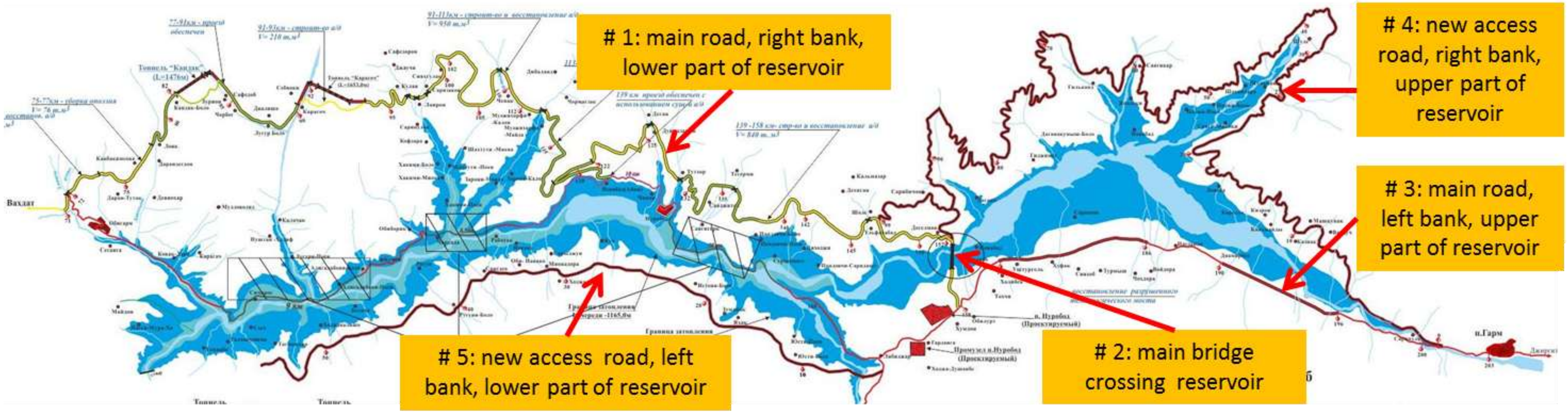


Figure 3-5: Map indicating road sections

Source: Overview map of road projects in reservoir area, Research and Design Institute, Dushanbe

3.5.2.6 Transmission and Distribution Network

TEAS studies have investigated the impact of Rogun on the high voltage transmission system of Tajikistan, evaluating the export capabilities of the system and identifying the best network expansion solution. The growth projections in energy demand for the years considered will lead to a significant increase, from a peak of about 3.8 GW in 2013 to a peak of more than 5.9 GW in 2031, with consequent problems on the transmission and distribution network. These problems can be solved with proper network reinforcements on the high voltage internal transmission system and the transformer substations.

The TEAS study, Transmission System (TEAS, Chapter 3.6, April 2014), provides a list of transmission lines required in the context of adding Rogun HPP to the grid. While some of these transmission lines already exist, others will have to be built. For each of them, a detailed planning, including an ESIA, will have to be done; this, however, is not part of the present studies.

3.5.2.7 Operating Regime

According to TEAS studies, the Nurek operation pattern is known from 1991 to 2011, revealing that part of the summer inflow is stored in the reservoir to increase flow in winter as well as the energy production, to meet Tajikistan’s winter electricity demand. The water shift varies, generally not fully using the Nurek active storage capacity of 4.2 km^3.

For the operation of the Vakhsh cascade with Rogun HPP, two operation scenarios were applied in the Reservoir Operation Simulation Studies (TEAS, Chapter 5, November 2013):

- **TEAS Scenario A – Current status extrapolated:** Vakhsh cascade will be operated in a way that seasonal flow patterns downstream of Nurek remain unchanged.
- **TEAS Scenario B – Base line – Future use of Tajikistan water share:** The effect of full use of Tajik water share of Vakhsh is taken into account, respecting the downstream water requirements as ruled by ICWC and agreed in the Nukus declaration and Protocol 566.

Nurek will be operated as a run-of-river HPP, whereas all regulation will be done by Rogun HPP. Thus Nurek reservoir water level will remain at FSL throughout the year. Rogun reservoir will be filled during summer and emptied to the required or agreed respective level in winter.

The corresponding energy production for an average year is the following:

- **TEAS Scenario A – Current status extrapolated:**
  - Annual total energy production in an average year
    - Rogun HPP 14.4 TWh/yr
    - Vakhsh cascade 35.3 TWh/yr
  - Annual firm energy production in an average year
    - Rogun HPP 9.3 TWh/yr
    - Vakhsh cascade 22.8 TWh/yr
- **TEAS Scenario B – Base line – Future use of Tajikistan water share:**
  - Annual total energy production in an average year

Rogun HPP	14.4	TWh/yr
Vakhsh cascade	34.4	TWh/yr

- Annual firm energy production in an average year

Rogun HPP	9.3	TWh/yr
Vakhsh cascade	22.4	TWh/yr

Rogun HPP will contribute an average of approximately 30% of electricity needed to Tajik electricity demand between 2020 and 2050 and thus significantly enhance supply security in the country.

3.5.2.8 Economic Analysis

TEAS studies have estimated the investment costs including physical contingencies for their recommended alternative.

The dam construction time is of about 14 years, whereas the filling of the reservoir takes 16 years. Taking into account the sediment supply to Rogun reservoir, the ultimate reservoir lifespan, when there is no more regulation possible, has been estimated to 115 years.

According to the TEAS least cost expansion plan and the economic analysis, Rogun HPP is better suited for meeting the Tajik electricity demand, especially in winter, and provide higher export potential than other production facilities in Tajikistan.

The TEAS analysis shows the economic viability of the Rogun design under a range of agreed assumptions.

3.6 Construction Site

The construction site facilities are mainly existent, since the construction started already in the1980s. It covers about 20 km². At Rogun construction site there are several camps, providing living quarters for the work force. In the summer of 2011 there were 2’800 employees working at the construction site and 1’800 were accommodated within the construction site camps. The main construction site, including camp, is located at a terrace below Rogun town at an elevation of about 1160 m asl. It has a number of infrastructures, as e.g. office buildings for contractors, the workers’ quarters, health posts, a gas station as well as workshops.

Spring water and five artesian water wells supply the site. The administration buildings, the main worker camp and part of the construction site are connected to the water distribution network. Additionally the main construction site has water storage tanks. There is no water purification plant within the construction site. The domestic Wastewater Treatment Plant (WTP) with a full capacity of 700 m^3/day is not in operation yet. A second WTP is under construction.

Furthermore several construction facilities are on the construction site, as e.g. eight concrete batching plants with an effective capacity of 40 m^3/h, about 25 concrete mixers with an average capacity of 6 m^3/h and six crushers facilities, a closed one with 1 million m^3/yr aggregate production capacity and five open area crusher facilities with an aggregate production of between 12 to 15 m^3/month each.

The construction site occupies a total area of approximately 20 km², which includes the dam and camp sites as well as the appurtenant structures, including quarries, borrow and dumping sites, intermediate storage areas for construction material etc.; most of this area is occupied by the large storages of construction material (see Figure 3-6). The construction site also contains one small dam whose purpose is to retain mudflows from a small tributary just downstream of the Rogun dam; without this dam, there is a risk that such mudflows could block the outlets of diversion or tailrace channels.

The reservoir will be filled gradually during the construction of the dam. This means that according to the original schedule the main construction site will be submerged in year 10 of the construction period, when the level will reach 1165 m asl. Thus it will be necessary to implement an additional construction site for the later stage of construction, which will probably have to be dimensioned for a smaller workforce. It will be located within the present construction site.

As the Figure on the following page also shows, several villages are located within the construction site; these, referred to Stage 1 villages, need to be relocated with priority.

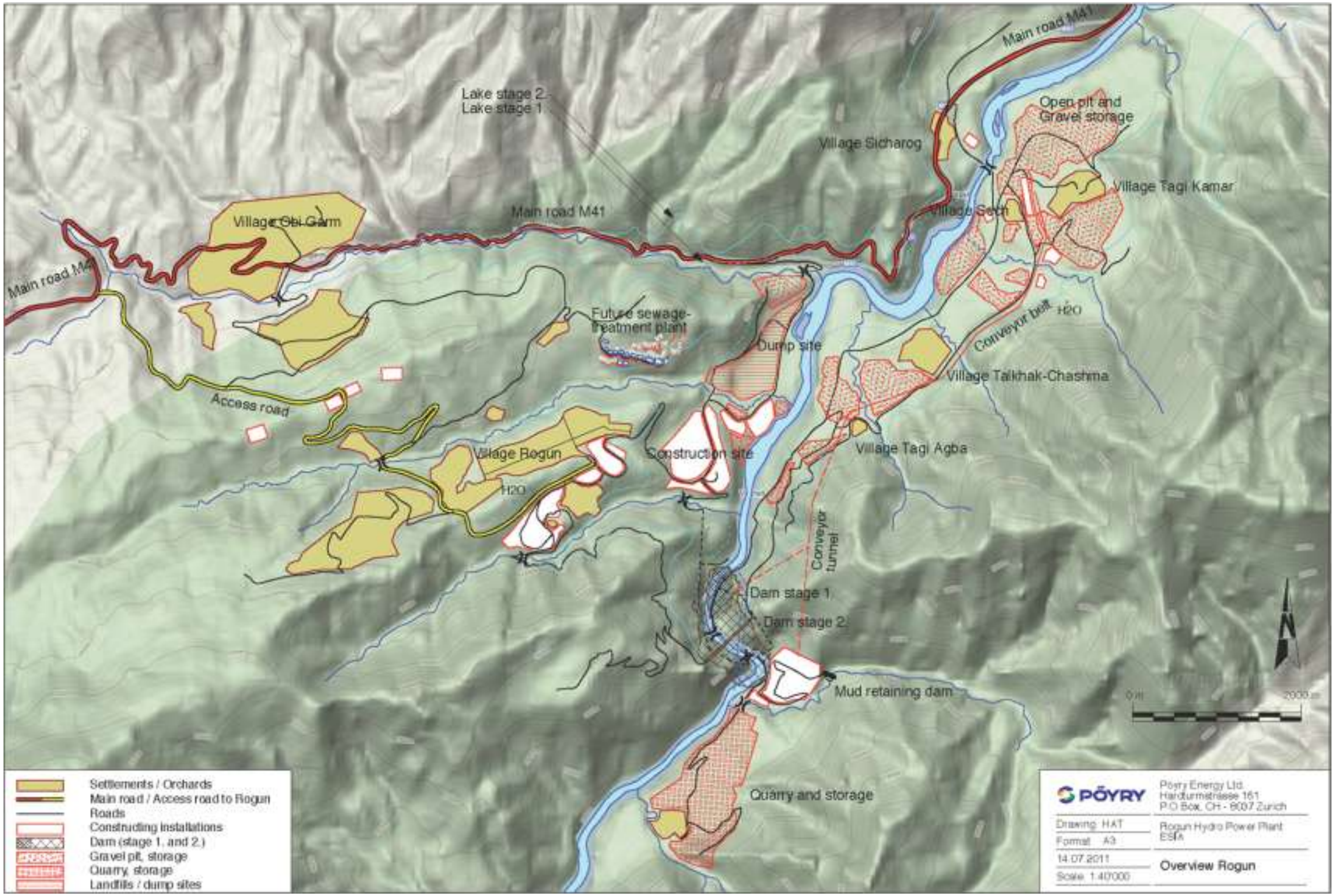


Figure 3-6: Layout of the construction site

3.7 ESIA for the TEAS Recommended Alternative

A full ESIA is undertaken for the TEAS recommended alternative of FSL 1290 and an installed capacity of 3200 MW; however, throughout the report, comparisons are made with the two other alternatives evaluated, FSL 1255 and FSL 1220. A detailed analysis of alternatives based on environmental and social parameters is presented Chapter 22 of the ESIA.

4 THE STUDY AREA

4.1 Key Messages

As for every hydropower project, there are different areas, which can be influenced by the project in different ways, which have to be taken into consideration in the ESIA. The most important points are:

- The project is located in the Amu Darya basin, which is one of the two main tributaries of the Aral Sea. This basin is shared between Kyrgyzstan, Afghanistan, Tajikistan, Turkmenistan and Uzbekistan.
- The project is located on an international river (although, strictly speaking, the river called "Vakhsh" is exclusively Tajik), and therefore cross-boundary impacts have to be assessed.
- Dam and reservoir will ultimately cover an area of about 170 km².
- Section 4.4 provides a more detailed description of the Study area.

4.2 The Amu Darya Basin

The study area is located within the Amu Darya basin (see following Figure).

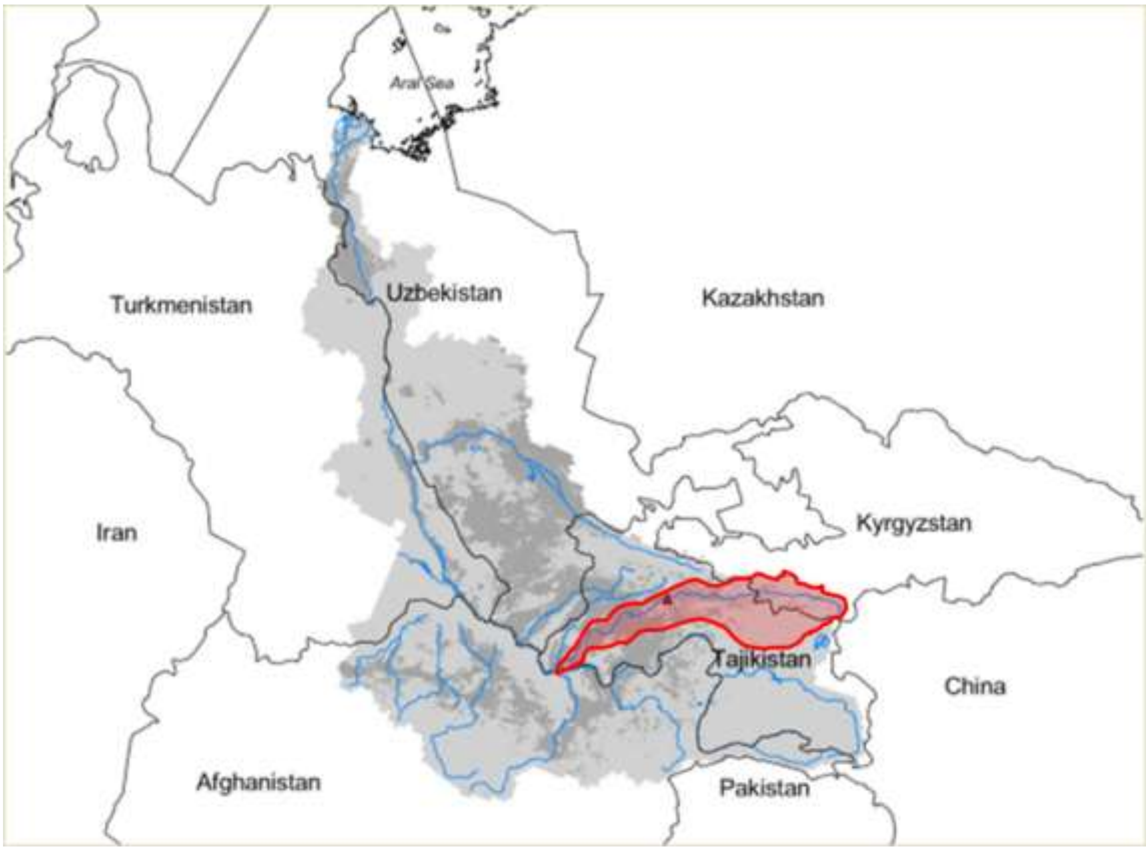


Figure 4-1: The Amu Darya basin and Vakhsh subbasin

The area shaded in red indicates the Vakhsh subbasin, the red triangle the location of Rogun dam
Source of map: www.cawater-info.net/**amudarya**/geo_e.htm

The Amu Darya is the largest river in Central Asia. Its length from the origin of Pyanj river is 2’540 km, the catchment area is 543’739 km² (however, see information on the catchment area in Section 8.2.1). It is called the Amu Darya downstream of the point where Pyanj and Vakhsh rivers meet. Four large right bank tributaries (Kafirnigan, Surhan, Sherabad and Zeravshan) and one left bank tributary (Kunduz) flow into the Amu Darya within its middle reach; today, the Zeravshan does not reach the Amu Darya any longer, since its water is being used for irrigation within the territory of Uzbekistan. Further downstream towards the Aral Sea it has no more tributaries. It is fed largely by water from melted snow, thus maximum discharges are observed in summer and minimum ones in January-February.

4.3 Vakhsh River

4.3.1 The Origin of Vakhsh River and Main Characteristics

One of the river's sources, its tributary Kizil-Su, lies in a very remote area of southern Kyrgyzstan near the Chinese border, where it runs westwards for 262 km; it then flows through Tajikistan for a length of 524 km before joining the Pyanj River to form the Amu Darya at the border of Tajikistan and Afghanistan.

The Figure on the following page illustrates in diagrammatic form the river system in the wider study area. As can be seen from this graph, the river gets the name “Vakhsh” at the confluence of Surkhob and Obihingou rivers; the former of these two is formed by the confluence of Muksu and Kizil-Su rivers; Kizil-Su, which is one of the major spring rivers of Vakhsh, originates in Kyrgyzstan. Muksu river, which originates from Fedchenko glacier - the largest glacier of Central Asia - is the main source river of Vakhsh. Vakhsh runoff is approximately 20 km³/yr, to which Muksu contributes 3.53 km³ and Kizil-Su 1.65 km³.

For most of its route, Vakhsh rushes through high mountains, before slowing down in the plains of southern Tajikistan. The river, which is fed mostly by melting snow and glaciers, achieves maximum flow during the summer months of July and August. The river flows through very mountainous territory, which frequently restricts the river's flow to narrow channels within deep gorges. The river's watershed area is 39’100 km², of which 31’200 km² lie within Tajikistan.

In its upper parts, Vakhsh is a mountain stream with a rather marked gradient, flowing mostly through a rather narrow valley with steep slopes. On a considerable part of this mountain section it flows in a gorge-like valley deeply cut into lateral alluvions. Only on a few sections the valley is wider and almost flat, and here the river has formed extensive floodplains. Two of these, one near Komsomolobod, the other near Novobod, are located within the area of the future reservoir. Likewise, the confluence of Surkhob and Obihingou will also be submerged by the reservoir.

Downstream of Nurek, Vakhsh river flows in a south-westerly direction through a gradually widening plain. In its lowest part it flows in wide meanders in a wide plain; this is the protected wetland area called Tigrovaya Balka. It then reaches the border with Afghanistan, where it meets Pyanj river. These two then form Amu Darya. Downstream of the Pyanj-Vakhsh confluence, only one more river of some importance joins the Amu Darya within the territory of Tajikistan, the Kafirnigan.

	HPP	ГЭС
1	Rogun	Рогун
2	Shurob	Шуроб
3	Nurek	Нурек
4	Baipaza	Байпаза
5	Sangtuda 1	Сангтуда 1
6	Sangtuda 2	Сангтуда 2
7	Golovnaya	Головная
8	Perepadnaya	Перепадная
9	Central	Централ

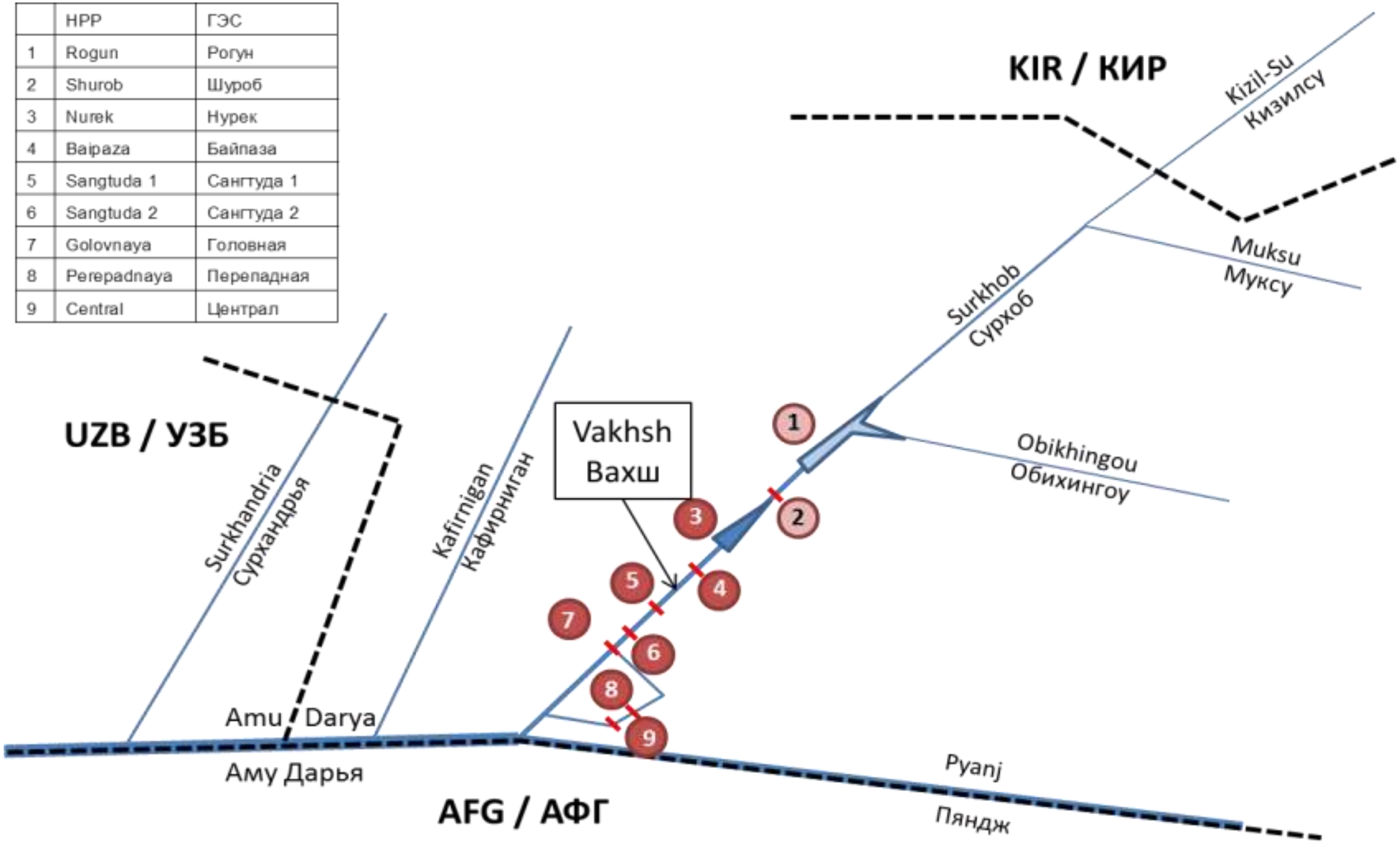


Figure 4-2: Diagrammatic view of river system in the study area

Black dotted lines: international borders. Graph not drawn to scale.

4.3.2 Vakhsh as an International River

As has been shown above, the river named “Vakhsh” starts at the confluence of its two main tributaries, and it ends at the confluence with Pyanj river within the territory of Tajikistan.

As was shown above and as the Figure below illustrates again, a part of its waters comes from Kyrgyzstan, and Vakhsh is a major tributary of the Amu Darya. Hydrologically, it is certainly a unit, in spite of the changes in name along its course.

Figure 4-3: Vakhsh river

In its publication on shared rivers, ICOLD (2007: 233), for the case of Central Asia, under the heading International Shared Rivers does not list individual rivers, but the entire Aral Sea basin as a unit. As for the Amu Darya basin (see Section **Error! eference source not found.**8.4.1), depending on the source, information on the size of the basin and the respective parts in different countries vary greatly, as exemplified by the figures provided in the following Table.

Table 4-1: Country areas in the Aral Sea basin (km²)

Country	ICOLD 2007	FAO 2013	
		Aral Sea basin	out of which Amu Darya basin
Kazakhstan	424'739	345'000	
Uzbekistan	382'286	425'030	364'630
Turkmenistan	69'671	461'740	359'730
Kyrgyzstan	112'093	118'370	7'800
Tajikistan	135'942	141'130	125'450
China	1'583		
Afghanistan	100'691	246'000	166'000
Pakistan	3'349		
Aral Sea basin total	1'230'408	1'773'270	1'023'610

Relevant international water laws are discussed in Section 2.6.

4.4 Definition of the Study Area

For the purpose of this ESIA, the study area had to be divided into several specific areas, which not all needed the same level of detail in the study. The following are the main parts:

- Construction site including dam and powerhouse site, appurtenant structures and immediate surroundings (construction camps, quarries, borrow and disposal areas, etc.); see Figure 3-6 for a layout of this site. This area had to be considered with much detail, especially for the construction phase. Furthermore, it will be affected in a relevant and permanent way by the Project. This therefore was a high intensity area for field investigations.
- Reservoir area: the future reservoir, i.e. the area which will be covered by water (approximately 170 km^2), is also an area in which the effects of the Project will be direct and very apparent and which therefore needs to be considered in detail (especially the resettlement of an elevated number of villages).
- Immediate reservoir catchment: this is the area directly surrounding the reservoir, which can be influenced by the project in different ways (e.g. change in groundwater regime, triggering of landsides, increasing pressure on habitats, etc.).
- Downstream area during the construction phase: the main effect on the downstream area is the risk of water pollution and its potential impacts on water users in this area. This includes the risk of an increase in sediment load due to construction activities, which is potentially quite considerable.
- Downstream area during filling and operation phase: starts below the powerhouse outlet, where the river discharge pattern will be influenced by reservoir filling and turbine operation. The impact can be small in the case of run-of-river schemes (Stage 1), and potentially very important in the case of storage schemes with intermittent (e.g. peaking) power production (Stage 2),

which can cause seasonal changes in river discharge pattern and important short term fluctuations. The extent of the area to be taken into account depends on the specific situation. Potential issues are flow conditions as influenced by the project, cumulative impacts with existing power plants, water quality issues, effects on floodplain habitats, and effects on d/s water users. For Rogun HPP the downstream area can be divided into three main parts:

  - Between Rogun HPP and the upper end of Nurek reservoir, river discharge will be influenced directly by the operation of Rogun power plant; discharge will be very high during peaking production and can be reduced, when turbines are shut down.
  - Downstream of Nurek HPP until the confluence with Pyanj River (forming the Amu Darya), cumulative impacts of the hydropower cascade, provision of water for irrigation, and effects on floodplain habitats. However, this part of the river will not be directly affected by Rogun HPP; since regulation here is or can be done by Nurek HPP.
  - Amu Darya until the Aral Sea: in the case of international rivers (as is the case for Vakhsh River, an important tributary of Amu Darya), this includes effects on riparian countries. For this purpose, it is important to assess the amount of water flowing across the border, as well as its seasonal distribution, in order to verify whether Rogun HPP will cause any changes in this, during the filling and the operation phase.

- Catchment area: the catchment or watershed area of Rogun HPP will not be affected by the Project as such, but the situation in this area can greatly influence the reservoir. The most important of these effects are eutrophication and pollution of the reservoir water by input of nutrients (stemming mainly from agriculture and human settlements) and siltation of the reservoir (due to erosion in the catchment, which again is often caused or at least considerably exacerbated by human activities).

- River basin: for some effects, other developments in the same river basin have to be taken into account, since they can increase or reduce environmental (or social) effects of the project in question. However, it has to be pointed out that this is an ESIA for a specific project and not a CIA of all the projects in the Amu Darya basin, nor a SEA for the entire development plan of this river basin.

- Access roads: access roads can have major direct or indirect environmental impacts and will therefore have to be addressed. The project does not require the construction of any new access roads to the construction site. Work for upgrading the existing road to Rogun from the main road near Obigarm is presently under way. However, the existing main road will have to be replaced; this is a separate project, for which an EIA had been prepared, and this is therefore not covered in the present study. New access roads will have to be built to villages on both banks of the reservoir which would otherwise lose their access.

5 THE ENVIRONMENT: GENERAL CONSIDERATIONS

The major direct and indirect impacts of any hydropower project are always the same; their relative importance, of course, will be determined by the site- and project-specific conditions. Most other impacts that may arise are likely to be related to these major effects, very often as secondary consequences.

These main impacts are listed (from Zwahlen 2003) in the Table on the following page, and compared with the specific case of Rogun HPP; this is not an impact assessment yet, it just serves the purpose of pointing out some specific characteristics of the project to be analysed.

In a first general appraisal, concerning the list of main types of impacts listed in the Table, the following can be said for the specific case of Rogun HPP:

While in this sense Rogun can be considered as a “normal” hydropower project producing the effects generally associated with such projects, it still presents a condition that makes it different from most other such projects for which an ESIA has to be done, namely, the fact that construction - and resettlement - started a rather long time ago, and that some construction work is presently under way. This mainly means that for Environment, Health and Safety (EHS) issues related to the construction phase it is not sufficient to prepare a draft EHS plan as part of the ESMP.

The present conditions on the construction site needed to be taken into consideration, and proposals for improvement had to be made, where required.

Likewise, it was not possible to plan resettlement in the “usual” way, since this plan needs to take into account and to be integrated into an ongoing process, and resettlement already carried out needs to be audited. This is described in a separate document, the Stage 1 RAP, while the present document contains an outline for the RAP which will still have to be prepared for Stage 2.

Table 5-1: Main impacts of HPPs

Main Environmental Impacts of Hydropower Projects	The Case of Rogun HPP
1. Interruption of a river continuum. The fact that a dam is built across a river will always interrupt a system that was, up to now, an entity. Direct consequences of this interruption are a change in river flow patterns, a change in sediment transport (mainly due to sediment retention in the reservoir), an interruption of fish migration (complete for upstream migration, obstacle and risk for downstream migration), and the interruption of drift (i.e., the more or less passive movement of various organisms downriver).	1. Interruption of a river continuum. This is certainly the case for Rogun HPP. However, it has to be taken into consideration that there is already a high dam, Nurek, a rather short stretch downstream of Rogun site. This means that any fish migrations that might have taken place before have already been interrupted. Rogun reservoir will also serve as a trap for sediments, and in this way it will increase the useful life span of Nurek reservoir. Other ROR schemes are in operation d/s of Nurek.
2. Change in river discharge pattern downstream of the dam. This effect is closely related to the first one. In this respect, two main parts of the river can be identified: (1) between the dam and powerhouse outlet, where discharge is reduced, in extreme cases to zero, and (2) downstream from the power house outlet, where river discharge is influenced by plant operation.	2. Change in river discharge pattern downstream of the dam. Here again, the fact that there is already a high dam and a large reservoir on this river has to be considered. The discharge pattern of the river in its lower section is and will continue to be determined by Nurek. However, Rogun HPP will add substantially to the regulating capacity through its storage volume. This means that with Rogun the potential to shift water from the high flow (summer) to the low flow (winter) period will increase.
3. Change from river to lake conditions in a part of the former river at the formation of the reservoir. Water quality will change due to this effect, and the new lake is a habitat very different from that of the former river.	3. Change from river to lake conditions in a part of the former river at the formation of the reservoir**.** The dam will form a large and deep lake, with a surface of 170 km^2 and a total volume of 13'300 million m^3 .
4. Destruction of terrestrial habitats. All terrestrial habitats within the reservoir area will be permanently destroyed, because they are going to be covered with water. This has effects on vegetation and fauna, as well as on the human population living in this area.	4. Destruction of terrestrial habitats. The reservoir will cover an area of about 170 km^2. Most of this land is used for agriculture or as pasture, only little of the original forest cover remains. There are no especially valuable types of terrestrial habitats in the area to be submerged.
5. Access to the area provided by new access roads. Although the direct impact of the roads (e.g., on vegetation) might be rather small, the roads can trigger a development, especially in cases when hitherto inaccessible areas are opened in this way, that can have very considerable environmental effects.	5. Access to the area provided by new access roads. In the case of Rogun, no new access road to the site needs to be built, since access is provided by existing roads. The road leading from the main road to Rogun town and the construction site is in the process of being upgraded. However, roads to settlements along the reservoir will be required.
6. Social impacts. These can be manifold. The most important in many cases is the involuntary resettlement as a consequence of a dam project, but there are also other socioeconomic effects, such as effects on the population in the downstream area (through disruption of river floodplain dynamics, groundwater table changes, etc.); immigration into the area, especially during the construction phase, as a consequence of job opportunities; and effects on the host population for the resettlers. An HPP has also positive effects on the local community, like providing jobs and therefore income (although often limited to the construction phase), improved access through better roads, improved infrastructure, rural electrification etc. These positive items have to be evaluated, planned and implemented carefully in order to have the expected effect.	6. Social impacts. main negative social impact: a number of 77 villages, with a total population of around 42'000, will have to be resettled (see RAP). Positive socio-economic effects: (i) during the construction period of about 16 years, it will provide a large number of jobs, and in this way will have a major positive impact on the economy of the project area; (ii) Once in operation, the power plant will provide much needed electricity supply which will solve the country's present supply problems, and it will produce electricity for export; both of these effects will have a positive impact on the country's economy.

PART B SECTORAL STUDIES

In this Part, the relevant aspects of the environment, with its three main components physical, biological and human environment, are described. Each of these Chapters basically contains the following Sections; however, depending on the subject, and mainly on its importance and complexity, this basic structure can vary:

- Key Messages: this is a very short list of the main points addressed in the chapter, and/or the main findings.
- **Theoretical considerations:** what is the subject and scope of this Chapter? what are the effects usually expected in relation with hydropower projects, and what is their potential importance?
- **Material and Methods:** how was the subject approached?
- **Prevailing situation:** detailed description of the item, supported by Tables, Figures, Maps and Photos as required; there is an Annex to each Chapter which contains supporting material (like e.g. large Tables etc.)
- **Impacts:** in which way will the Project influence this item? Evaluation of impacts (importance, magnitude, need for mitigation). Any environmental “no-go”?. This Section covers the following points:
    - **Impact of construction:** effects of the construction phase and related activities (land occupied, construction work, transport and traffic, work force, etc.)
    - **Impacts of the Project as such:** effects of the operation of powerhouse and dam at final height (large reservoir, large storage capacity).
- **Measures:** what measures (avoidance, minimisation, compensation) will be required to reduce the impact to an acceptable level?
- **Conclusions and Recommendations:** additional work required in the next phases of the Project? Other recommendations as might be required.

I. THE PHYSICAL ENVIRONMENT

The physical environment encompasses the non-living aspects of the environment as climate (atmosphere), geology (lithosphere) and water (hydrosphere).

6 GEOLOGY AND SOILS

6.1 Key Messages

This chapter deals with the geological situation of the project area, and especially of the reservoir area, and with possible project impacts on this situation. The main messages of this chapter are:

- No large unstable slopes were found during past studies. Thus landslides as well as debris and mudflows are not considered as a major threat for the feasibility of the Rogun project, as long as accurate monitoring and mitigation measures are undertaken.
- To address the salt wedge concerns in the design criteria of Rogun dam, a monitoring system and a contingency plan are proposed.
- A strong-motion and a microseismic network for seismic monitoring are requested to be implemented as soon as possible in order to estimate the baseline seismicity prior to dam construction.
- TEAS studies expect a maximum magnitude from Rogun reservoir triggered seismicity of less than 5 units on the MSK-64 scale, considering the recommended slow filling of the reservoir.
- Design criteria for the Rogun dam include the Maximum Credible Earthquake (MCE).

6.2 Theoretical Considerations

The geological conditions of the project site are decisive for the design and layout of the dam and hydropower project, and for this reason, geology has to be investigated as part of the techno-economic assessment study (TEAS). Nevertheless, there are mainly three points to be considered in the ESIA:

- **Landslides, debris and mudflows**: slope stability under the changed conditions, e.g. the presence of a reservoir; the water body as such, and especially the seasonal drawdown of the reservoir, can influence slope stability, especially if such slopes consist of loose material, and can therefore lead to landslides;
- **Seismicity**: the dam will have to be designed and built in a way as to resist seismic activity of the site; this is obviously a technical task.. The risk for the downstream areas will have to be assessed;
- **Reservoir triggered seismicity**: the presence of the reservoir can influence the local seismic activity. Since the reservoir is located along the seismically active Vakhsh fault zone, reservoir triggered seismicity is of concern, intensifying the seismic activity of this area.

All these points need to be dealt with in close cooperation with TEAS studies.

6.3 Available Information

The review of the existing documents of the Rogun project that were provided by the Client (see Annex - References) allows to make a preliminary analysis of the project area in terms of geology and project impacts on the geological situation.

The most important of the reviewed documents are the volume 1174-T15 “Rogun HPP on the Vakhsh River. Engineering design. Part 1- Natural environment. Volume 3- Engineering-geological conditions” (1174-T15 «Рогунская ГЭС на реке Вахш. Технический проект. Часть 1 — Природные условия. Том 3 — Инженерно-геологические условия»), the HPI (2009) report (Рогунская ГЭС на реке Вахш в Республике Таджикистан. Концепция достройки станции. Гидропроект-Москва, 2009), the document # 1861-2-II-3 “Volume II - Engineering-geological conditions, Book 3 – Engineering-geological conditions (№ 1861-2-II-3 «Том 2 Природные условия. Книга 3 -Инженерно-геологические условия») and the document #1861-2-VIII “Volume VIII – The procedures for reservoir area preparation” (№1861-2-VIII “Том VIII Мероприятия по подготовке зоны водохранилища). These documents refer to a large number of drawings, layouts, cross-sections, tables, and provide information about the general geology of the project area, especially about the stratigraphy, lithology, faults systems and seismicity of the dam site and its surrounding area. Further relevant information is provided about rock jointing, quarries location, slope instability in and around the reservoir area, tributaries with a high sediment load etc. Most information concerns the technical aspects of the HPP design.

TEAS studies (Phase II Report – Volume 1: Summary, April 2014) describe and discuss geology (Chapter 2.2), geotechnics (Chapter 2.3), seismicity (Chapter 2.4) and sedimentation (Chapter 2.6) of the Rogun project. It is stated, that the existing investigations is deemed sufficient to assess the feasibility of the project. Nevertheless, additional surveys have been requested to address specific issues for detailed design phase.

6.4 Present Situation

The Rogun reservoir area is located in a basin subject to very active erosion processes, mainly due to the soils conditions and tectonics. The Vakhsh river valley upstream Rogun site is characterized by mainly quaternary alluvium as well as debris flow deposits and terraces.

The main geological formations of the Rogun area are the Paleozoic granite mainly on the right bank of the Vakhsh river valley and Mezo-Cenozoic terrigen-carbonate formation on the left bank (see following Figure).

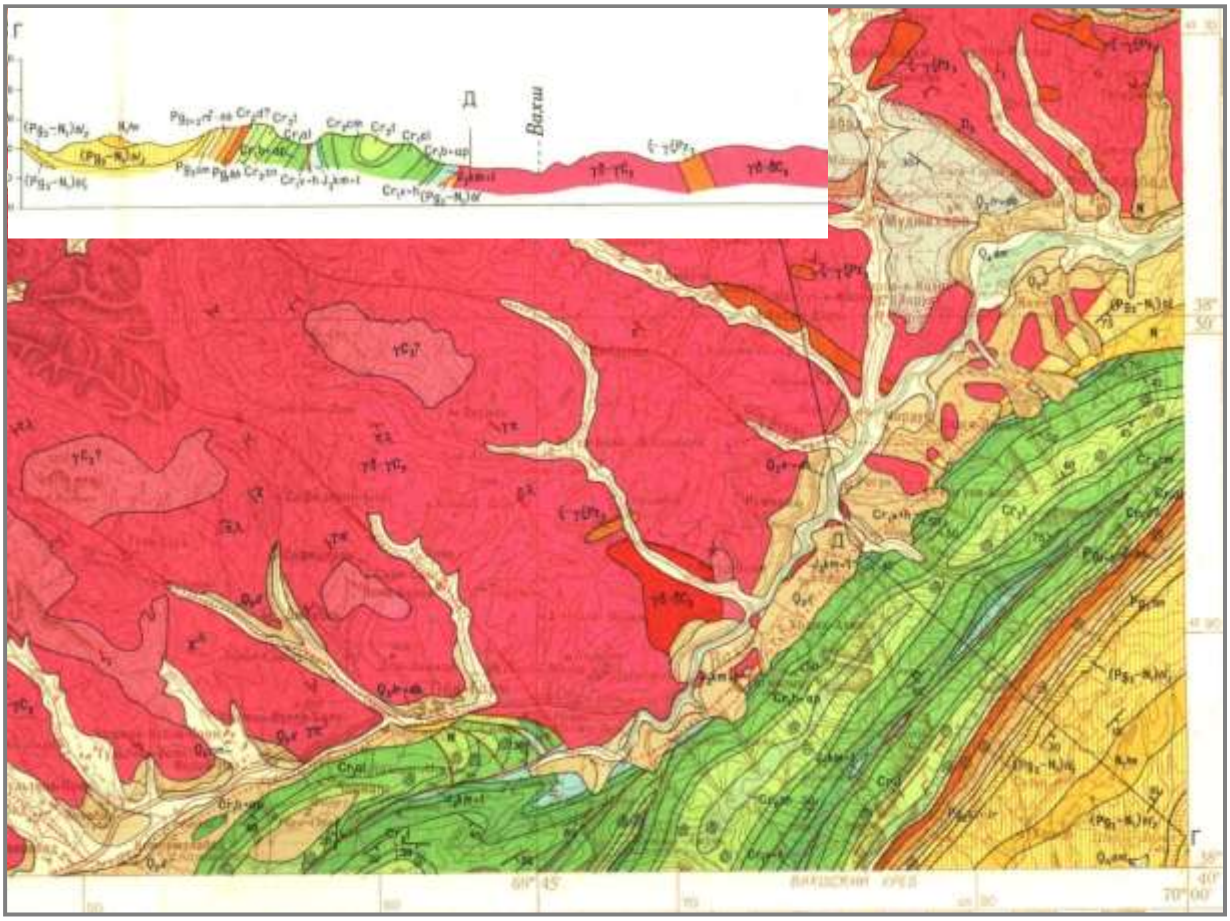


Figure 6-1: Geological map and profile of Rogun HPP area

The South-Hissar group of structural-formational zones (in red on the above map) is located on the right bank of the Vakhsh valley and covers a territory with predominant development of volcanic eugeosyncline structural-material complex and volcanic-plutonic orogenic structural-material complex.

The left bank of the Vakhsh valley consists of deposits of the so-called "Afghan-Tajik depression" (ATD). The most ancient formations in the ATD are Middle-Jurassic carboniferous formations: sandy-argillaceous in the east and sandy-conglomerates in Pre-Hissar step. Large hydrochloric diapire (HCl salt wedges) are located in this formation (Khoja-Sartis, Khoja-Mumin, Tanapchi and Alimtoy) in the south part of the ATD. The salt content in Vakhsh river is the result of the wide distribution of the Jurassic-Cretaceous deposits along the left bank of the Vakhsh river. In the Rogun area this formation also locally appears along the faults as 5 to 20 m thick layers.

The Obigarm anticlinorium in the Rogun area includes sandstones, aleurolites and slates as well as some limestones, gypsums and conglomerates from the Late-Cretaceous time; they combine in a formation of quartz sandstones and clay slates. The accumulation of sulphates and the formation of thick sulphate-carbonate rock layers during the Later-Cretaceous explain the high content of sulphate in Vakhsh water.

Coarse-fragmented rocks in the margin zones of ATD consist of products from mountain core rocks, among which a significant part are igneous rocks of various composition. In the central zones of ATD, conglomerates were formed mainly due to denudation of Mesozoic-Cainozoic terrigenously, carbonate rocks from the arches of inside-depression uplifts.

TEAS studies (Phase II Report – Volume 1: Summary – Chapter 2.2: Geology, April 2014) have refined the analysis on faults and major discontinuities, especially the kinematic model of main faults. The problem of the tectonically active faults, either creeping at a rate of 1 or 2 mm/yr or susceptible of co-seismic displacement, has been examined. Such active faults have been defined as the Ionakhsh Fault, Fault 35, and some of the S4 faults between these two main faults.

The regional tectonic stresses at the Rogun site are adjusted by deformation which is both seismic, involving sudden co-seismic rupture, and aseismic, mainly by creeping. This creeping, which is permanent, takes place principally on the main faults, where monitoring was implemented to measure the deformation rate. Special protection measures must be designed for the underground structures crossing the main discontinuities with evidence of significant shear. Additional investigations are requested to verify the cause of damages to support at all identified locations. If necessary the rock masses should be exposed for inspection and installation of monitoring devices. Monitoring of displacements along the main faults should be resumed and additional devices installed. In addition, monitoring should be extended to the major discontinuities showing offset. Taking into account the complex tectonic setting, these tests should also be carried out at different locations into the abutments.

In the left bank of the river, some foothills of the Vakhsh Ridge are formed by evaporite rock masses aligned on the Vakhsh Fault. They were also identified in the valley of Passimurakho, which is the extension along strike of the Vakhsh Fault lineament. A salt diapir might underlie the interfluve between Passimurakho and Obi-Djushon valleys. All these occurrences exhibit intensive halide karst dissolution features. Resulting formation of sinkholes may initiate superficial landslides, leading to sinking of inhabited areas and causing damages to buildings, e.g. in Rogun city. As the mostly superficial sliding and creeping processes are expected to develop progressively during impounding. The impact of impounding on dissolution and subsequent instabilities should be considered at detail design stage.

6.5 Specific Issues

6.5.1 Landslides, Debris and Mudflows

The original project of 1978 (volume 1174-T15 “Rogun HPP on the Vakhsh River. Engineering design. Part 1- Natural environment. Volume 3-Engineering-geological conditions” (1174-T15 «Рогунская ГЭС на реке Вахш. Технический проект. Часть 1 — Природные условия. Том 3 — Инженерно-геологические условия») describes the general situation of the slope failures and erosion processes. The majority of the landslides are located just near the dam site in the Obi-Garm river, Obi-Chushon and Passimuraho valleys. Not anymore active small rock slides (so-called “ancient rock slides”) were detected with volumes from 1000 to 1 million m^3 just at the dam site on the left and right sides of the Vakhsh river. The biggest rock slide mentioned in the report is located just downstream of the dam site. The assessed volume of this rock slide is up to 900 million m^3, but its activity could not be defined at this time. The last investigation of this unstable slope by drilling and geophysical survey in 2012 denied the presence of a big landslide body. No risk of landslides at the dam site was identified, although this area is very fragmented, and many cracks of different sizes are present. The biggest debris flow occurred from the Darainamak stream on the left side of the Vakhsh river 4’000 to 6’000 years ago, which dammed the Vakhsh river.

The exposure of the reservoir to landslides, mud and debris flows is mostly from its left bank. The volume identified for such events amounts to maximum a few million m³. The soils most prone to erosion are located on the left side of the Vakhsh river as well, represented by Quaternary deposits like diluvium, proluvium and alluvium. All these deposits have a high content of sandy loam with a clay fraction and carbonate cement, reason for potentially very active erosion processes.

Regarding the influence of the future reservoir on the slope failure processes, the original project of 1978 comes to the conclusion that the reservoir will not lead to big landslides along its shore significantly impacting the assets of Rogun HPP. However, erosion process and landslides will contribute to an accelerated sedimentation of the reservoir.

HPI (2009) report contains the results of the previous study about slope failure processes, sediment flows and erosion, but additionally gives the results of more recent investigations. For instance, sediment load of small tributaries near the dam site, e.g. Obi-Garm, Obichushon, Passimuraho and Obishur were addressed in more detail. The big volume of sediment stemming from the Obishur valley, which joins with the Vakhsh River on left bank immediately downstream of the dam site, is of special concern. Measures will have to be assessed and built to handle the mudflows from this river.

The area prone to reservoir bank transformation was estimated to comprise 550 hectares in the original project of 1978 (page 170-171, table 2.7.3 - volume 1174-T15 “Rogun HPP on the Vakhsh River. Engineering design. Part 1- Natural environment. Volume 3- Engineering-geological conditions” (1174-T15 «Рогунская ГЭС на реке Вахш. Технический проект. Часть 1 — Природные условия. Том 3 — Инженерно-геологические условия»)). However, this area was estimated as being 3500 hectares in the HPI (2009) (page 9, #1861-2-VIII “Volume VIII – The procedures for reservoir area preparation (№1861-2-VIII “Том VIII Мероприятия по подготовке зоны водохранилища)).

Based on interpretation of satellite images and previous work carried out by the Institute of Geology, Earthquake Engineering and Seismology of the Academy of Sciences of the Republic of Tajikistan, an assessment of the landslide risk in the Rogun reservoir area has been carried out. The results are shown in Figure 6-2.

For mapping landslide prone areas, the following criteria have been applied:

- presence of morphological signs of actual, mostly small, landslides of different types (cracks, scarps, big old landslide bodies containing discrete smaller areas of more recent movement, areas of erosion) within the areas identified as a risk related to geomorphological characteristics;
- geological conditions of potentially unstable slopes (tectonics, lithology, slope angles and conditions, indicators of abnormal water content);
- probability of further development of landslide processes within these areas.

Figure 6-2 indicates the reservoir areas of the FSL 1220, FSL 1255 and FSL 1290 alternatives in addition to the landslide prone areas, where landslide processes have been observed and are expected in future. All these areas are located in the soft deposits of deluvial and proluvial genesis and some crushed rock outcrops, characterised by very active erosion processes.

In Figure 6-2 these areas are subdivided into two groups, located:

(i) **on the shoreline of the future reservoir** (shown in red in the Figure), which therefore can be affected by the oscillation of the reservoir water level;

(ii) **out of the reservoir area** (in brown in the Figure), which therefore are not influenced by it, but could block tributaries of the Vakhsh river.

There are no large active landslide blocks in immediate proximity to the shoreline of the reservoir which could trigger large impulse waves in the reservoir.

Rockslides could be triggered by the dissolution of salt in the foot of slopes. Oscillations of the reservoir water level can accelerate landslide processes in the areas (shown in red in the Figure), but will not create a problem for dam safety. Preventive measures should be taken in cases where such areas are in close proximity to infrastructure and settlement areas.

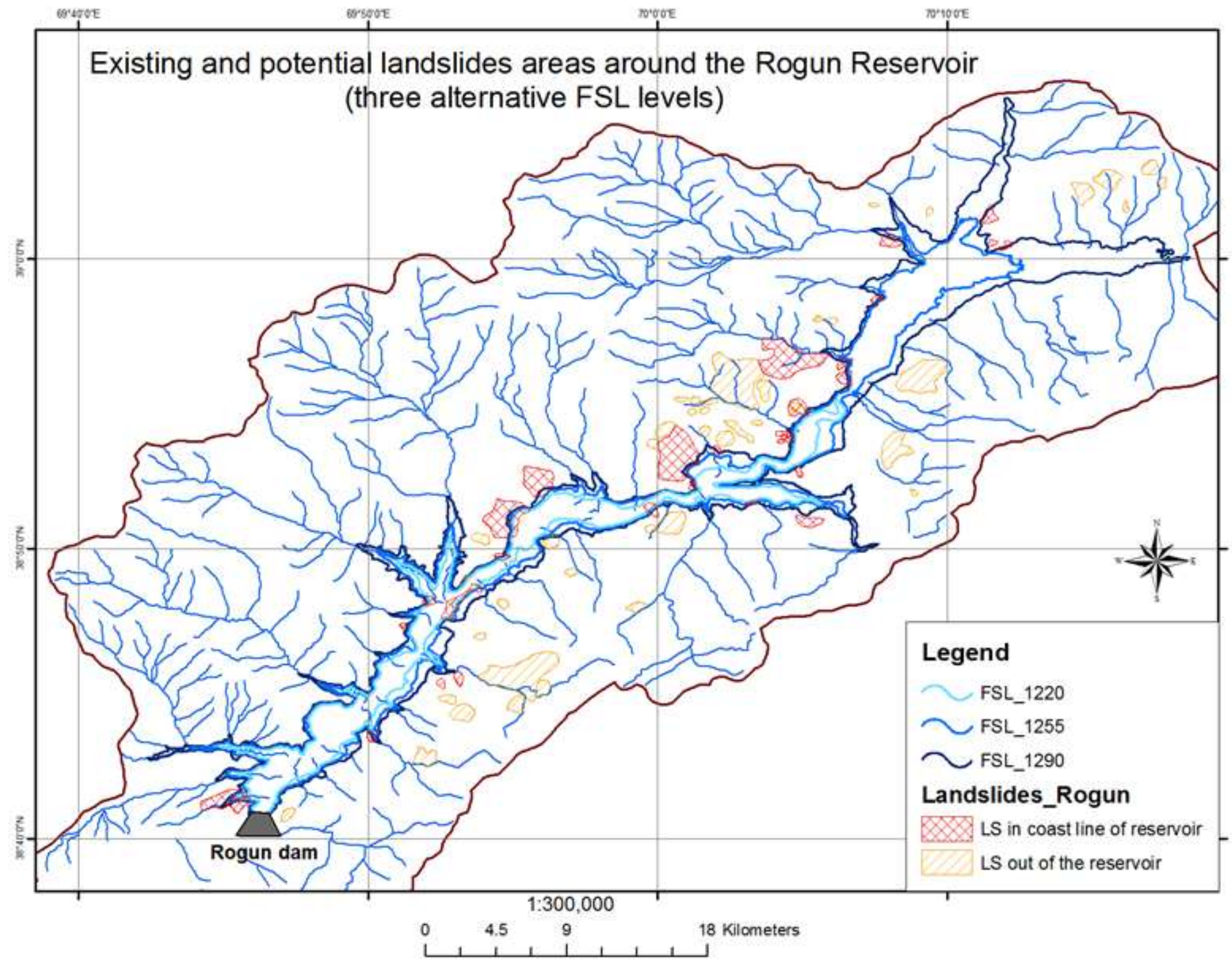
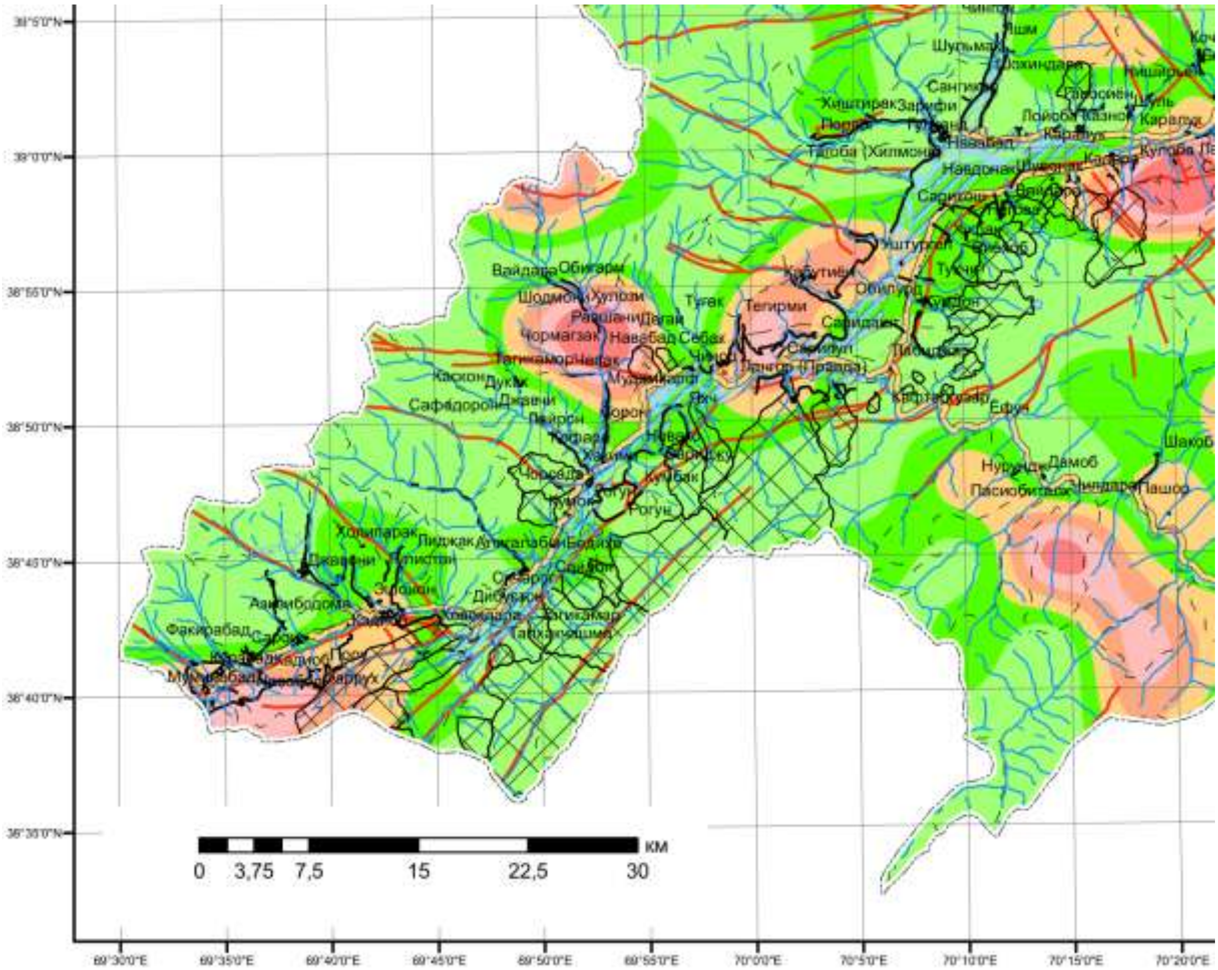


Figure 6-2: Map of landslide prone areas around the future Rogun reservoir

The areas of highest risk for landslides, which might be influenced by the drawdown of the reservoir, are located between Chorsada and Nurobod, and near the confluence of Surkhob and Obihingou rivers, both on the right bank of the river. This is also confirmed by the map on landslide risks in Rasht District produced by SDC (Swiss Agency for Development and Cooperation) and UNDP (United Nations Development Program); the relevant part of this map is shown overleaf.

Landslides in these two areas are not expected to present the risk of impulse waves overtopping or damaging the dam and the hydraulic facilities. However, they present a risk for the settlements located nearby. This will have to be studied in more detail at further stages of the project. Thus it is requested to install a monitoring system in these two areas. The costs for such a system are included in the TEAS study, and details will be studied in the detailed design phase.

It is recommended to install a geodetic network using GPS measurements or a satellite SAR interferometry system at these two locations. These are state-of-the-art techniques which allow detecting slope deformations with sufficient accuracy and efficiency to an order of magnitude of 1 mm/yr. As an example, the Interferometric Synthetic Aperture Radar (InSAR) would allow to observe large areas (practically the entire reservoir area) in an effective and economically acceptable manner (Ketelaar, 2009; Droz et al., 2008; Lazecky et al., 2013).



	Legend	Условные обозначения
	Landslide area ratio of total area	**отношение площади оползней к общей площади**
	Less than 0.1	Менее 0.1
	0.1-0.2	0.1-0.2
	0.2-0.3	0.2-0.3
	0.3-0.4	0.3-0.4
	0.4-0.5	0.4-0.5
	More than 0.5	Более 0,5
	Area of high mudflow risk	Район интенсивного развития селей
	Border pilot area	Граница пилотной территории
	Infrastructure	**Объекты инфраструктуры**
	Power lines	Линии электропередачи
	Underground water pipeline	Подземные трубопроводы
	Qanat (water supply system)	Подземные водоводы
	Permanent stream	Постоянные
	Intermittent stream	Пересыхающие водотоки
	Channel	Каналы
	Main paved road	Главные дороги с твердым покрытием
	Other paved road	дороги с твердым покрытием
	Dirt road	Грейдерный и проселочные дороги
	Larger river	Крупные реки
	Lake	Озера
	Area of the planned reservoir	Зона планируемого затопления

Figure 6-3: Landslide risk in Rasht area

Source: SDC and UNDP (n.d.)

TEAS studies (Phase II Report – Volume 1: Summary – Chapter 2.2: Geology, April 2014) do not consider the landslide involving slope cover deposits as a major threat for the feasibility of the Rogun project, as long as accurate monitoring, e.g. visual inspection, measure of pore pressure and crack opening etc., and mitigation measures, e.g. galleries filled with reinforced concrete across the S4 discontinuities, slope reshaping or drainage, are undertaken. As landslides are preceded by several months of progressive opening of cracks, visual monitoring is a technically and economically efficient method before, during and after Rogun construction phase. Furthermore, a comprehensive program for mudflow risk assessment is recommended, as several events have impacted the construction site, especially during flood events of the Obishur river.

6.5.2 Salt Wedge

A salt wedge (salt dome or salt stock) is located close to the upstream cofferdam, and there is a risk that the reservoir will affect vertical movements of this salt wedge, which in turn could lead to dam deformations. This was analysed in the original project of 1978 as well as in HPI (2009).

The construction of special tunnels to solve the salt wedge problem was proposed in the original project of 1978 (№ 561ТП-3VII-2906 “The measures for saline protection of the salt wedge. 1978 (№ 561ТП-3VII-2906. Мероприятия по защите пласта соли от размыва. 1978). The main idea was to establish a protection curtain for the salt wedge by means of special saline and hydraulic protection, using salt brine injections to the salt wedge location on both sides of the river near the coffer dam. It was assumed that this measure would exclude the dangerous deformations of the salt wedge, and, as a result, dam deformations.

In HPI (2009) (#1861-1-KH2. Explanation note. Page 91 – 96. (№1861-1-КН2. Пояснительная записка. стр. 91-96), physical and numerical modelling allowed estimating the salt wedge movements under the influence of the reservoir. Modelling was done for two dam types, a concrete dam and an embankment dam. For both cases the maximum value of the salt wedge dissolving is estimated at less than 7 to 8 m. In the same chapter the proposal was made to provide more detailed analyses of the embankment dam rigidity for such changes in the salt wedge surface.

According to TEAS studies, the area is tectonically very active. In the past Ionakhsh Fault and Fault 35 were creeping at a rate of about 1.5 to 2 mm/yr. When salt is dissolved, leaching may be very rapid and generate dramatic consequences. To address the salt wedge concerns in the design criteria of the Rogun dam, TEAS studies propose a monitoring system to be installed as well as a contingency plan to be defined. However, the leaching issue at the Ionakhsh Fault does not affect the technical feasibility of Rogun project.

6.5.3 Seismicity

The seismic conditions and seismic hazards assessment are described in detail in the original project of 1978 as well as in HPI (2009), but in accord with the rules and codes accepted in the former Soviet Union, Tajikistan and Russia.

In the original project of 1978 the return period of the earthquake with an intensity of 9 units on the MSK-64 scale was assessed as 1000-year event, and 8 units as 500-year event, for the Vakhsh fault zone in the Rogun area. The background seismicity for the construction site was assessed as 9 units, and on the basis of the soil conditions of the site the background seismicity of 8 units was recommended (page 197, volume 1174-T15 “Rogun HPP on the Vakhsh River. Engineering design. Part 1- Natural environment. Volume 3-Engineering-geological conditions” (1174-T15 «Рогунская ГЭС на реке Вахш. Технический проект. Часть 1 — Природные условия. Том 3 — Инженерно-геологические условия»)). Moreover, the analysis of the seismic impact on the dam site was based on the existing seismic and active tectonic data for that time period. Thus a seismic impact estimate of 9 units on the MSK-64 scale for the HPP area and 8 units for the dam site is not sufficient according to today’s international standards.

The seismic conditions of Tajikistan and the Rogun area are described in HPI (2009) (# 1861-2-II-3 “Volume II - Engineering-geological conditions, Book 3 – Engineering-geological conditions. Chapter 5 (№ 1861-2-II-3 «Том 2. Природные условия. Книга 3 -Инженерно-геологические условия». Раздел 5). The description of the locations of seismic events, seismically active faults and the history of the seismic hazard assessment are given. All estimations indicate an intensity of 9 units on the MSK-64 scale for Rogun site.

TEAS studies (Phase II Report – Volume 1: Summary – Chapter 2.4: Seismicity, April 2014) reconsidered the past findings. Based on a Deterministic Seismic Hazard Assessment (DSHA), they defined a Peak Ground Acceleration of 0.71 g for the Maximum Credible Earthquake (MCE). A seismicity assessment based on a state-of-the-art Probabilistic Seismic Hazard Assessment (PSHA) in accordance with international standards and the ICOLD recommendations is planned for the next project phase. According to TEAS, the DSHA will need an update after disclosure. Further assessment will be needed in accordance with the project progress, responding to the very high requirements of such a large dam.

Dam break scenarios and the downstream impacts are to be studied in the framework of the emergency preparedness plan, which will be carried out at a subsequent stage. However, flood wave propagation would have dramatic impact on downstream areas in any case. Occurrence probability and amplitude have therefore to be reduced to minimise the risk. This has been done, since very stringent design criteria have been adopted by TEAS, including Maximum Credible Earthquake (MCE).

TEAS studies propose a strong-motion as well as a microseismic network for seismic monitoring. This should be implemented as soon as possible in order to estimate the background (baseline) seismicity prior to dam construction (see Section 24.3).

6.5.4 Reservoir Triggered Seismicity

Neither the original project of 1978 nor HPI (2009) provides an analysis of possible Rogun reservoir triggered seismicity. There is only a very short citation of the study of the results of Nurek reservoir triggered seismicity, which leads to the conclusion that the future reservoir will not trigger any big seismic events either, but will increase the quantity of smaller ones in this area. It is also stated, that some research institutes had studied the reservoir triggered seismicity of Rogun (paragraph 1.5 Volume 1174-T15 “Rogun HPP on the Vakhsh River. Engineering design. Part 1- Natural environment. Volume 3-Engineering-geological conditions” (1174-T15 «Рогунская ГЭС на реке Вахш. Технический проект. Часть 1 — Природные условия. Том 3 — Инженерно-геологические условия»)). However, there is no precise seismic monitoring network in the area of interest. Reservoir triggered seismicity was investigated with sufficient detail for Nurek. The seismic potential of the Rogun area is more substantial. Thus it is requested to install a digital seismic network in the Rogun and the future reservoir areas as soon as possible.

TEAS studies (Phase II Report – Volume 1: Summary – Chapter 2.4: Seismicity, April 2014) expect a maximum magnitude from Rogun reservoir triggered seismicity of less than 5 units on the MSK-64 scale. Higher earthquakes could be observed if the changes in the stress field affect the closest active faults, but this will not increase the maximum magnitude on the faults. Maximum observed magnitude clearly related with a dam is 6.3. It is recommended by TEAS to undertake a slow filling of the reservoir in order to minimise the impact.

Based on the experience of Nurek reservoir triggered more precise analysis for Rogun reservoir is needed (see Section 24.3). An outline of such a network is provided in Vol. III (ESMP).

6.6 Conclusions and Recommendations

Through the study of the available documents, the original project of 1978, HPI (2009) as well as the TEAS studies and a number of site visits the ESIA Consultant comes to the following main conclusions and recommendations:

- According to TEAS studies, the regional tectonic stresses at the Rogun site are adjusted by deformation which is both seismic, involving sudden co-seismic rupture, and aseismic, mainly by creeping. This creeping, which is permanent, takes place principally on the main faults, where monitoring was implemented to measure the deformation rate. Special protection measures must be designed for the underground structures crossing the main discontinuities with evidence of significant shear.
- Additional investigations are requested to verify the cause of damages to support at all identified locations. If necessary the rock masses should be exposed for inspection and installation of monitoring devices. Monitoring of displacements along the main faults should be resumed and additional devices installed. In addition, monitoring should be extended to the major discontinuities showing offset. Taking into account the complex tectonic setting, these tests should also be carried out at different locations into the abutments.
- Superficial sliding and creeping processes due to the presence of halide karst are expected to develop progressively during impounding. The impact of impounding on dissolution and subsequent instabilities should be considered at a further stage.
- No large unstable slopes were found. Thus landslides as well as debris and mudflows are not considered as a major threat for the feasibility of the Rogun project, as long as accurate monitoring and mitigation measures are undertaken.
- Oscillations of the reservoir water level can trigger landslide processes in the reservoir area, but will not create a problem for dam safety. Preventive measures should be taken where such areas are in close proximity to infrastructure and settlement areas.
- When salt comes to evaporate, leaching may be very rapid and generate dramatic consequences. To address the salt wedge concerns in the design criteria of Rogun dam, a monitoring system and a contingency plan are proposed. However, the leaching issue at the Ionakhsh Fault does not affect the technical feasibility of Rogun project.

- A strong-motion and a microseismic network for seismic monitoring are requested to be implemented as soon as possible in order to estimate the background (baseline) seismicity prior to dam construction.
- Reservoir triggered seismicity has been investigated with sufficient detail for Nurek. The seismic potential of the Rogun area is more substantial. Thus it is requested to install a digital seismic network on the Rogun site and its reservoir area as soon as possible. TEAS studies expect a maximum magnitude from Rogun reservoir triggered seismicity of less than 5 units on the MSK-64 scale, considering the recommended slow filling of the reservoir.

7 CLIMATE

7.1 Key Messages

After a characterisation of the climatic situation in the project area the question on whether and how the project could influence the climate is addressed. Key message is the fact that the project will not have any measurable effects on the local climate. While the presence of a large water body can influence temperature (cooling in warm conditions and warming in cold conditions, increase in humidity), the reservoir will be too small for having a noticeable effect in this sense.

7.2 Theoretical Considerations

Large water bodies influence the climate of their surroundings, especially temperature and humidity. The most noticeable effects are a general cooling in summer, a warming in winter, and a reduction of the daily and seasonal temperature variation. This effect can be clearly seen when the climate of a place on the seashore, with maritime climate, is compared to the one of a place far away from sea influence, with a continental climate type. Direct measurements have documented this effect. So it has been demonstrated that for instance a small island in the Finnish Bay exhibited a January temperature that was 1.3°C higher than that of a station in the nearby land some distance away from the coast, while the average May temperature was 2.5°C lower. Similar effects have been demonstrated in the vicinity of two lakes (Lake Peipus, Lake Chelkap), although in these cases the differences were smaller, reaching only +0.3° in winter, -0.7° and -1.8°, resp., in summer (Alissow et al., 1956). This is also illustrated for Lake Aral in the Figure below.

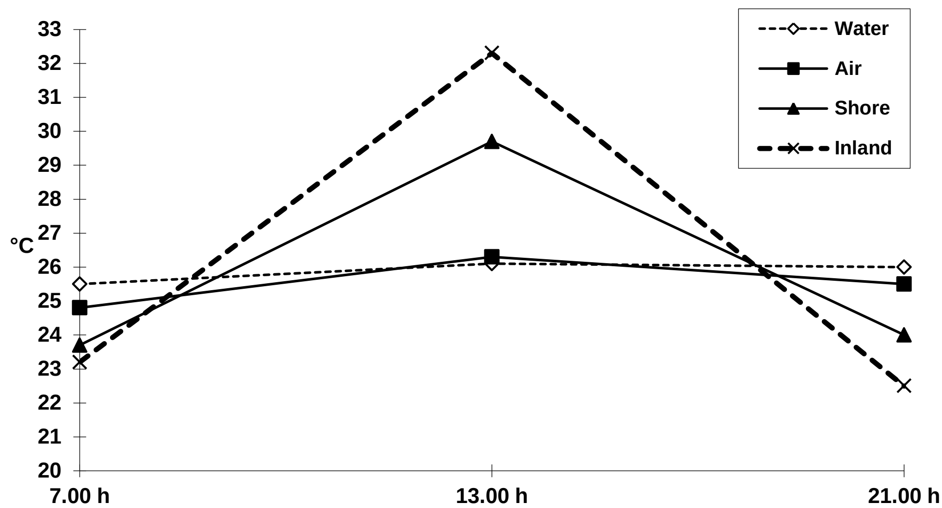


Figure 7-1: Daily temperature variations as influenced by a lake

Measurements from Lake Aral, August 1902. The daily amplitude of water temperature is merely 0.6°, of the air above the water 1.5°, at the shore 6.9° and in greater distance from the lake 9°C (Alissow et al., 1956).

This is mainly due to the fact that the water is able to store a considerable amount of heat, and that it reacts very slowly to changing temperatures. While on land the temperature (soil and air layers close to it) can exhibit large daily fluctuations, this is not the case for water. In Irkutsk, the daily variation in summer is 13.5 to 21.7°C, in winter 5.7 to 14.5°C (air 2 m above ground), the soil surface variation is even greater (29.8° in summer, 6.2° in winter; measurements for a day with rather low air temperature variation). It will be noted that Irkutsk is exhibiting a continental climate in spite of the proximity of Lake Baikal, which is one of the largest inland water bodies of the world. The biggest daily variations in air and soil temperature are recorded from deserts, which lack the cooling effect of evapotranspiration. In African deserts, daily surface temperature differences of up to 43°C have been recorded, in middle Asian deserts up to 50°C.

In larger water bodies (seas and very large inland waters), normal daily fluctuations of temperature close to the surface are usually below 1°C (and smaller for deeper layers), and this is also the case for the air layer of approximately one meter above the water surface, this difference getting more pronounced in higher air layers (Alissow et al., 1956; Geiger, 1950).

In the case of smaller lakes, it is very difficult to define clearly the effects of the proximity of the lake on ambient temperatures, as the complex mixing processes due to local winds tend to blur this influence. Nevertheless, it can be said from experience that, as a general rule, lakes have a beneficial effect on the local microclimate. This is shown by the fact that, in temperate regions, some plants normally limited to a warmer climate grow exclusively or at least much better in the vicinity of lakes (e.g. vineyards in central Europe). Furthermore, settlements tend to concentrate around lakes. While this has certainly different reasons, historical and scenic ones among others, the microclimate certainly contributes to it.

In temperate and cold regions, the effect of a lake on the climate takes place only while it is not covered with ice. A compact ice layer covering the water body effectively blocks temperature exchange of the lake with its surroundings.

A few publications are concerned with the question of evaporation from lake surfaces (Kuhn, 1977; Hoy and Stephens, 1977). However, there does not seem to exist, to date, a thorough climatic study in relation with a man-made lake, which would compare temperature and humidity values before and after dam construction. The studies that at least mention potential climatic effects of artificial lakes attribute to them a minor or almost negligible effect (e.g. Odingo, 1979; Olivetti, 1983). this seems perfectly understandable given the fact that, while artificial lakes certainly create considerable impacts on the environment, climatic changes can, in the light of the details given above, be considered as of minor importance and, if at all noticeable, then rather beneficial.

While the effect of reservoirs on the local climate is, as has been shown, small or almost negligible, climatic conditions are important for the operation of hydropower plants. The most important parameter is precipitation, since this influences and determines directly (in the case of rainfall) or indirectly (snow) the availability of water. In this respect, temperature is also relevant, especially in colder climates where in winter much water freezes or is available in the form of snow. Finally, evaporation plays a certain role, since the creation of a large open water surface in form of a reservoir can increase the loss of water due to evaporation.

In addition to that, climate change has to be considered, and this in two ways:

- Emission of greenhouse gases: under certain conditions (large amounts of biomass submerged, eutrophication of the reservoir with high productivity or organic material) there is a risk that due to high oxygen consumption for the breakdown of this biomass the water gets anoxic in deeper layers of the reservoir, which in turn can lead to an emission of methane from the reservoir, a very potent greenhouse gas. This is the case mainly in large reservoirs in moist tropical areas. On the other hand, hydropower can reduce greenhouse gas emissions by reducing the amount of fossil fuels (coal, oil and gas) burned for producing electricity in thermal power plants, and thus the emission of CO_2.
- Water availability: overall climate change can, over the long run, influence hydropower projects by changing water availability, either positively (by increasing rainfall, or, for a limited period, by increasing melt water from glaciers), or negatively (by regionally reducing precipitation).

These aspects are discussed in the following Sections.

7.3 Climatic Situation

A short description of the climatic situation is given here, based on data from meteorological stations in the project area.

7.3.1 Temperature

As can be seen from the following graph, which shows average monthly temperatures from two stations (Komsomolobod within, Garm just upstream from the future reservoir), the area shows a distinctly continental climate, with marked differences between summer and winter.

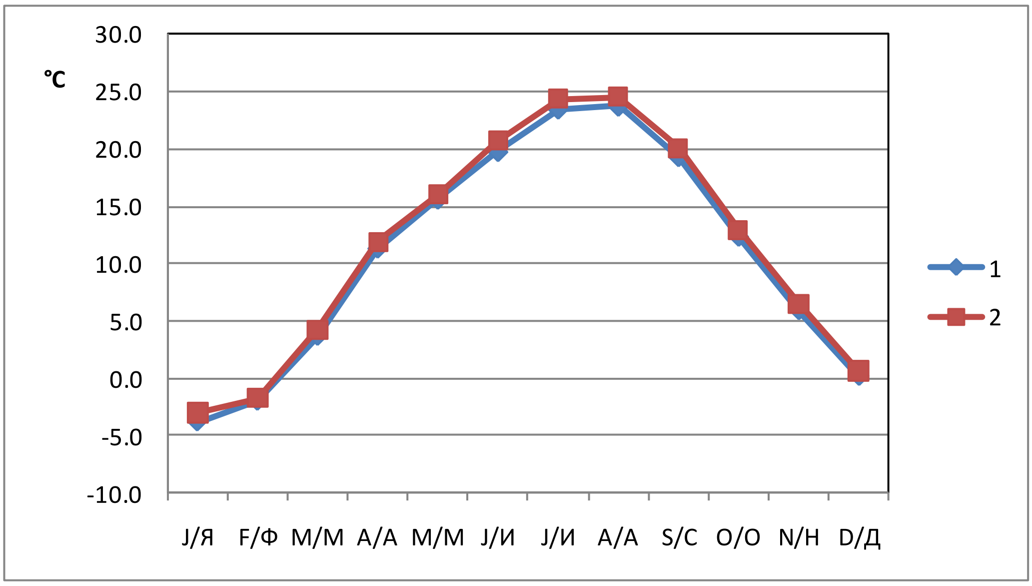


Figure 7-2: Average monthly temperature

1 = Garm 2 = Novobod (Komsomolobod)

The following Figure shows the average yearly, summer and winter temperature for Rasht (Garm) over the available period 1933 - 2010 (with, as is the case for many measurements, a gap between 1992 and 2006). The data do not show any trend for the time span on record.

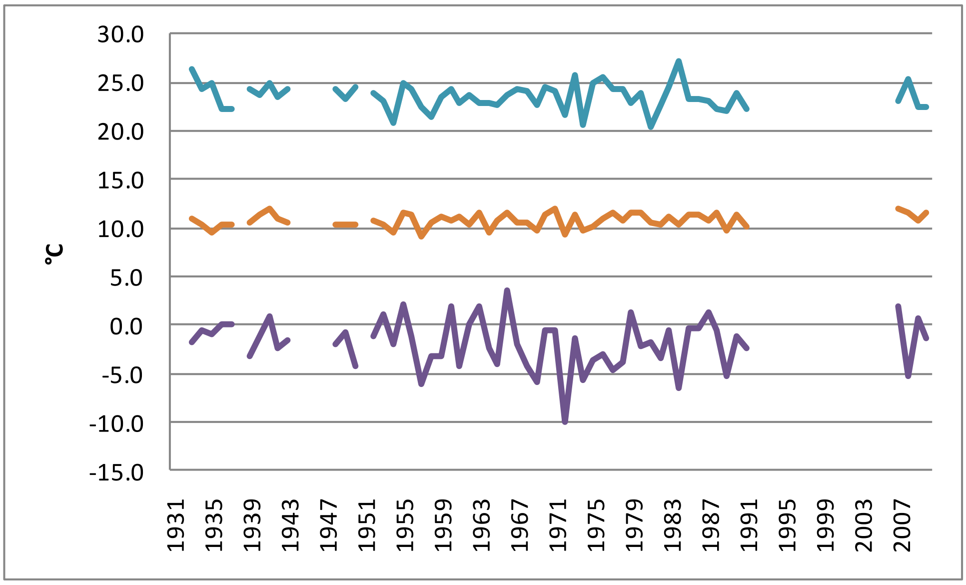


Figure 7-3: Temperature 1931 to 2010

Hottest month (August, top), yearly average, coldest month (February, bottom)
Source: Hydromet, Tajikistan; 58 years with complete records (Rasht, Garm)

7.3.2 Precipitation

The three stations within the project area for which data on precipitation are available all show the same pattern of yearly distribution of precipitation: the maximum is in winter and spring (December to May). Much of this falls as snow, especially at higher altitudes. In the summer months there is very little precipitation.

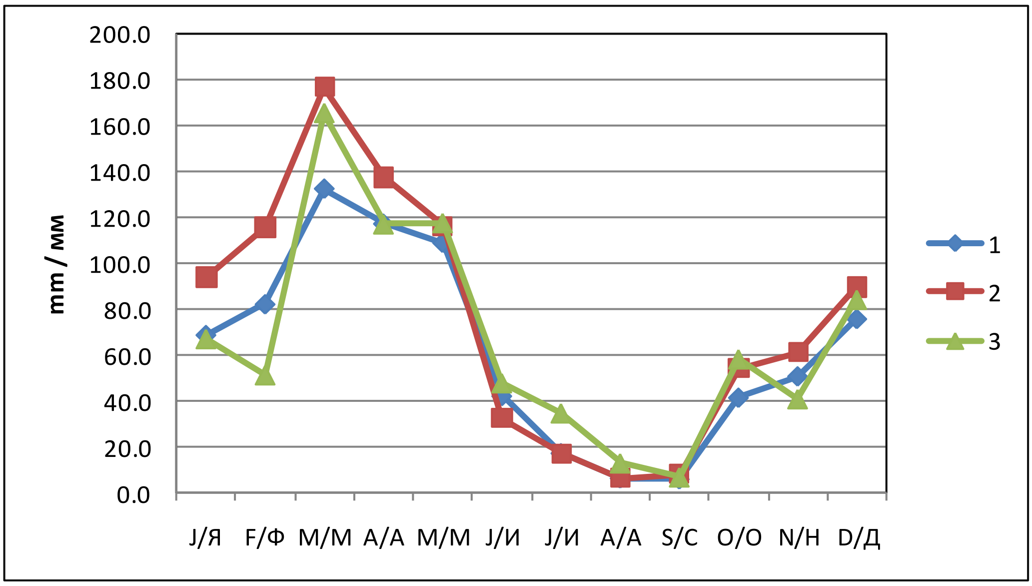


Figure 7-4: Average monthly precipitation

1 = Garm 2 = Novobod (Komsomolobod) 3 = Obigarm

This pattern of rainfall is typical for the mountainous regions of Tajikistan, but is basically the same for the lower laying areas, which however receive less precipitation in total. This lack of precipitation, and especially rainfall during the vegetation period, is the main reason why agriculture depends almost exclusively on irrigation.

7.3.3 Evapotranspiration and Evaporation

Evapotranspiration (i.e. the evaporation from the surface and transpiration from plants) in the project area is in the order of magnitude of 750 to1000 mm/yr.

According to PPCR Phase I Project A4, evaporation from the reservoir will be in the range of 800 to 1200 mm/yr (depending on the method of estimation).

These two figures are usually in the same order of magnitude in cases, where a reservoir is replacing an ‘average’ vegetated area not having long draught conditions. This means that the evaporation of Rogun reservoir will cause only a small increase of the amount of water that is released locally to the air.

7.4 Effects of Rogun Reservoir on Local Climate

The presence of a surface of water of 170 km^2 will increase evaporation, and it can have a moderating effect on temperature. However, the lake will be too small for having have a noticeable effect on the climate. The effects (reduction of the number of frost days, reduction in summer temperatures, increase in humidity) will be limited to the immediate surroundings of the reservoir, and they will be too small to play any decisive role.

7.5 Climate Change

7.5.1 Basic Considerations

It has to be stated clearly that the concept of Climate Change refers to the effects observed on a global level, induced by man-made greenhouse gas emissions, and that this is a very different issue as the effect of the reservoir on local climate, which was discussed above. Here, the focus is on effects of climate change on water availability for hydropower production (and for irrigation, as far as this is of concern in the context of this ESIA). Obviously, the fact that reservoirs, under certain conditions, can be sources of greenhouse gasses has to be taken into account (see Section 8.11.3).

According to Ray et al. (2008), historic and projected trends in temperature, precipitation and extreme events have several general implications for mountain regions and, more specifically, for the hydropower sector:

- Higher winter and spring air temperatures mean that a smaller fraction of the precipitation total falls as snow.
- The altitude of the snowline increases, changing the local albedo (reflectivity) of the landscape, thereby amplifying regional warming.
- Long-term wastage and reduced mass balance of glaciers (assuming no change in winter precipitation).
- On average, less snow cover and snowpack storage at the end of winter, especially at lower elevations.
- Earlier thaw of permafrost and melting of snowpack and glacier ice.
- Earlier incidence of avalanches, landslides and flooding.
- Earlier (and potentially larger, due to rain with snowmelt) peak inflows to reservoirs.
- Lower summer minimum inflows to reservoirs.
- More intense summer storms enhancing soil erosion and conveyance of sediment.

Considering socio-economic effects and impacts on ecosystems, dam operation is proposed as an “adaptation option” given their capability to moderate the expected increased seasonality of river runoffs (IPCC, 2014: 24.4.2.5).

7.5.2 Expected Development Central Asia

According to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC, 2007), and confirmed in the recently published Fifth Report (IPCC, 2014), there is evidence of climate change to be observed in the next few decades. The evolution of climatic conditions could have important consequences on the hydrological regime of watersheds all over the world and this key issue needs to be addressed in either existing or planned hydropower projects. The most likely expected general effects of climate change in Central Asia are shown in the following Figure.

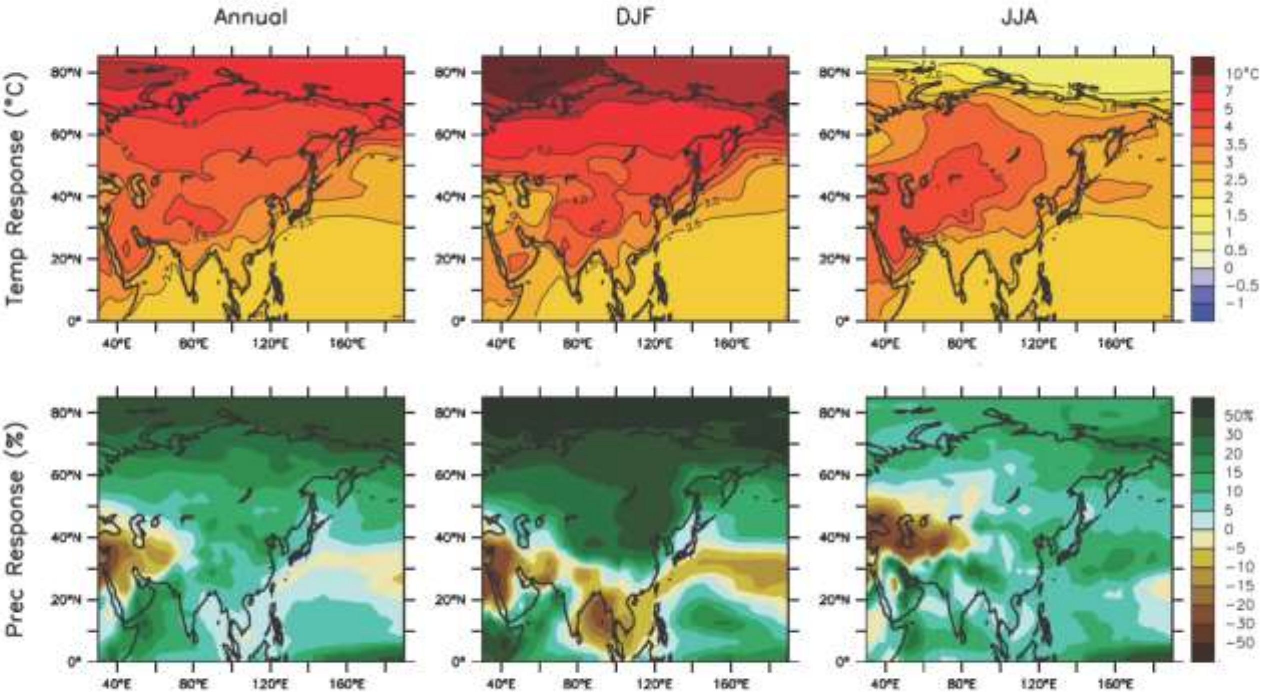


Figure 7-5: Expected climate change in Asia

Annual, winter (DJF) and summer (JJA) temperature and precipitation changes over Asia between 1980-1999 and 2080-2099
Source: Christensen et al. 2007

The most important results of this analysis for the project area are the following:

- Temperature is expected to increase by about 2to 3°C by the end of the century. The effect will be more marked in summer, but winter temperatures also will increase. In general, it is assumed that an increase in temperature by 1° C leads to a rise of the snow line of about 150 m. As a result, less precipitation will be stored in the snow cover and snowmelt will begin earlier.
- All recent basin-scale studies document multi-decadal glacial area loss (IPCC, 2014). Most of the surveys show accelerated loss. Annual rates in the Pamir are in the order of magnitude of -0.13 to -0.30%/yr. The two Figures below show the decreasing ice masses in the greater Himalayan area compared to other regions. In the case of the Vakhsh catchment, with its high proportion of high mountain areas, this is expected to have an impoact on snow cover and therefore on river runoff.
- Overall, a small increase in the total amount of precipitation is predicted for this century. What might be more important in the case of the study area, however, is the shift in seasonal distribution with as increase in winter and a decrease in summer. This would mean that the situation shown above, with humid winters and dry summers, will become even more accentuated. In many areas, a greater proportion of total precipitation appears to fall as rain than before (Eriksson, 2009).

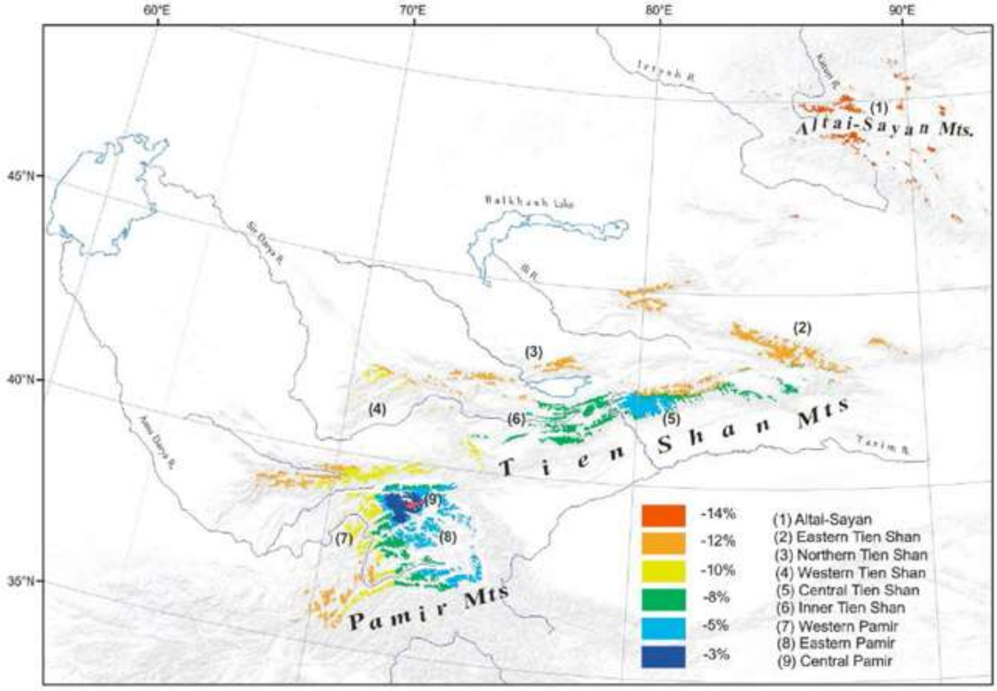


Figure 7-6: Losses of glacier areas in Central Asia 1960-2008

Source: IPCC, 2014

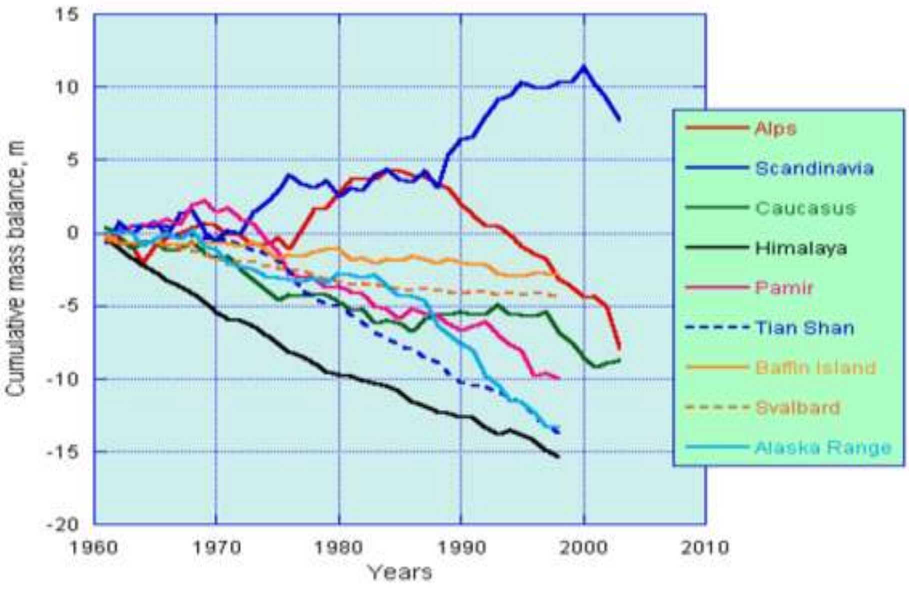


Figure 7-7: Comparison of the retrat of glaciers

Source: Eriksson, 2009

7.5.3 Analysis of Climate Change Effects

A more specific analysis of the consequences of climate change on Rogun HPP operation is given in Chapter 20.

8 WATER

8.1 Key Messages

Hydrology is a central issue of the study. The objective of this chapter is to address issues related to water (in terms of quantity and quality) in the perspective of Rogun HPP project:

Key messages are:

- The Rogun HPP is located on the Vakhsh river, one of major tributaries in the upper reaches of the Amu Darya, the largest river of Central Asia, and one of the two tributaries of the Aral Sea. Most of the water flowing in the Amu Darya basin stems from the mountainous areas of Tajikistan and Afghanistan.
- Due to climatic conditions, river flow is highly seasonal, with high flows in summer due to snow and glacier melt in the mountains, and low flow in winter, since most of the precipitation in the catchment area falls as snow.
- Amu Darya is formed by the confluence of its two most important tributaries, the Pyanj and the Vakhsh; Vakhsh contributes about 26% of the total water flowing in the Amu Darya. Further downstream there are only a few more tributaries.
- The Aral Sea has suffered greatly due to massive irrigation schemes which were built in the 1960s, and which led to a very severe reduction of water inflow, to less than 10% of natural inflows. It has been shrinking very considerably, and salinity has increased. Today, the southern part, also called "Large Aral Sea", which is alimented by the Amu Darya, is almost dead, with no identified solution for recovery in the foreseeable future. Rogun HPP will not cause any change in the situation of the Aral Sea.
- Water use in the Aral Sea basin is dominated by irrigation, which is a consumptive use in the sense that only a small fraction of the water which is withdrawn from the river will return to it, the so-called return flow.
- The use of water in the Amu Darya basin (with the exception of the part used by Afghanistan) is regulated among the riparian states (Kyrgyzstan, Tajikistan, Uzbekistan and Turkmenistan) by agreements (Nukus Declaration and Protocol 566), and water is allocated by a basin water organisation (ICWC).
- During the past decades there has been progress in the development of the interstate regional cooperation in the Aral Sea Basin as multiple agreements and conventions were signed and institutions established. However, the legal basis for the interstate cooperation between the Central Asian states is still in the development process.
- Afghanistan is not a member of these agreements, although a considerable part of Amu Darya basin is located within this country.
- Hydropower is a non-consumptive use of water resources; in the case of storage plants it can result in a seasonal shift, from the high flow (summer) to the low flow (winter) season.

- Tajikistan uses a part of the water downstream of Nurek for irrigation; so far, it has not yet fully used the amount of water allocated to it by ICWC.
- It is recommended to maintain a minimum flow from Rogun HPP of at least 10 m^3/s. Flow of lower Vakhsh is regulated by Nurek, not by Rogun.
- Water quality in Vakhsh is generally good, since there are no major sources of pollution in its catchment.
- Sediment load is very considerable, and is already causing problems in Nurek reservoir.
- Given the climatic conditions of the project area, a seasonal thermal stratification will develop in the Rogun reservoir. This will however not have any negative consequences.
- Oxygen content in the reservoir will be high, and there will be no risk for anoxic conditions and the gross emissions of greenhouse gases from the reservoir will not be significant.
- In future, Tajikistan will use its full water share of Vakhsh, respecting the downstream water requirements as allocated by ICWC.
- It is anticipated that Afghanistan, which is not member of ICWC, will in the mid-term expand its irrigation activities in the Amu Darya basin, increasing its annual water consumption from now 2.5 to up to 6 km^3.

Impacts of the project on water availability - both positive and negative - are dealt with in detail in Chapter 21.

8.2 Scope

The hydrological assessment presented hereafter presents a description of (i) the Vakhsh and Amu Darya rivers basins, (ii) a review of water quality issues (chemical and physical aspects), (iii) a description of the existing water uses in the Amu Darya basin, and (iv) a presentation of the existing water allocation rules within Amu Darya river basin.

The expected impacts of Rogun HPP are then presented, including a review of the mitigation measures that were discussed together with TEAS on the basis of the numerical model developed to simulate the potential scenarios for the filling and operation of Rogun reservoir and HPP.

This chapter was developed on the basis of the following information:

- site visits to the Rogun project site and to Nurek HPP;
- meetings and collection of data with technical or administrative services of Tajikistan (the list of people met is attached in Annex);
- data from Rogun's technical literature (from the Soviet time or after independence);
- data and information from reports or studies developed within the framework of other studies (all references are mentioned in Annex);
- data from the Amu Darya Basin Water Organization (BVO) that was made available on the Cawater website at the time it was publicly open (despite

request from the Consultant, no meeting with ICWC representatives could be organized);

- suggestions and comments made by stakeholders during the transboundary public consultations;
- hydrological data from Nurek HPP and BVO and results from the simulation model prepared as part of TEAS and other TEAS reports.
- information obtained from various sources on the anticipated future development of water consumption in Tajikistan and Afghanistan.

8.3 Theoretical Considerations

An HPP will normally have influence on surface water bodies in three ways, namely:

- by changing water discharge patterns downstream of the dam;
- by creating a reservoir, i.e. by changing a portion of the river from its natural running water into a lake (stagnant water) condition; this also has implications on water quality;
- by potentially changing the water balance locally (gains from direct precipitations, and losses from evaporation and infiltration).

8.3.1 Downstream Hydrology

A dam and the reservoir, in relation with turbine operation, can change the river discharge downstream of the dam considerably. This is especially the case in strongly seasonal climates with a marked change between wet and dry seasons. In such cases, water is stored during the wet period to be released during the dry period; therefore, the seasonal variation will be less marked than under natural conditions; this is shown, for one real case, in the following Figure. It can be seen that each additional dam has the tendency to increase the effect of reducing wet season flows and increasing dry season flows.

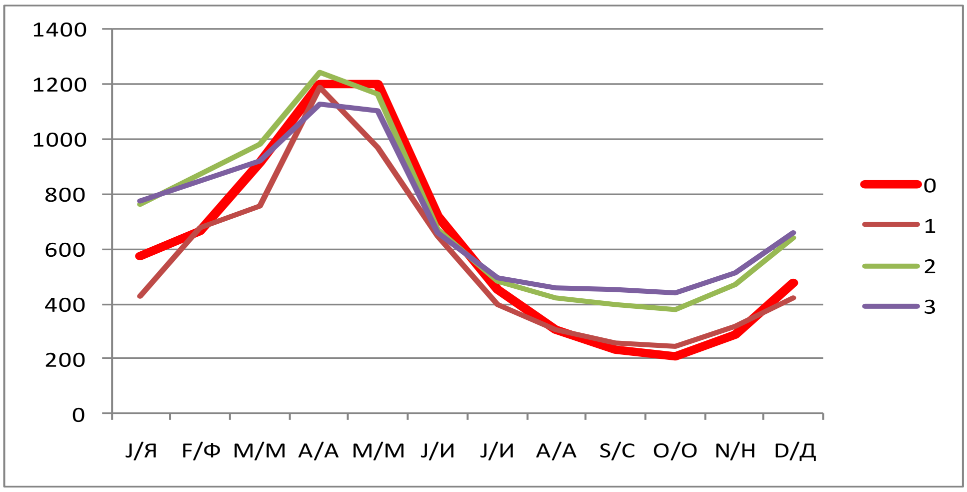


Figure 8-1: Cumulative effects of storage dams (Karun river, Iran)

0 = natural conditions, no dam;
1-3: situation with 1 to 3 dams in a cascade

Reservoirs have a flood mitigation effect, depending mainly on their size and storage capacity. While attenuating effects on river flows, and especially reduction of flood peaks, are normally welcome by people living along the river, other effects can be less beneficial, and certain floodplain habitats that depend on river dynamics might be negatively affected (see Section 12.6).

8.3.2 Residual Flow

Other effects of an HPP could be short term fluctuations caused by turbine operation, so-called peaking. When the powerhouse is not situated directly below the dam, but further downstream, a stretch of the river between dam and water outlet could become completely dry. Hydropower projects designed for peaking production can lead to very marked short term fluctuations in river flow directly below the power house. This is shown for one example in the following Figure.

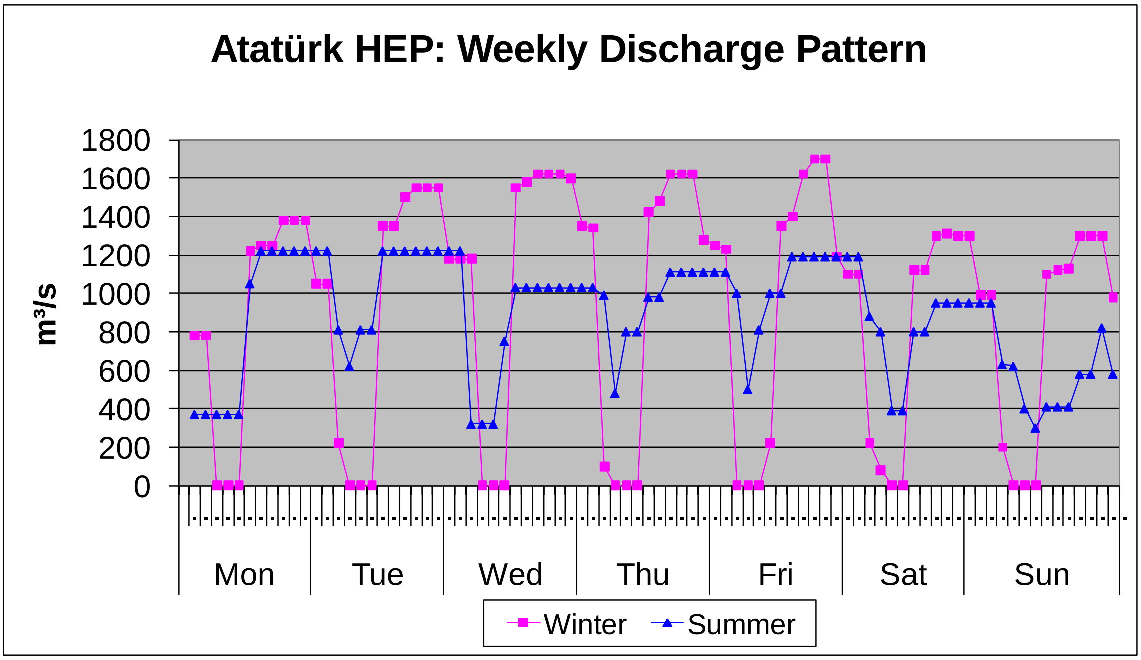


Figure 8-2: Discharge from a peaking hydropower plant

Example of Attatrürk dam, Turkey; it is evident that discharge, and therefore river flow below the power house, change very markedly each day. In winter, there are a few hours each day with zero flow.

In cases where zero flow can occur, a residual (often called environmental or ecological) flow has to be defined in order to (i) maintain the river as a habitat for aquatic species and (ii) preserve downstream socioeconomic water uses.

8.3.3 Changing River to Lake Habitat

A reservoir or a lake presents very different living conditions for aquatic organisms in comparison to those that prevail in a river. Many riverine species will not be able to adapt to these new conditions, while others will thrive. This aspect will be dealt with in Chapter 11.

8.3.4 Water Quality

Reservoir water quality will depend to a great deal on the preimpoundment condition of the reservoir area. Whenever a large amount of biomass is submerged, the rotting plant material will lead to water quality deterioration in the deeper layers of the reservoir. This in turn can lead to fish deaths, but it can also impair water quality downstream of the dam. This aspect is especially important when the river or the reservoir itself is used as a source of drinking water. Water quality in the reservoir will also be influenced by input from the catchment area. Namely, large settlements and/or industrial activities without proper waste water treatment will influence water quality. Effluents from agricultural areas can lead to high input of fertilisers into the reservoir, which in turn leads to reservoir eutrophication.

8.4 The Amu Darya Basin and the Aral Sea

8.4.1 Amu Darya Basin and Sub-Basins

The Amu Darya is the largest river in Central Asia by discharge. Its length is 2'540 km and the size of the catchment area, depending on the source, is indicated as 227'000 km² (BVO), 534'739 km² (Water Resources of USSR - 1971) or 1'023'610 km² (FAO 2013); see also Table 4-1.

The difference between these figures is because some of Amu Darya's tributaries either do not permanently contribute to the river flow, or have been diverted (for example the Zeravshan river), or end up in the desert / steppe without reaching Amu Darya. One additional question is whether or not the area of the Karakum Channel, which diverts water from the Amu Darya to Turkmenistan, should be considered as part of the Amu Darya Basin.

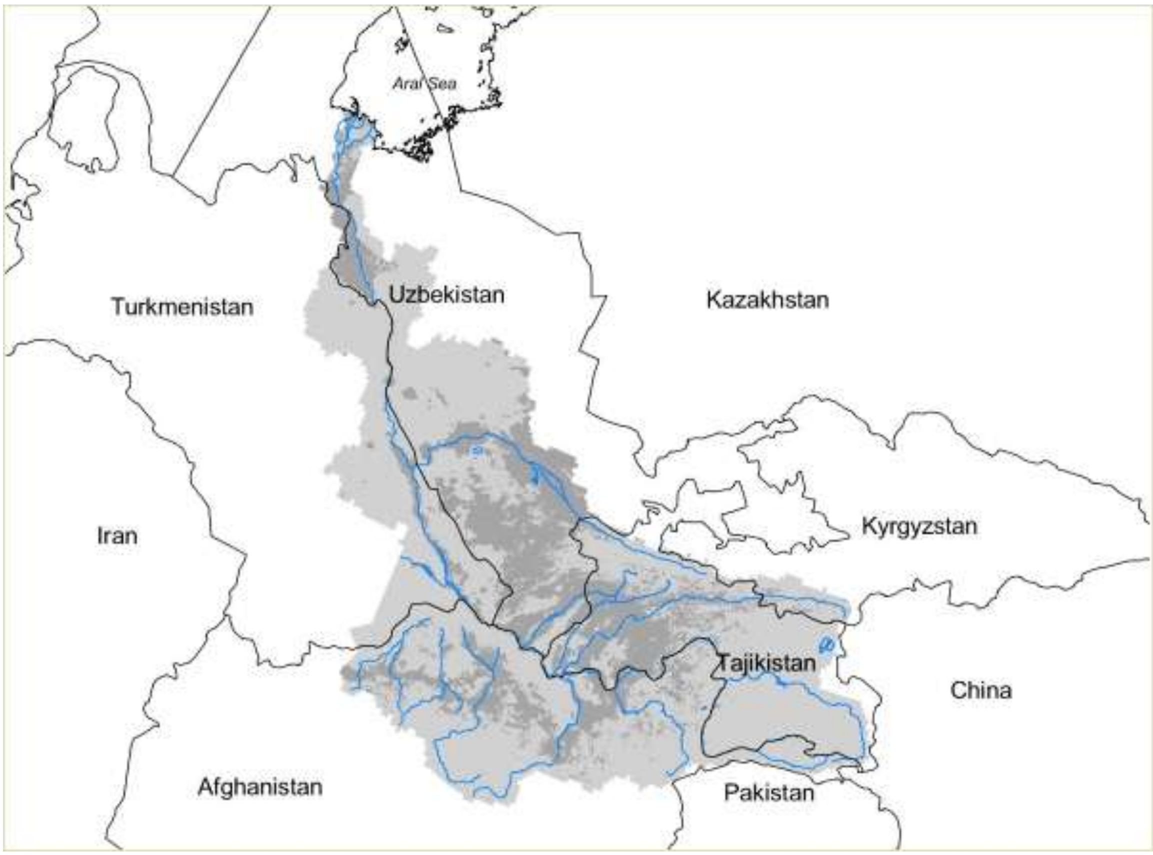


Figure 8-3: Amu Darya river basin with main tributaries

Upstream from the confluence with the Vakhsh, the Amu Darya is called Pyanj. Downstream from this confluence, the Amu Darya is joined by several tributaries, the main ones being the Kunduz (from Afghanistan), the Kafirnigan (from Tajikistan), the Sherabad and the Surkhandarya (from Uzbekistan).

The Amu Darya basin is shared by Afghanistan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan and terminates in the Aral Sea. Most of the Amu Darya river flow is formed in the upper part of the catchment area, i.e. in the mountains of Afghanistan and Tajikistan, as shown in the following Table.

Table 8-1: Contribution to Amu Darya annual flow by country

Country	Annual flow generated (km³)	%
Tajikistan	62.90	80.17
Afghanistan	6.18	7.88
Uzbekistan	4.70	5.99
Kyrgyzstan	1.90	2.42
Turkmenistan	2.78	3.58
Total	78.46	100

Source: Main guidelines of water strategy of the Aral Sea basin 1996 (ICWC) (received from the Ministry of Energy and Water Resources of the Republic of Tajikistan, 2014)

As Horsman (2008) points out, there are considerable variations in hydrological data, especially on the part stemming from Afghanistan (see e.g. Ahmad and Wasiq (2004), an important source for the role of irrigation in the Amu Darya basin).

On the way to the Aral Sea the river forms the boundary between Afghanistan and Tajikistan as well as between Afghanistan and Uzbekistan, but also crosses the boundaries between Turkmenistan and Uzbekistan.

Table 8-2: Main characteristics of Amu Darya basin, Vakhsh and Pyanj sub-basins

River	Basin area (km²)	Length (km)	Altitude (m)		Average flow (km^3/yr)	Catchment yield factor (l/s/km²)
			lowest point	highest point		
Amu Darya (entire basin, incl. Vakhsh and Pyanj)	534'700	2'415	28	7'495	78.46	4.6
Vakhsh	39'100	786	326	7'495	20.1	16.3
Pyanj	114'000	921	326	6'974	31.6	8.8

8.4.2 The Aral Sea

The Aral Sea is a large lake without outflow, inflows are balanced by evaporation. Around 1960, it had a surface of 66'458 km² and was then the fourth largest lake in the world in terms of surface area. Average depth was 16 m, maximum depth was 68 m in the western and 29 m in the central and eastern part; these two parts were separated by islands which today form an almost complete separation between the two parts.

In historical and prehistorical times, the lake level has known rather important fluctuations, the amount of which is still a matter of debate. However, at least for a time span of at least two centuries before 1961 it has been very stable, with a variation in the order of magnitude of 1 to 2 m.

The Aral Sea has only two tributaries of importance, the Syr Darya in the North and the Amu Darya in the South, both originating in the high mountain areas to the east of the lake, in Kirgizstan, Tajikistan and Afghanistan. Records from the 20th century show that the overall runoff of the Amu Darya at the foothills of the mountains (i.e. in the region of Termiz, a short stretch downstream of the Tajik-Uzbek border) was 78.6 km³/yr, with high year to year fluctuations, however without showing a downward trend (see Figure 8-4). Out of this, originally (i.e. before about 1960) around 60 km³/yr reached the Aral Sea (see Figure 8-6). The fact that in spite of the high annual variation of inflow the lake level remained rather stable might have been due to the mitigating effect of the groundwater reserves in the soils along the river plains and the lake.

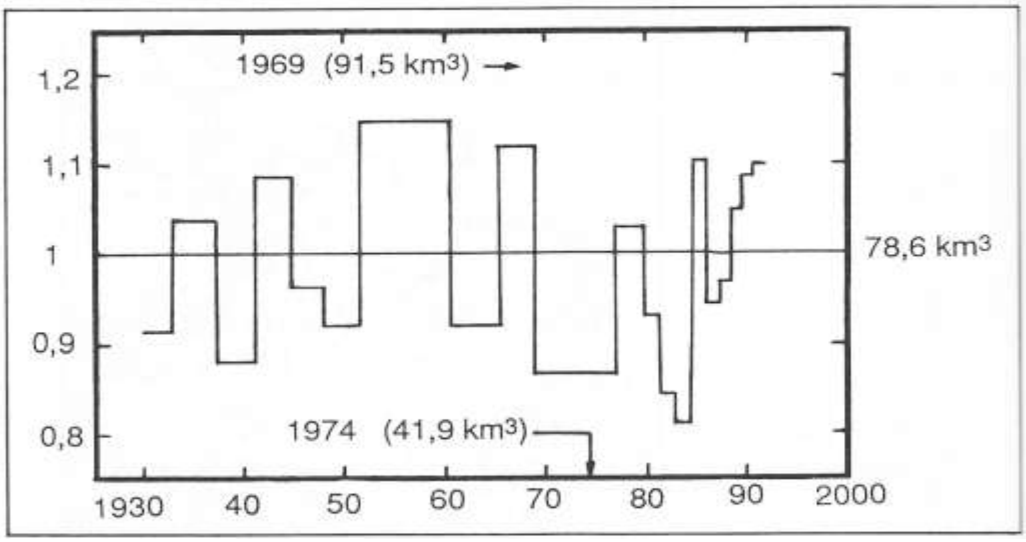


Figure 8-4: Overall water inflow into the lower Aral basin

Source: Létolle et Mainguet 1993: 50.

8.4.3 Amu Darya

The origin of the Amu Darya (which has this name only from the point of the confluence of its main tributary, the Pyanj, with Vakhsh, 1445 km upstream of the lake) is in the Pamir, in Afghanistan, close to the Chinese border, at an altitude of 4900 m asl. The total length of Pyanj-Amu Darya is 2540 km. The total catchment area is 534'739 km^2. Most of its water stems from snow and glacier melt. Two major tributaries come from Afghanistan, the Kochka (upstream from Pyanj-Vakhsh confluence) and the Kunduz (between Vakhsh and Kafirnigan), bringing about 7 to 8% of the total flow. These two rivers form extensive floodplains near the city of Termiz, which marks the end point of the mountainous section of Amu Darya. Further west, there are no other major tributaries. The Amu Darya has a highly seasonal flow pattern, as shown in the following Figure.

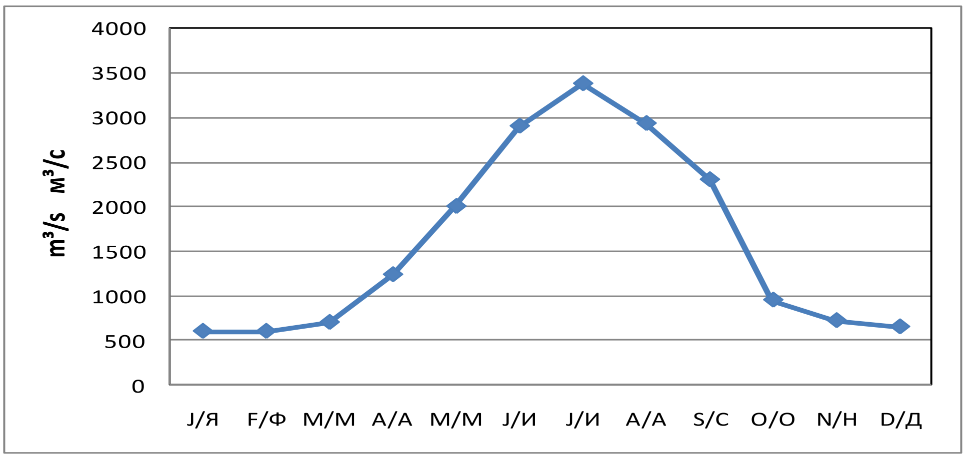


Figure 8-5: Monthly discharge of Amu Darya at Kerki (1959, 50 year average)

Source: Létolle and Mainguet (1993: 58)
Kerki is located in Turkmenistan, about 250 km downstream from the Tajik-Uzbek border.

The water of Amu Darya has high concentration of calcium carbonate, and its content in organic matter is very low, due to the low content of humus in the catchment area. Salt content has increased markedly due to drainage water from irrigated areas and waste water inflow from settlements.

8.4.4 Development in the 20th Century

After the end of World War II, and especially towards 1960, large irrigation projects were implemented in the Aral basin, along the Amu as well as the Syr Darya (see Figure 8-8).

This increased the irrigated area and agricultural productivity mainly in Uzbekistan and Turkmenistan (for the Amu Darya), but it also had the immediate effect of massively increasing water abstraction from Amu Darya, thus reducing inflow to the Aral Sea (see Figure 8-6).

The massive reduction in inflow had as consequence a very marked reduction in the total amount of water in the Aral Sea, since the losses from evaporation were no longer compensated. Thus the level of the lake decreased, (from around 53 m asl before 1960 to 42 m asl in 1985), and the surface shrunk from 65'000 km² to 45'000 km² in the same time span.

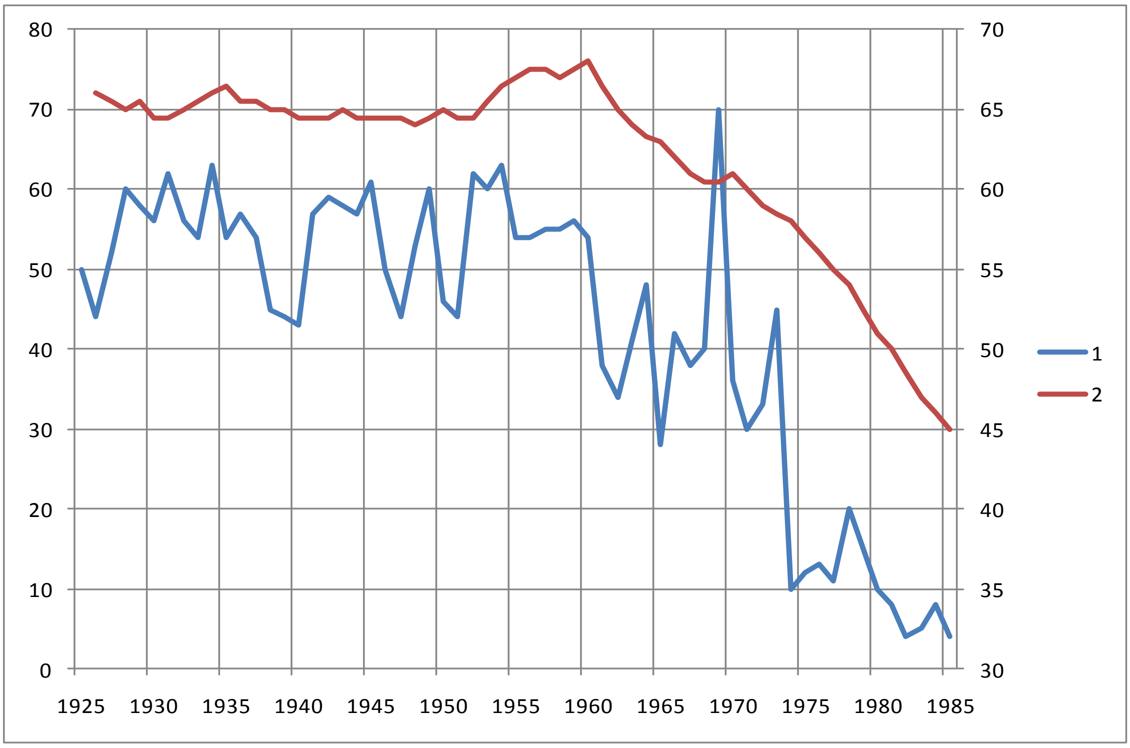


Figure 8-6: Inflow to and surface of Aral Sea

1: inflow to Aral Sea (in km³/yr, left axis)
2: surface of Aral Sea (in '000 km², right axis)
Source: Létolle and Mainguet, 1993 (p. 186)

8.4.5 Present Situation

8.4.5.1 Water Use and Water Balance

This development has continued since 1985, as can be seen in the following Figures, which show the shrinking water surface from 1960 to 2009.

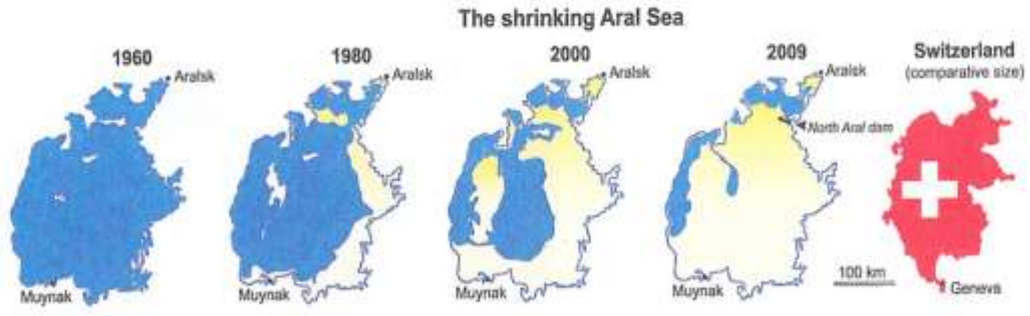


Figure 8-7: Aral Sea 1960 - 2009

Source: WWF 2010

The present situation of water use in the Amu Darya basin is shown in the following Figure.

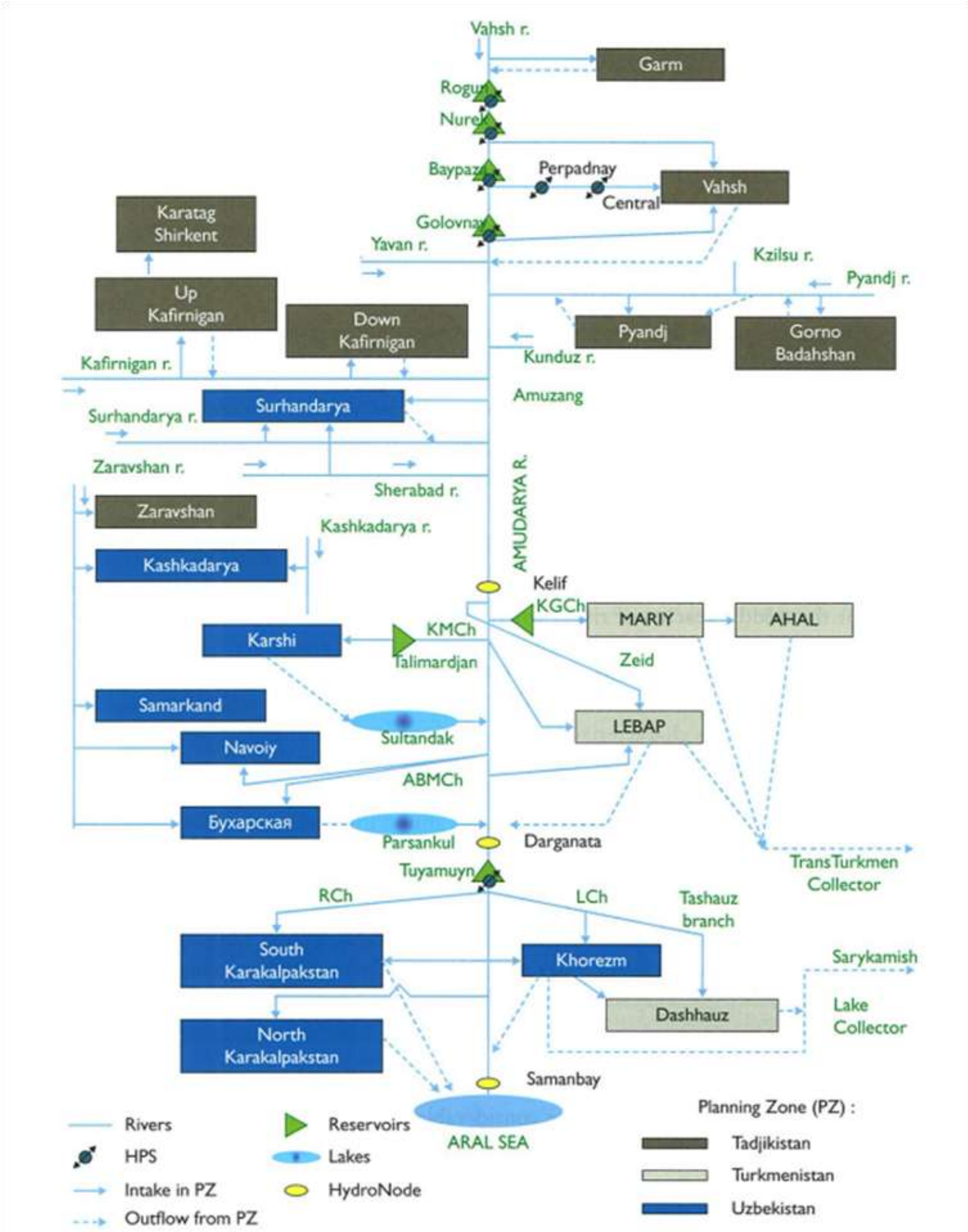


Figure 8-8: Present water use in the Amu Darya basin

Source: Dukhovny and de Schutter (2011)

A recent publication (Micklin et al. 2014) provides up to date information on the development of the Aral Sea. The following Figure indicates the development of the water balance over the last 100 years.

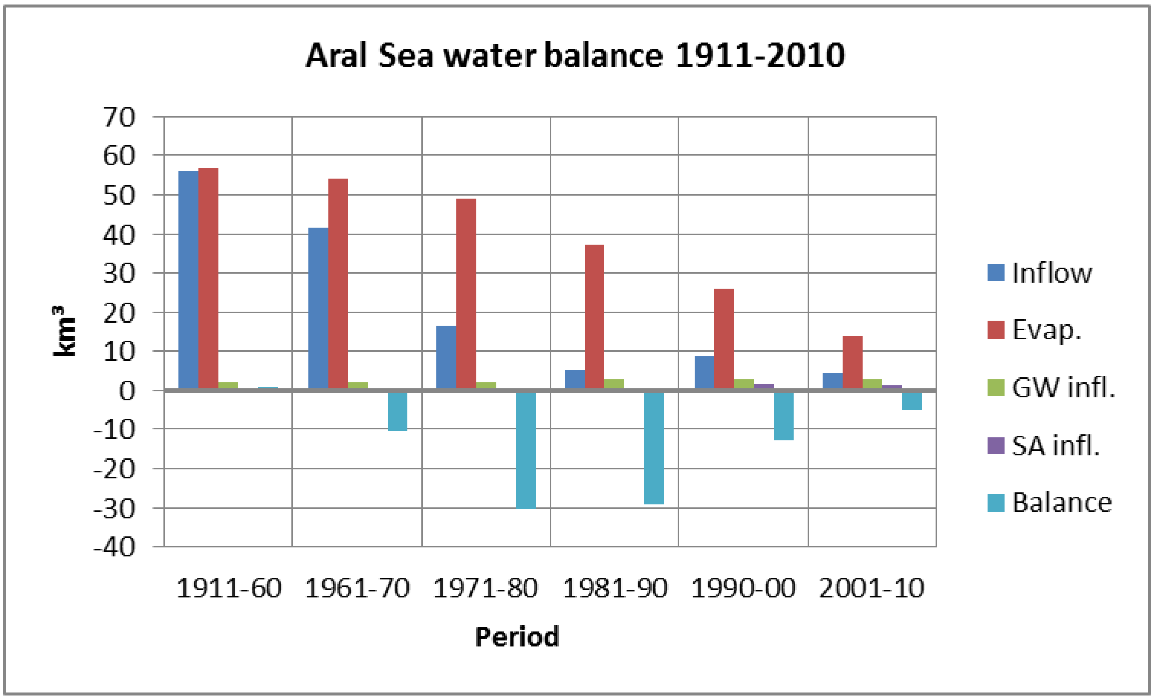


Figure 8-9: Aral Sea water balance 1911-2010

Source: Micklin et al. 2014 (Tables 5.1 and 5.2)
Explanations see text

The graph shows the following:

- **Inflow:** this is the total inflow (i.e. from Amu and Syr Darya combined). It was stable (around 56 km³/yr) for the period 1911-1960. After that, with the construction and operation of the major irrigation and diversion schemes, inflow started to drop. In recent years, annual inflow was between 0 (in dry years) and about 8 km³ (in wet years). The last two series from 1990 to 2010 are for the South Aral Sea only, since by then the northern part (Small Aral Sea) got separated from the (originally much larger) southern part.
- **Evaporation:** before 1960, there was a balance between total inflow and evaporation. Since the early 1960s, evaporation, although it also decreased in line with the shrinking surface of the sea, was always considerably larger than total inflow.
- **Groundwater (GW) inflow:** estimated at 2 to 3 km³ /yr. Lower sea level has led to a slightly larger inflow of groundwater, which however did by far not compensate the decrease of surface inflow.
- **Small Aral Sea (SA) inflow:** since the separation of the two parts, the Large Aral Sea received inflow from the northern part, the Small Aral Sea. This has decreased since the construction of the dam between the two parts. However, this inflow was (and is) too small to make any difference in the southern part.

- **Balance:** with evaporation being higher than inflow, the water balance was (and continues to be) negative.

Around 1990, northern and southern parts of the Aral Sea became separated. The northern part, the Small Aral Sea, which receives the inflows from Syr Darya, was then isolated from the southern part (Large Aral Sea) by the construction of the North Aral Dam between the two parts. This lead to a recovery of the Small Aral Sea; salinity there has dropped from around 30 g/l to pre-shrinking values of 10 g/l or less. The southern part, however, continues to shrink and salinity is rising accordingly.

8.4.5.2 Impacts on Aral Sea Biology

Before 1960, salinity of the Aral Sea was around 1% (10 g/l). With the increase in salt content due to the shrinking water volume salt content started to rise and reached approximately 3% (30g/l) in 1990. This development led to a gradual extinction of a large number of invertebrates and of most freshwater fish species in the lake, not in the least due to detrimental effects of the shrinking lake on spawning areas, but mostly due to mortality caused by increasing salinity. Natural reproduction of freshwater fish had stopped completely at a salinity of 14 g/l, which was reached in the mid-1960s. To compensate this, some marine invertebrates and fish were introduced into the lake, and some of these species developed very well, allowing even for a considerable commercial fishery as a replacement for the original freshwater fisheries (see Plotnikov et al. 2014 for details). Hypersaline conditions (i.e. salt contents of >35 g/l, the content of sea water) then led to a gradual decrease in the number of the introduced species of marine invertebrates and fishes as well. Since the late 1990s, when salinity reached 60 g/l, the Large Aral Sea is completely without fishes, and only a few crustaceans, which are adapted to conditions of such extreme salinity, survive.

8.4.5.3 Prospects for Saving the Aral Sea

As mentioned above, the Small Aral Sea has recovered since its separation from the southern part of the lake. The drop in salinity led to the re-establishment of populations of some fresh water fish which had disappeared before, and some fisheries is possible there today.

However, the situation for the "Large" Aral Sea is completely different (Micklin et al. 2014:361 ff.). To actually restore the Aral Sea to its former condition over a period of 100 years, an annual inflow of 54 km³ would be required. The following options were considered:

- Improving irrigation: the irrigation systems along the Amu Darya are highly inefficient, and losses through seepage and infiltration are very high. It would be possible to save considerable amounts of water by improving these systems, albeit at a high cost. A 1996 estimate for a complete rehabilitation all irrigation systems in the Aral basin (about 8 million ha) came up with costs of 16 to 22 billion USD, and this would save 9.2 km³ of water. At the most, and obviously at still much higher costs, it might be possible to increase inflow to the Aral Sea by up to 20 km³/yr. Even this, however, would not be sufficient for restoring the Aral Sea.
- During the Soviet period, a project was developed to transfer water from Siberian rivers to Central Asia and to the Aral Sea. This project was stopped in

the 1980s, due to its negative environmental impacts, but probably even more so due to prohibitive costs. In fact, in addition to the construction costs there would also arise very high operation costs, since this water would have to be pumped over the continental divide which has an elevation of about 120 m asl. Under this scheme, it was planned to divert 27 km³/yr to Central Asia, out of which an estimated 15 km³ might have actually reached the Aral Sea, not really sufficient to save it.

- Another more recent project envisages the transfer of water from Lake Zaysan (source of the Irtysh) in Kazakhstan to the Aral Sea. Here again, detrimental environmental impacts (lack of water in the Irtysh) and high costs (e.g. for a 100 km long tunnel to convey the water) would have to be faced. In an extreme case, directing all the outflow from the lake towards the Syr Darya, this would amount to 18 km³/yr, out of which about 12 to 13 km³ would reach the Aral Sea.

With this, there is no prospect of restoring the Large Aral Sea in the foreseeable future. Salinity is increasing, and the eastern (shallow) part could dry out completely, while the deeper western part "could turn into a lifeless water body akin to the Dead Sea" (Plotnikov and Aladin 2014: 355).

8.4.6 Water Uses in the Amu Darya Basin

8.4.6.1 Irrigation

Historical development of irrigation: Until the 1950s, irrigation water demands were relatively low and the Amu-Darya river was regularly discharging into the Aral Sea. Since the 1960s, however, the large-scale opening up of new lands through irrigation disrupted the equilibrium between the water demand of man and that required for a balanced functioning of Amu Darya and Aral Sea water. See also Micklin (2014: 207 ff) for a description of the historical development of irrigation in the Aral Sea basin.

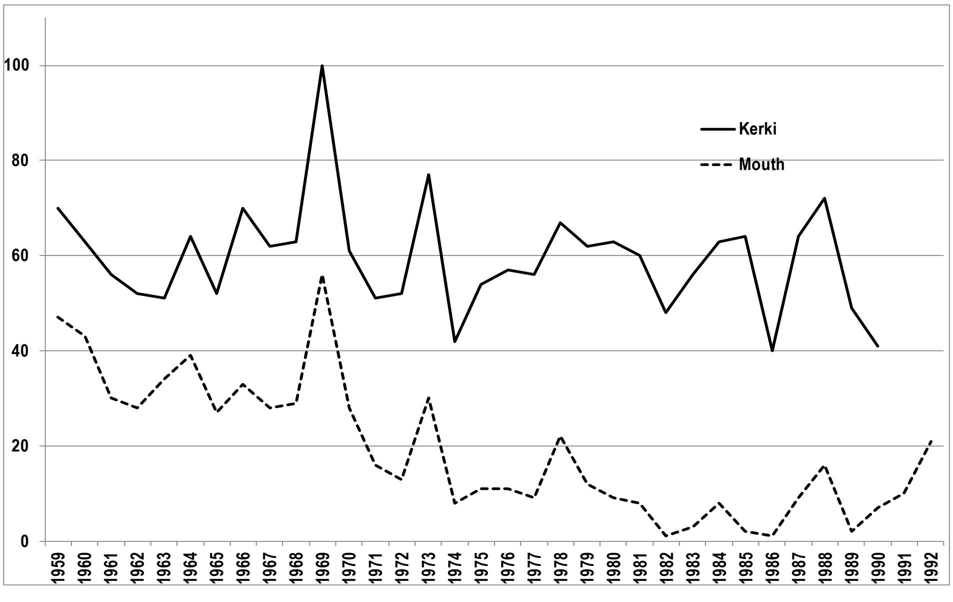


Figure 8-10: Amu Darya annual discharge in Kerki and to the Aral Sea

Source: FAO, 1995

The period between 1950 and 1990 saw huge investments in the water infrastructure of the region with the construction of reservoirs, irrigation canals, pumping stations and drainage networks to support the cultivation of cotton, wheat, fodder, fruit, vegetables and rice in the arid steppe and desert areas. In 2005-10, the area under irrigation in the Amu Darya basin exceeded on average 5 million ha (ENVSEC, 2011). The actual area under irrigation each year depends on the climatic conditions of the current year as authorities decide how much land can be put under irrigation. Uzbekistan has the largest area under large-scale irrigation followed by Turkmenistan, Tajikistan and Afghanistan.

Compared to other water uses, irrigation is by far the main source of water abstraction in the Amu Darya basin (see the example of year 1997 in the following Figure).

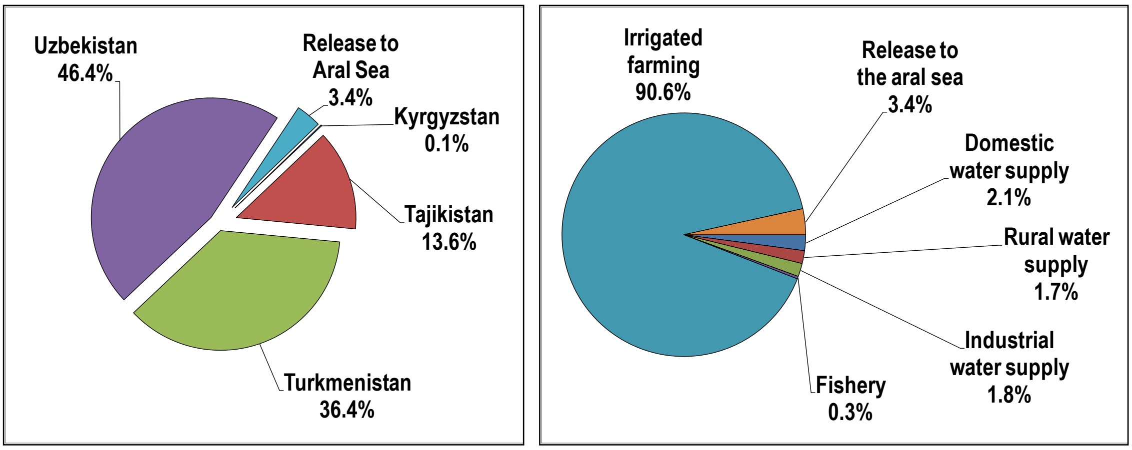


Figure 8-11: Country and sector distribution of Amu Darya water abstraction (1997)

Source: BVO

The largest irrigation canal is the Karakum Canal (Garagum Darya), the main section of which was completed in the 1960-70s to carry water from the Amu Darya at Kerki, Turkmenistan, westward to Mary, Ashgabat and ultimately to the Caspian region.

Figure 8-12: The use of water resources for irrigation in the Aral Sea basin

Source: ENVSEC, 2011

Drainage: Apart from water abstraction, irrigated agriculture implies the discharge of drainage water back to the Amu Darya from irrigated fields in the mid- and upstream reaches: about 3-4 km^3 are discharged directly into the river every year (ENVSEC, 2011). Greater amounts of drainage water are diverted into the deserts and other lands deemed unsuitable for cultivation.

Overall, drainage water constitutes 30% of the water consumption in the Amu Darya basin. Despite its significant volume, drainage waters in general do not count as a resource. A fraction of irrigation runoff is used to supplement irrigation water, especially in dry years, while much of it is discharged and lost in the desert, and a significant amount flows back into the middle and lower Amu Darya, increasing the quantity, but substantially decreasing the quality of water and making it unsuitable for drinking.

Irrigation schemes along Vakhsh river: Within Tajikistan along the Vakhsh river, there are several irrigation schemes. All irrigated lands are located downstream from Nurek HPP:

- the Dangara tunnel with a capacity of 100 m^3/s was built to irrigate the land in Dangara area (70'000 ha) through a tunnel from the Nurek reservoir;

- the Yavan tunnel with a capacity of 75 m³/s. The tunnel irrigates the land in the regions of Yavan, A. Jomi and Hurason. The water intake is connected to the Baipaza reservoir;
- the Vakhsh main canal with a capacity of 210 m³/s is used to irrigate the land in the regions of Vakhsh, Bokhtar, Jilikul, Kumasangir and Rumi.

In addition to these major systems there are also several small size irrigation systems that provide public and private farms with irrigated water; their abstraction capacity usually does not exceed 1 m^3/s (observations made on site along the Vakhsh river).

Finally, a significant part of agricultural land in southern Tajikistan is currently not irrigated because of the too poor conditions of the irrigation infrastructure. When these irrigation systems will be rehabilitated, water withdrawals from Vakhsh river will increase, whether Rogun would be built or not.

Seasonality: Most of the water abstracted for irrigation is abstracted during the vegetation period which, subject to the altitude and type of crop, extends from April to October.

As shown in the following Figure, a first consumption peak is observed in March, which corresponds to the abstraction of water for inundating artificially the fields before actually starting the cultures. "Washing" water volumes are allocated to each country by ICWC, but in practice only Uzbekistan and Turkmenistan effectively use these volumes, as these two countries face more severe problems than Tajikistan with regards to soil salinity.

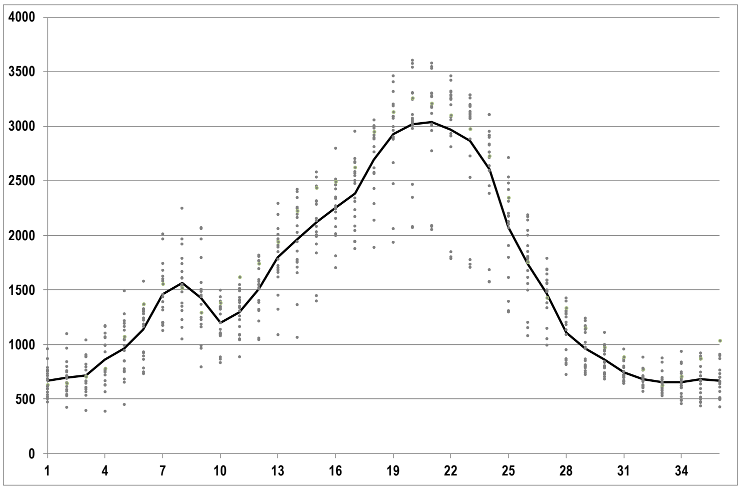


Figure 8-13: Seasonality of water abstraction (1992-2010 data per decades, m³/s)

8.4.6.2 Hydropower

The largest hydropower schemes of the Amu Darya basin are located in the Vakhsh river basin.

There are some small hydropower schemes in the Pyanj river basin (in particular the Pamir HPP near Khorog), which all work as run-of-river schemes (without regulation capacity) and therefore do not affect the seasonality of the Amu Darya flow pattern. The Kafirnigan river basin also accounts several small run-of-river hydropower schemes, notably in the Varzob river close to Dushanbe. In Uzbekistan, hydropower schemes exist in the Zeravshan and Kashkadarya basins (notably, Gissar HPP).

Table 8-3 shows the characteristics of the existing hydropower schemes along the Vakhsh river. The latest development occurred in 2011 with the commissioning of new turbine in Sangtuda 2.

Table 8-3: Characteristics of Vakhsh river cascade HPPs

HPP	Regulation capacity	Reservoir			Installed capacity, (MW(	Head, (m)
		Total volume (hm^3)	Active storage (hm^3)	Surface (km^2)		
Nurek	annual	10'500	4536.8	98	3'000	265
Baipaza	weekly/daily	97	80	8.04	600	60
Sangtuda-1	daily	258	12	9,75	670	64.4
Sangtuda-2	daily	66.5	3.53	-	220	22
Golovnaya	daily	94.5	18	7.5	210	23.3
Perepadnaya	daily	-	-	-	29.9	-
Centralnaya	daily	-	-	-	15.1	-

Nurek HPP was commissioned in 1972. It is the largest HPP, and the second largest regulation reservoir in Amu Darya river basin (after Tyuyamuyun reservoir in Uzbekistan).

Notably, Nurek is the highest dam in the world, and provides around 80% of the electricity used in Tajikistan.

Nurek is the only reservoir in upper Amu Darya basin (i.e. in Kafirnigan, Vakhsh and Pyanj basins) with an interannual regulation capacity. Other HPPs located in the upper Amu Darya basin have a maximum of a weekly (Baipaza) or daily (for peak production) regulation capacity.

Figure 8-14: Nurek reservoir from dam crest

In the lower Amu Darya, Tyuyamuyun hydro complex is the only reservoir with hydropower production capacity (the installed capacity is 150 MW).

8.4.6.3 Navigation

In the past the Amu Darya provided a major transport route into and out of the Central Asian region. In 1953, the Amu Darya was navigable on 2 000 km, from the Aral Sea to the lower reaches of Pyanj River (Annales de Géographie, 1953).

Historical data indicate that barges at least up to 500 tons were commonly used on the Amu Darya, which was the only navigable waterway for Afghanistan and Tajikistan.

During the Soviet era, long distance river travel became restricted by the construction of permanent pontoon bridges and in the 1980s by the construction of Tyuyamuyun dam.

Figure 8-15: Navigation on the Amu Darya, around the 1930s

Source: www.karakalpak.com

In addition, water abstraction for irrigation has resulted in increasing limitations to navigation possibilities, due to the decrease of water levels in the Amu Darya lower reach.

Navigation on the Amu Darya and on the Vakhsh and Pyanj rivers is nowadays limited to local activities using small size boats: local transportation, fishing, tourism, riverworks etc.

8.4.6.4 Domestic and Industrial Uses

Water abstracted or diverted from the Amu Darya basin is in majority (over 90%) used for irrigation needs, but also for domestic and industrial needs.

The volumes of water used for industrial, rural and urban needs are in the same order of magnitude: around 2% of the volumes abstracted from the Amu Darya.

8.4.6.5 Fisheries and Aquaculture

In Tajikistan and Vakhsh river: In Soviet times, fish production largely focused on pond culture. Kuybyshev, the first hatchery, was established at Vakhsh in Khatlon oblast in 1951, when the Vakhsh river changed course leaving a series of large ponds on its original watercourse. Originally covering 72 ha, the farm expanded within the space of 20 years to cover more than 200 ha and to produce 14 million larva for domestic and export purposes, after scientists introduced new herbivorous species (principally carp and bighead) into these ponds and established a small hatcheries facility in the early 1970s. In 1988, a larvae reproduction complex was constructed at Kuybyshev, with a projected capacity of 250 million units to supply all the former USSR’s needs for herbivorous stock. Fish breeding in Tajikistan reached its zenith in 1991. In that year, pond culture, which contributed 3’298 tonnes or 84% of the total fish production, was largely focused on carp and smaller quantities of freshwater bream. However, independence and the fracturing of economic links with the former Soviet bloc, caused production to decline, the main reproduction unit being destroyed during the civil war.

Figure 8-16: Kuybyshev fish ponds along Vakhsh river

Source: Google Earth

The decision was taken to privatize the facility, and the hatchery and feeding ponds passed into the hands of the joint-stock company A. Djami in 2002/2003, which has since invested in the reconstruction of the reproduction facilities. The present enterprise covers 23 ponds (varying in size from 10 ha to 43 ha) and more than 600 ha. The company sells fingerlings to pond culturists, including dekhan farms, and retails grown fish through shops in the capital of Dushanbe (FAO, 2009).

Commercial fishing was most in evidence at Kayrakkum, in the Syr Darya basin. Since 1991, however, there was a severe decline in production, as a general consequence of the deterioration of the economic and environmental situation. The country’s only trout cage-culture facility on the Nurek reservoir was destroyed during the civil war.

Along Amu Darya river course: The ecological degradation in the lower reaches of the Amu-Darya as well as the construction of dams, weirs and water diversion structures for irrigation use has resulted in a dramatic change in fish stocks of the major rivers, with sturgeon, shovelnose and Aral trout virtually disappearing from them. While formation of reservoirs provided new environment for lacustrine fish species, these had to be introduced, largely from the Far East. Pollution through agrochemical inputs has also caused a major problem. The future of the fishery in the lower Amu Darya depends much on solving the problem of the Aral Sea and its catchment. The FAO considers that only the implementation of a water resource rehabilitation programme could lead to the rehabilitation of fish stocks and fisheries.

Since November 2009 the Central Asian Republics are being supported in the rehabilitation of their fisheries and aquaculture sector by the Food and Agriculture Organization of the United Nations (FAO).

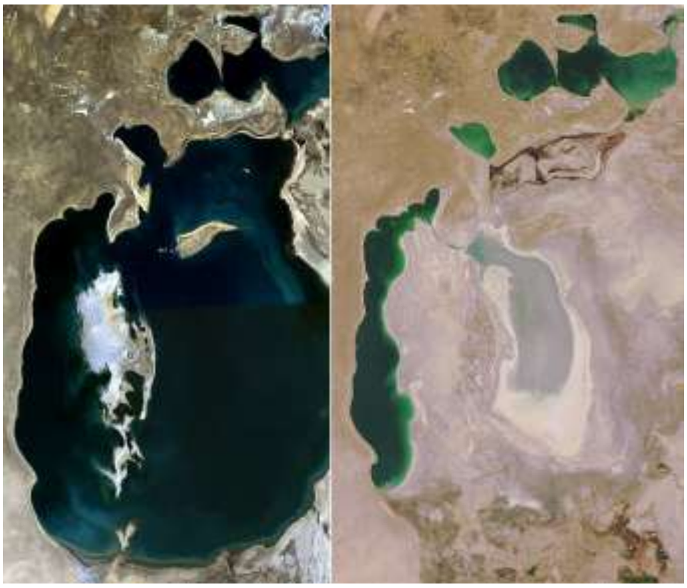


Figure 8-17: Aral Sea 1989 and 2008

Source: NASA / Wikipedia

8.4.7 Amu Darya Basin Management

There is a total of 59 reservoirs in the Amu Darya basin with a regulation capacity. They all are located downstream of Rogun projected site, or on tributaries connected to the Amu Darya downstream from Rogun.

The sum of active storage capacities of 23.4 km³ represents a third of the average annual run-off in Amu Darya river basin. The five largest reservoirs, with a regulation capacity of more than 1 km³, account for two thirds of the total regulation capacity in the Amu Darya basin (see following Figure).

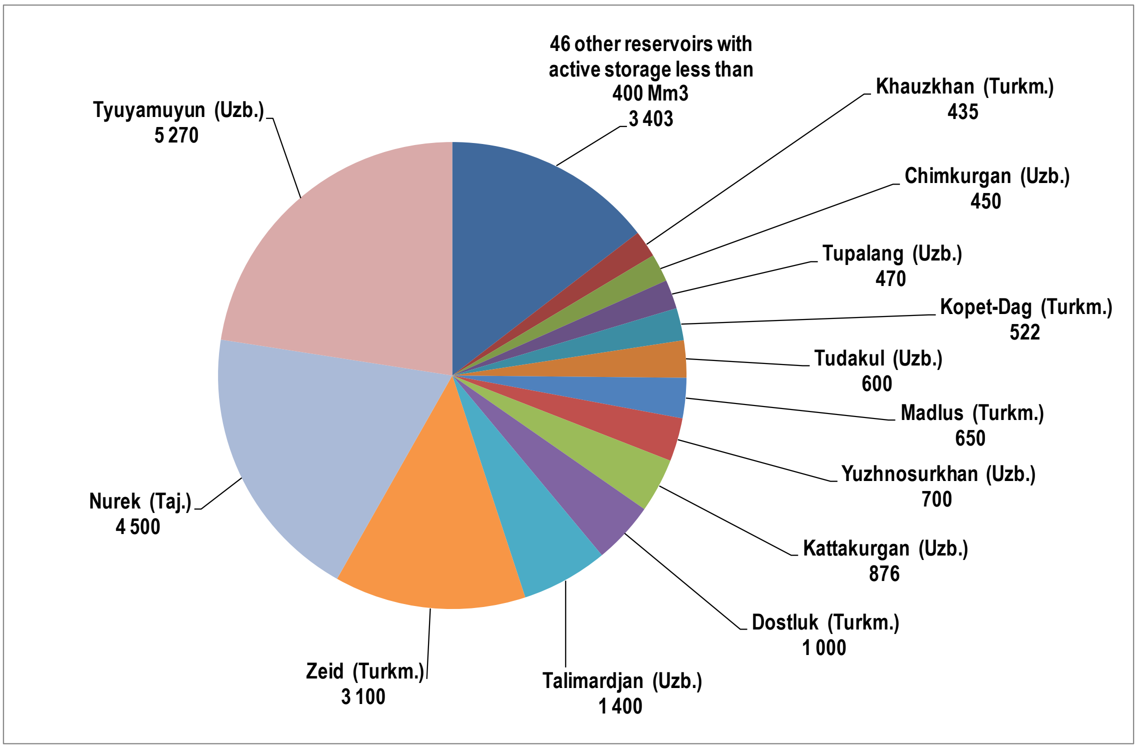


Figure 8-18: Distribution of the regulation capacity in the Amu Darya basin by reservoir

(active storage capacities in millions m³)

None of these reservoirs is located in Afghanistan or Kyrgyzstan.

Nurek is the only reservoir with a significant regulation capacity located in Tajikistan. It is also the only large reservoir predominantly used for hydropower production; most regulation reservoirs are actually used for irrigation (see following Figure).

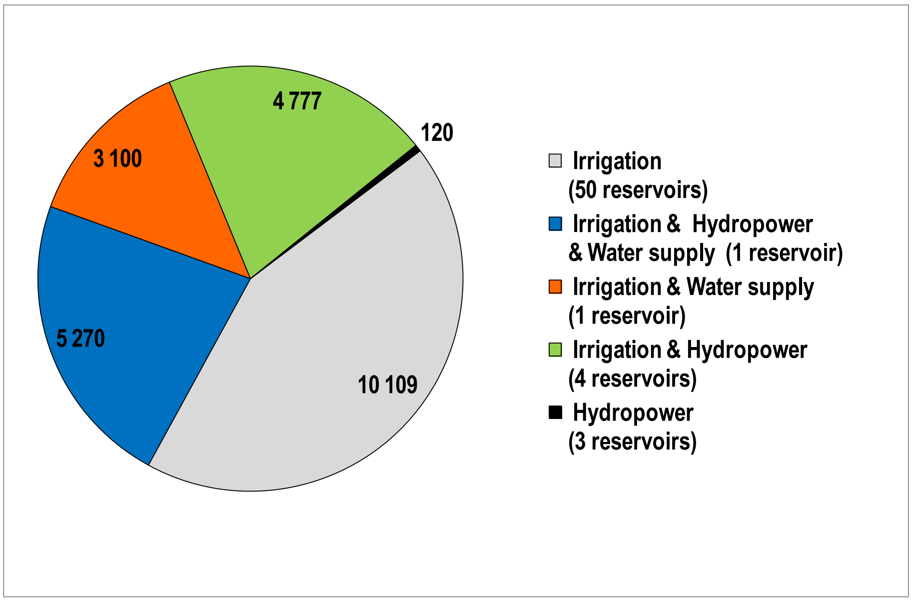


Figure 8-19: Distribution of the Amu Darya basin regulation capacity by water use

(active storage capacities in millions m3)

Nurek was built during the Soviet time and its purpose was in priority to regulate water for downstream irrigation needs, hydropower production being a second priority. Since the end of the Soviet Union, due to the lack of agreement in the energy sector with neighbouring countries, Tajikistan has been operating Nurek in priority for energy production.

The configuration of the main water regulation structures located in the Amu Darya basin is shown in the following Figure.

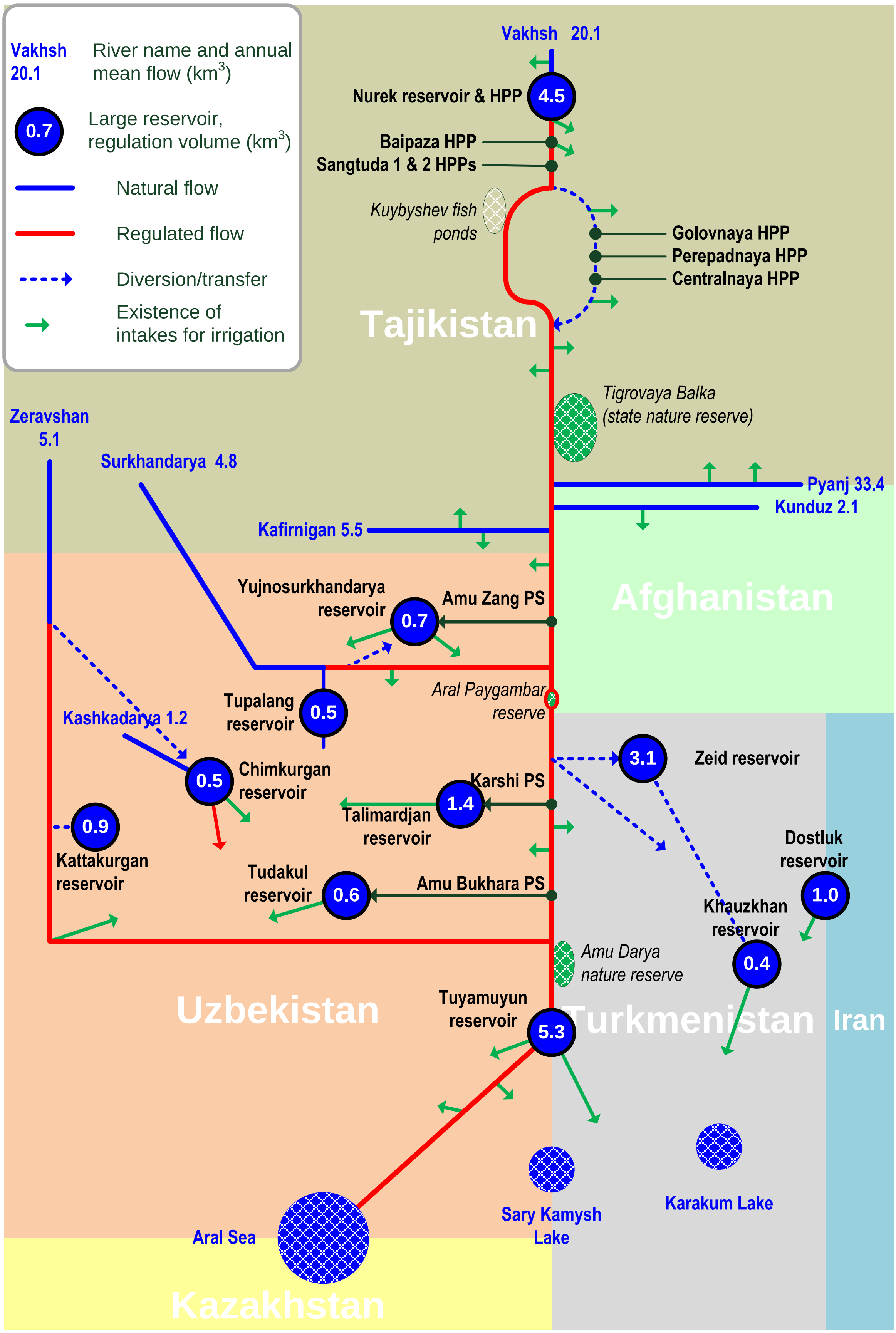


Figure 8-20: Amu Darya regulation scheme

8.5 Basin-wide Interstate Agreements

Given the lack of clarity of the present framework, the study assumes that past practices used to date adequately reflect the approach to water allocation, which establishes the rationale for the flow assumptions used for the assessment of downstream risks and impacts.

This section provides a history and the present status of agreements and practices that countries in Central Asia have used for allocating water to themselves.

Practices include biannual negotiated decisions on volumetric allocations that are accepted by ICWC. In the context of this study, these practices are assumed as the basis for future water allocations.

8.5.1 History

Up until 1987, the allocation of the Amu Darya waters among the four Central Asian republics (Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan) was based on the water development master plan for the Amu Darya basin. In 1987, two important steps were passed: first, based on an analysis of water shortages in 1974–1975, and especially in 1982, two Basin Water Organizations: BVO “Amu Darya” with headquarters in Urgench, and BVO “Syr Darya” in Tashkent were created. Secondly, a water allocation plan named "Protocol No. 566" of the Science and Technological Council of the USSR Water Management Ministry was prepared.

8.5.2 Protocol No. 566

Protocol No. 566, dated September 10, 1987, is still used today as a reference document for discussions on water allocation between the four formerly soviet countries of the Amu Darya basin: Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan. It provides an interesting background on earlier views on water management in the Amu Darya basin.

The first part of Protocol 566 provides a review of the available water resources and their planned future uses in Amu Darya basin based on the following hypothesis:

- available water resources are estimated on the basis of long term averages;
- year 1980 is used as a reference regarding the development of irrigated surfaces in Amu Darya basin, and expansions planned up to 2005 according to the five-year plans are taken into consideration;
- the protocol addresses water sharing principles between the Soviet Union countries, assuming Afghanistan would abstract 2.1 km^3/yr;
- the protocol included a scheme of water saving and protection measures, aimed at optimizing the use of water resources. This included among others:
    - o improving long term regulation by adding Rogun and Zeid reservoirs to the system;;
    - o improving existing irrigation systems whose "current efficiency is considerably lower than accepted" to reach an average weighed irrigation efficiency of 75% ;
    - o regulation of drainage water release to the Amu Darya, so that Amu Darya salinity does not exceed 1000 g/m^3;

- several measures to reduce the impact of sanitary water, domestic and industrial wastewater, livestock effluents and pesticides on surface water resources.

Protocol 566 states that, if the plan was to be followed, the total irrigated surfaces in the Soviet part of Amu Darya basin could extend up to 4'831'000 hectares, which is almost 1'700'000 hectares more than in 1980.

The second part of Protocol 566 provides a resolution ("решение") on the actions to be undertaken for the future management of Amu Darya basin water resources. This resolution establishes the future allocation of water resources in Amu Darya basin, once the basin is fully developed (i.e. after the construction of Zeid and Rogun reservoirs):

Table 8-4: Long term water allocations as per Protocol 566

	km³	%
Uzbekistan	29.6	48.2%
Tajikistan	9.5	15.4%
Kyrgyzstan	0.4	0.6%
Turkmenistan	22.0	35.8%
Total	61.5	100%
Downstream of Kerchi:		
Uzbekistan	22	50%
Turkmenistan	22	50%

This Table gives rise to the following two important comments:

- The key assumption behind the figures in this Table is the construction of Rogun and Zeid reservoirs (Zeid was built in the meantime), and the coordinated operation of Amu Darya basin water infrastructures in order to guarantee the availability of 61.5 km^3 of water every year (without Rogun and Zeid, i.e. with only Nurek and Tyuyamuyun reservoirs as major regulating structures) the guaranteed volume was 54.6 km^3).
- The protocol does not give any information on the way these water allocations shall be split in time (during the year) or in space (by sub-basin). More generally, the Protocol is a document that defines objectives but does not provide any tool for the achievement of these objectives.

It is interesting to note, however, that Protocol 566 points out the inefficiency of the existing irrigation schemes, whose efficiency is "lower than accepted" and stresses the need for improving them with the overall aim of improving water resources management.

8.5.3 Agreements Reached After Independence

8.5.3.1 October 12, 1991 Declaration

When the republics in the region gained their independence as new nations, it became necessary to set up a mechanism for regional cooperation in the organization of water resource management. In a meeting held in Tashkent, on 12 October 1991 the Ministers in charge of water resources of the new independent states in their Statement of Heads of Water Economy Organizations of Central Asian Republics and Kazakhstan jointly declared they would continue cooperating in a mutual interest for the management and allocation of Aral Sea water resources. Despite what is stated in several documents, the statement signed on by these Ministers does not refer to the use of the earlier Soviet principles of water allocation (in particular, it does not refer to Protocol 566).

8.5.3.2 February 18, 1992 Agreement

An interstate agreement "On Cooperation in the Field of Joint Water Resources Management and Conservation of Interstate Sources" was signed on 18 February 1992 in Alma-Ata to reflect this commitment.

The most relevant points of this agreement are listed and commented shortly in the following Table.

Table 8-5: Relevant points of February 18, 1992, Alma-Ata agreement

Art.	Statements	Comment
2	Obligation to observe agreed order.	Although Protocol 566 is not explicitly mentioned, this can be interpreted as a reference to it.
3	Obligation to prevent activities which can cause damage to other parties, lead to deviation from agreed values of water discharge.	The term "agreed values" is not specified more precisely, but in the context of water use the agreed values were those of Protocol 566 and the water allocation by BVO.
4	Special separate decisions to be taken in extremely dry years for water supply to regions with acute water deficiency.	
6	Decisions to be taken on just use of production potential of water economy.	Production potential is not specified further, but energy production is certainly one of the potentials, in addition to agricultural production.
7	Decision to establish the Interstate Commission for Water Management Coordination ICWC	Organisation presently in charge of water allocation.
8	ICWC will elaborate and decide annual water use limits for each country, operation schedules for reservoirs, depending on water availability.	
9	ICWC shall specify the basin water management associations “Syrdarya” and “Amudarya”	Refers to the two BVOs, which carry out the determination of yearly water allocations to the member states.
11	Decisions adopted by ICWC on limits for water withdrawal are binding for all water users and consumers.	No reference is made to any means of sanctioning in case of non-compliance. However, all the member states have taken this commitment.

8.5.3.3 The Nukus Declaration of September 20 1995

In a meeting in held in Nukus, Uzbekistan, the states signed the so-called Nukus Declaration, which defined the policy to be taken for the Aral Sea. The main points of this declaration were (IFAS 2008; Edelstein et al. 2012: 276):

1. Recognition of the importance of water, soil and biological resources as the basis for regional economic development.

2. Need to change current agriculture and forest management practices into more balanced and scientifically based systems.
3. Urgency to change the efficiency of irrigation systems through wise water usage and support conservation of nature in the region.
4. Supports the long-term land and water resources use by local farmers.
5. Supports initiatives for the improvement of living conditions and health in the region.

The Nukus Declaration does not specifically address water allocation to and distribution among the riparian countries, and it does not refer to Protocol 566 or any other agreement on water resources. It also does not mention the use of water resources for hydropower. However, it contains the following statement: " We agree that the Central Asian States recognise previously signed and existing agreements, contracts and other legal acts regulating the relationship between them on water resources in the Aral basin…".

Two points of importance in the context of water resources management are made in this declaration, namely:

1. The need to improve agriculture and irrigation systems in order to reach "wise" water usage; in a situation of chronic water shortage, inefficient water distribution and irrigation systems, where a very considerable amount of water is lost due to seepage and infiltration, does certainly not qualify as "wise usage". An estimate of the (very considerable) potential for reducing water losses through improvement of agriculture and irrigation systems is provided by Jalilov (2010, 2011).
2. Improvement of living conditions in the region certainly also includes electricity supply, although this is not specifically mentioned.

8.5.3.4 Other Agreements

On March 26, 1993, the five states of Central Asia signed a new agreement that affirmed the commitment of these states to cooperate in the management of the basin's water resources. The agreement established regional institutions charged with comprehensive water management, including Interstate Council on the Aral Sea Problems (ICAS), a high level body charged to recommend actions to the five governments in the name of the basin as a whole and the International Fund for the Aral Sea (IFAS), a high level body charged with financing the activities of ICAS.

Following a Heads of State meeting in February 1997, ICAS and IFAS were merged into a newly structured IFAS – International Fund for Saving the Aral Sea. As a result, the political decisions related to water and environmental sectors in the region are being taken on the level of the Board of IFAS, which consists of the Deputy Prime Ministers of the five states. This is the highest political level of decision-making before approval by the heads of state (if appropriate). The most important issues can be decided only at the meetings of the heads of states followed by their recommendations/approval for IFAS. IFAS Executive Committee was established as a permanent body that included two representatives from each state and implements the IFAS Board decisions through the IFAS National Branches. ICWC is institutionally integrated under IFAS.

In 1994, the Heads of States adopted the Aral Sea Basin Program that was designed to be administered by the new regional institutions. The Program aimed at preparing a general strategy for water distribution, rational water use, and protection of water resources in the Aral Sea basin. Following the establishment of the Program, the Heads of States have met at least once a year during the next 6 years to further develop, approve and express support to the Program. In 1999, the Heads of States adopted the Ashgabat Declaration where they stressed their support for joint actions to address shared environmental problems in the basin and promote better quality of life for people living in the Aral Sea basin. At the summit of the Head of States in 2002 in Dushanbe, Main Directions of a program of specific measures aimed to improve the socio-economic and ecological situation in the region for the period until 2010, were adopted.

8.5.4 Problems in Water Allocation

A good description of the problems encountered in water allocation is provided by Mr. Y. Khudaiberganov, former director of BVO Amu Darya (Khudaiberganov 2007: 40), who states the following:

"Under conditions of normal water availability in the basin, there are no particular problems in managing and allocating surface waters. In low-water periods, however, water management is complicated. This is especially so in extreme cases, where, despite double control by BVO and ICWC, decisions made by ICWC on the reduction of water withdrawal limits, and held as obligatory for all water consumers, are not always observed. This is caused by a number of factors, such as an imperfect legal and regulatory base for ICWC's executive organisations, differences in national interests regarding water use, and poor equipping of BVO organisations with water meters and monitoring facilities. As a result, decisions made by ICWC have not always been implemented in accordance with set volumes and time limits.

Some problems emerged under extreme low-water conditions in 2000-2001 and the beginning of 2002 that are deserving special attention:

1. Inequity of water resources use along the river arising when upstream water users divert more water than downstream users.
2. Increase of non-productive losses on all river reaches.
3. Breach of water discipline by water users, especially relating to intake by pumping stations.
4. Interference of local authorities in day-to-date (sic!) water control."

Not surprisingly, in a situation of such an extremely dry year this leads to a situation described as follows (Khudaiberganov 2007: 42): "Despite these measures, however, we failed to avoid the negative consequences of water shortage in the region as a whole. As a result, **downstream water users have suffered most of all**" (emphasis added). It is important to point out that in this description of the situation, "downstream water users" does not refer to downstream riparian countries, but to the situation in Turkmenistan and especially in Uzbekistan. According to the same source, in case of water shortage allocation of water to the different users, i.e. different regions, within one country is made by ICWC in proportion to the available amount of water. However, what is then often observed it that more water than allocated is abstracted in the upstream parts of the system, leaving the lower parts in a situation with further aggravated water shortage.

8.6 Present Water Allocation in Amu Darya Basin

Water allocation shares are calculated annually by BVO Amu Darya. In the absence of written publicly available rules, the principles for the calculation of water allocations were explained to the ESIA Consultant by the Ministry of Water Resources of Tajikistan. These principles are described and commented hereafter:

Table 8-6: Principles of water allocation by BVO

Water allocation calculation steps	Comment
1. At the end of the winter and before the beginning of the vegetation period, the volumes of snow in the mountains are estimated, based on data provided by the national meteorological services.	1.1 There are agreements in place between the former Soviet states for the exchange of snow and meteorological data. 1.2 Afghanistan not being part of the ICWC, no information on snow stocks in Afghanistan is received, while Afghanistan contributes almost 7-8% of the Amu Darya river flow.
2. The volumes of water stored in the regulation reservoirs are collected and together with data on snow stocks, provide an estimate of the volumes of water potentially available for the vegetation period.	2.1 The estimation of snow stock is difficult; therefore the estimation of the volume of water that would result from snow melting is subject to significant uncertainties.
3. The national representations of Amu Darya BVO calculate their estimated water needs and send their requests (by ten-day periods) to the central office of Amu Darya BVO in Uzbekistan.	
4. Water allocations are calculated for each country by the central office of Amu Darya BVO and the final water allocations are agreed between the representatives of each country before being officially approved.	4.1 The Tajik Ministry in charge of water resources indicates that this allocation is made on the basis of the surfaces dedicated to irrigated agriculture. No written document that would explain the methodology for calculating water allocations is available; yet, the quotas allocated to the four countries have been rather steady (in percentage) over the last twenty years, which presumably means that there is a standard approach used to calculate the annual water share of each country. 4.2 The allocated volumes and percentages do not correspond to those mentioned in Protocol 566 (see Table 8-4). There is a set of possible reasons for the observed differences, which include (i) differences in definition of the Amu Darya basin (for example with or without Zeravshan River), (ii) surfaces of irrigated land used as a reference for the calculations. 4.3 BVO Amu Darya defines limits for water use (=allocated water share) by each country, which correspond to volumes abstracted minus return flows such as drainage water. BVO Amu Darya does not define any limit or requirement in terms of water regulation or water quality.
5. Adjustment of water allocations: two to four times per year, additional meetings are organized between the national representatives of Amu Darya BVO in order to adjust the volumes allocated to each country.	5.1 These adjustments are necessary because of the uncertainties on the initial estimate of snow/water stocks.

Table 8-7: Water allocation by country (1992-2010) compared to Protocol 566

Allocation by BVO Amu Darya	Tajikistan	Kirgizstan	Uzbekistan	Turkmenistan	Total
Average allocated	8.845 km^3	0.216 km^3	21.378 km^3	20.960 km^3	51.400 km^3
Protocol 566	9.500 km^3	0.400 km^3	29.600 km^3	22.000 km^3	61.500 km^3

Source: ICWC website, data for vegetation and non-vegetation period
Allocation in terms ofaverage 1992-2010

As can be seen from the following figure, the volume of water totally allocated to the four countries member of ICWC seems to be calculated as a percentage of the forecasted total flow of the Amu Darya; ICWC could not be met to confirm this assumption. The volume allocated to each member country is then calculated as a share of the total allocation. This share has appeared to be rather steady over the last years (see Figure 8-22). Overall, these two figures show that there is a mechanism in place to allocate water between the member countries of the Amu Darya basin. This mechanism is different from the one that was proposed by Protocol 566 (see Table 8-4) and its rationale (algorithm, formulae) is not publicly released.

Figure 8-21 also shows the actual flow in the Amu Darya basin, which in some years is significantly different from the forecasted flow. Two situations can be distinguished:

- if the actual flow in the Amu Darya exceeds the volume of water totally allocated to the member countries, each country can take its share and the Aral Sea gets the remaining;
- if the actual flow in the Amu Darya is less than the volume of water totally allocated to the member countries, adjustments to the allocated volumes are done during the year to re-evaluate the respective share of each country.

Over the period 2000-2010, ICWC has generally more often over-forecasted that under-forecasted water availability (see Table 21-3).

Figure 8-21: Amu Darya forecasted, allocated and actual flows from 1992 to 2010

Source: ICWC website

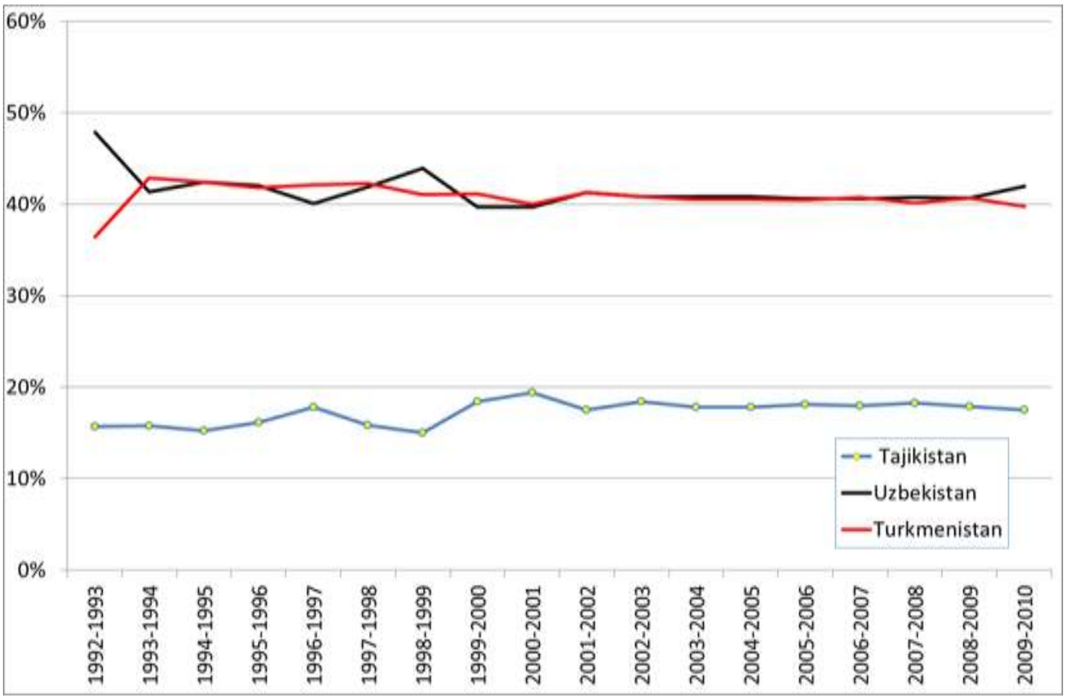


Figure 8-22: Relative water allocation to Tajikistan, Uzbekistan and Turkmenistan from 1992 to 2010

Source: ICWC website

Actual use of allocated volumes in Amu Darya basin: in average over the period 1992-2010, Tajikistan has been using around 83% of the volumes that were allocated to it and has never exceeded its water share (see Table 8-8). Uzbekistan and Turkmenistan have occasionally exceeded their water share, in particular during years when the volumes of water actually available appeared to be significantly less than those forecasted at the beginning of the vegetation period. Conversely, all countries have systematically used less than their water share during years when water availability largely exceeded the forecasts. The Aral Sea generally serves as a buffer, which receives less (resp. more) water than planned during years dryer (resp. wetter) than expected: this is reflected by the large differences between water actually received by the Aral Sea (from 7.6 times less to 4.9 times more than forecasted).

Table 8-8: Actual use of allocated water volumes (1992-2010)

	Tajikistan	Kyrgyzstan	Uzbekistan	Turkmenistan	Aral Sea release
Minimum	67.6%	1.8%	68.3%	74.8%	13.1%
Average	82.8%	51.9%	94.7%	92.9%	140.2%
Maximum	91.4%	100.0%	105.8%	101.4%	488.2%

Source: BVO

Figure 8-23 shows how the difference between allocated volumes ("limit") and used volumes ("fact") splits in time. It shows that, in average:

- all countries use less water than allocated during the end of springtime and summer periods;
- Turkmenistan and Uzbekistan tend to use more water than allocated during part of the autumn period;
- Turkmenistan and Uzbekistan use the water allocated for washing the fields before the vegetation period (ten-day periods 4 to 10), while Tajikistan does not.

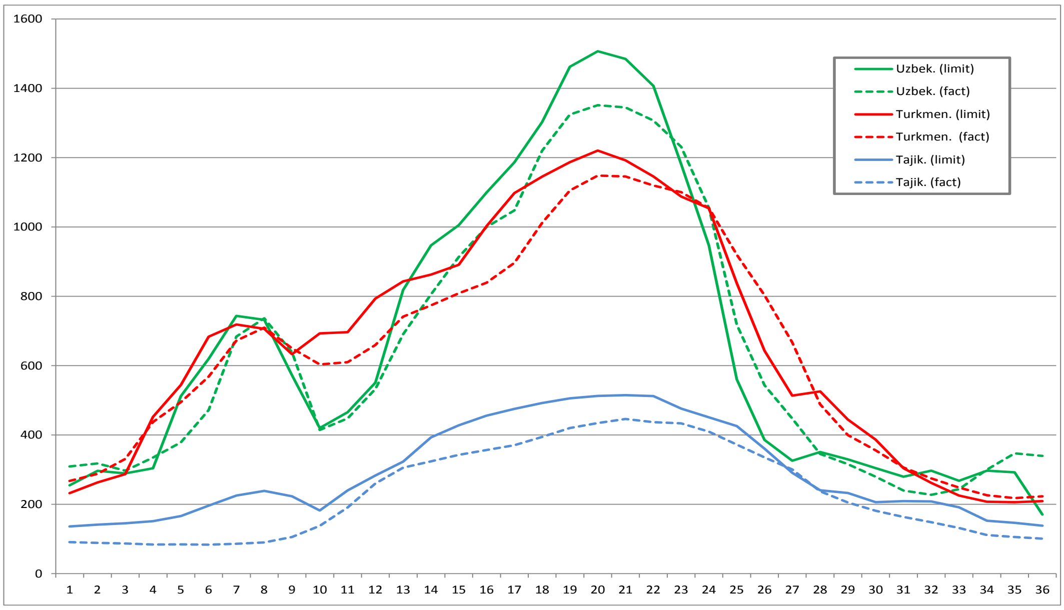


Figure 8-23: Allocated and abstracted volumes (average per 10 day period, 1992-2010)

Source: BVO

Figure 8-24 below shows that from 2000 to 2010 the unused water share of Tajikistan has been lower than the volume of water released to the Aral Sea in 9 years out of 10. In 2001, actual flows in the Amu Darya basin were 30% lower than forecasted (35.1 km^3 instead of 49.9 km^3) and 2001 ended up being the driest year at the basin level over the 2000-2010 period. Only in 2001 the volume of allocated water not used by Tajikistan exceeded the volume of water that reached the Aral Sea, which means that the water share not used by Tajikistan was partially used by one of the downstream countries.

Over the period from 1992 to 2010, the average unused water share of Tajikistan represents 1.57 km^3, which splits into 0.92 km^3 during the vegetation period and 0.65 km^3 during the non-vegetation period.

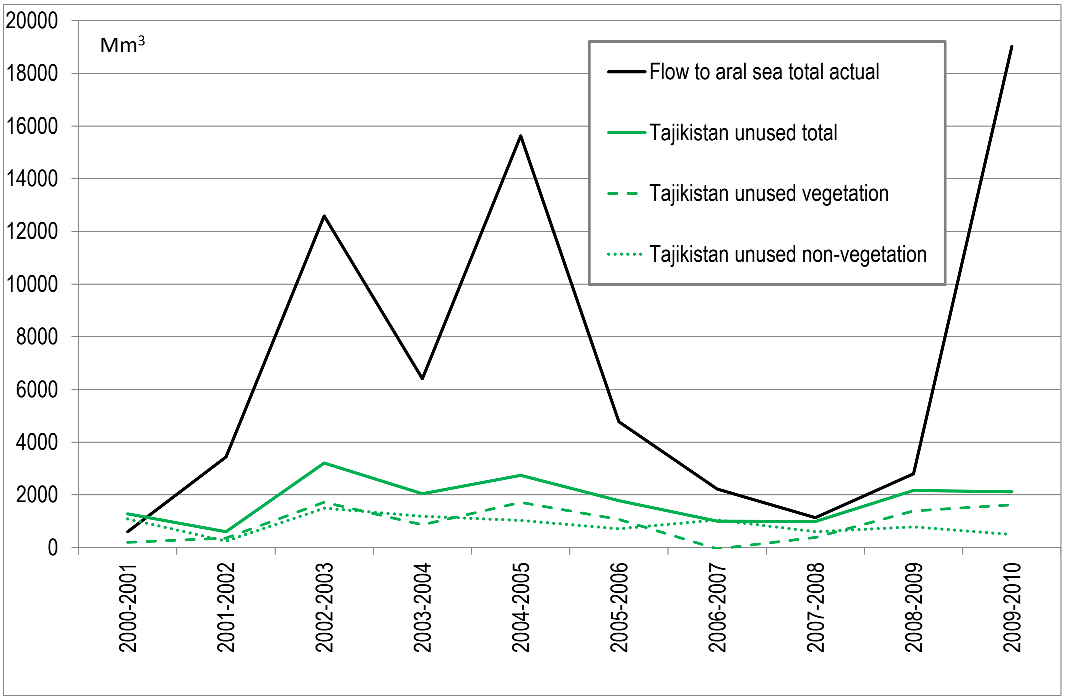


Figure 8-24: Comparison of flows to Aral Sea and Tajikistan unused water share

Source: ICWC website

8.7 Current Status of Interstate Cooperation

During the past decade there has been progress in the development of the interstate regional cooperation in the Aral Sea Basin as multiple agreements and conventions were signed and institutions established. However, the legal basis for the interstate cooperation between the Central Asian states is still in the development process.

In order to achieve genuine interstate cooperation in the Aral Sea Basin, and subsequently in the Amu Darya basin, there is still a number of developments to be done and issues to be addressed:

- **Afghanistan** accounts for 15% of Amu Darya basin and contributes 7 to 8% of its flow, but has so far remained essentially excluded from the Amu Darya management structures. One of the challenges for fostering cooperation within the Amu Darya basin is the inclusion of Afghanistan, as the total area of irrigated land in Northern Afghanistan is approximately 1.2 million hectares of which 385'000 hectares are on and along rivers with permanent flow to the Amu Darya.

- **Water quality:** unlike the agreements regulating water quantities, there are no legally binding provisions on water quality in a cross border context (however, all Central Asian countries of the CIS have national regulations on water quality).
- **Amu Darya basin management costs:** there is no interstate agreement for the Amu Darya basin that addresses responsibilities and cost sharing of operations, maintenance, rehabilitation and modernization of the regulation infrastructure.
- **Information system:** there is no interstate agreement for an Amu Darya basin common and reliable water monitoring system that would allow monitoring, managing and controlling river flows and water uses.
- **Environmental needs:** the existing regulations do not enforce the preservation of environmental flows in the Vakhsh and Amu Darya rivers, which creates a threat for the natural reserves located along the water courses, and results in chaotic release of water to the Aral Sea which is used like a buffer.
- **Water / Energy** interdependencies existed during the Soviet period, when water and energy were exchanged freely on a mutual interest basis; this is not done any longer.

8.8 Hydrology: River Discharge Downstream of the Dam

8.8.1 Hydrological Monitoring

8.8.1.1 Vakhsh River

The hydrology of the Vakhsh river basin is rather well documented:

- the earliest monitoring started in Nurobod in 1933;
- the monitoring of the water regime of the river was intensified in the Soviet time in connection with the planned construction of the Nurek HPP;
- since the 1990s, hydrological monitoring was completely or partially stopped. This affects the volume of hydrological data available for the last 20 years.

The main hydrological stations of Vakhsh river are listed in the Table below:

Table 8-9: Main hydrological stations of Vakhsh river basin

Station	Distance from confluence with Pyanj (km)	Catchment area (km^2)	Period of record for flow
Garm (Nurobod)	416	20'000	1933-92
Komsomolobod (Darband)	373	29'500	1949 - 1957, 1976 - 1997, 2000 - 2010
Nurek HPP			inflows and outflows since the start of operation
Sariguzar	249	31'400	1967 - 1990
Golovnaya HPP	171	32'200	1966 - 2010
Tigrovaya balka	58	36'200	1960 - 1962, 1983 - 1990, 2011

Darband is the closest historical hydrological station to the Rogun site. Darband station was visited within the framework of the site visits. The station should be upgraded and the water velocity meter calibrated regularly.

Figure 8-25: Darband hydrological station

8.8.1.2 Amu Darya

Apart from the Vakhsh sub-basin, the Amu Darya river runoff has also been monitored at several points. The most interesting hydrological stations for the Project are those located on the lower Pyanj river (the former Nyijni Pyanj is no more monitored; Tajikistan is preparing a joint project with Afghanistan for a new hydrological station), and on the Amu Darya itself (Termez, Kelif, Kerki and Samanbay are the most commonly mentioned stations).

Table 8-10: Key hydrological monitoring stations

Stations	Hydrology		Water quality monitoring
	parameters	years available	parameters & frequency
Garm (Nurobod), #46	flow, level, temperature, ice daily	1933-92	muddiness, sediment discharge, sediments grain size
Vakhsh (Darband), #47	flow, level, temperature, ice daily	1949-57;76-97;2000-2010	muddiness, sediment discharge, sediments grain size
Vakhsh (Tutkaul & / Sariguzar), #62	flow, level, temperature daily	1967 - 1992	muddiness, sediment discharge, sediments grain size
Vakhsh (Golovnaya HPP), #63	flow, level daily	1966 - 2010	-
Vakhsh (Tigrovaya Balka)	flow, level daily	1960-62, 83-90, 2011	muddiness, sediment discharge, sediments grain size
Pyanj (Nyijni pyanj), #9	flow, level daily	1965-67, 69-72, 76-90	muddiness, sediment discharge, sediments grain size
Amu Darya (Termez)	flow, level, temperature daily	1933-92	-
Amu Darya (Samanbay)	flow, level daily		

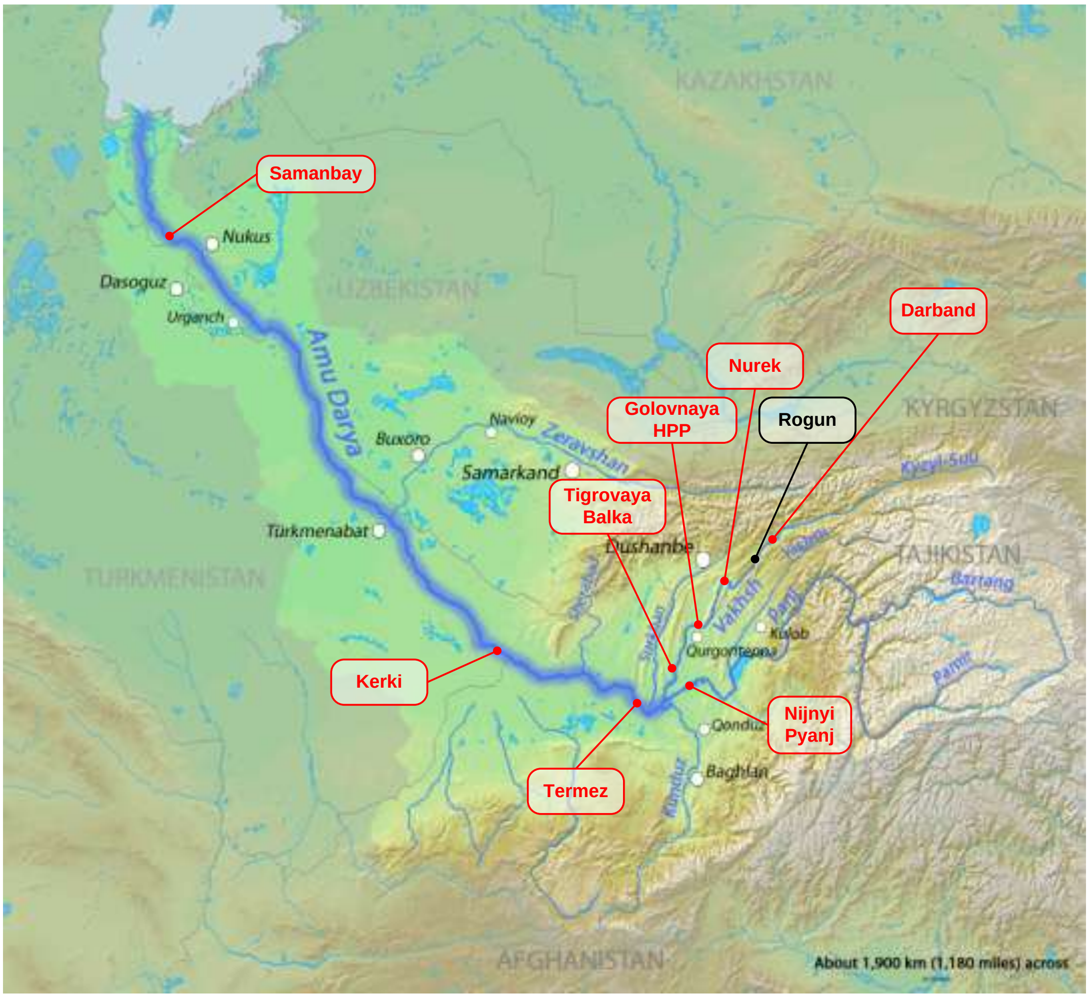


Figure 8-26: Key hydrological monitoring stations in Amu Darya basin

8.8.2 Amu Darya Basin Natural Regime

Precipitations in the Amu Darya basin vary mainly according to topography. Mid-latitude westerlies are the main source of precipitation in the river basin. Figure 8-27 shows the distribution of rainfall in Tajikistan (Source: Atlas of Tajikistan).

Precipitation falls mainly as snow during winter and helps feed the glaciers and snow stocks in the source areas of the Amu Darya. As a consequence, the natural hydrological regime of the Amu Darya is essentially driven by snow melting processes during spring and summer.

Figure 8-28 shows the hydrograph of Amu Darya at Chatly hydrological station (close to the Aral Sea) in the 1930's, i.e. before major agriculture or hydropower schemes were developed in the Amu Darya basin. This natural hydrograph can be compared on the figure to the actual releases of water (average over the last ten years, based on BVO data). Figure 8-28 also shows the natural hydrograph of Vakhsh river upstream (Darband) and downstream of Nurek (Tigrovaya Balka); the influence of Nurek HPP operation on Vakhsh river downstream regime appears when comparing these two hydrographs, with higher winter flows and lower summer flows downstream.

These hydrographs finally show that most of the flow of the Amu Darya occurs from May to September, in relation to snow melting.

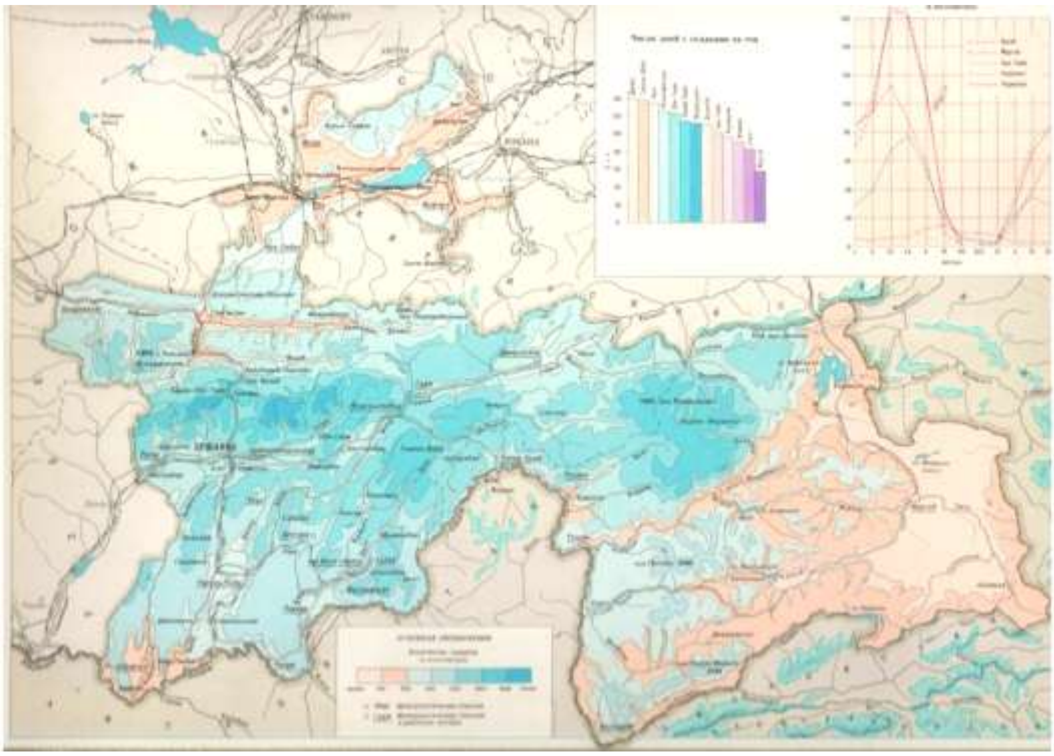


Figure 8-27: Distribution of rainfall in Tajikistan

Source: Atlas of Tajikistan

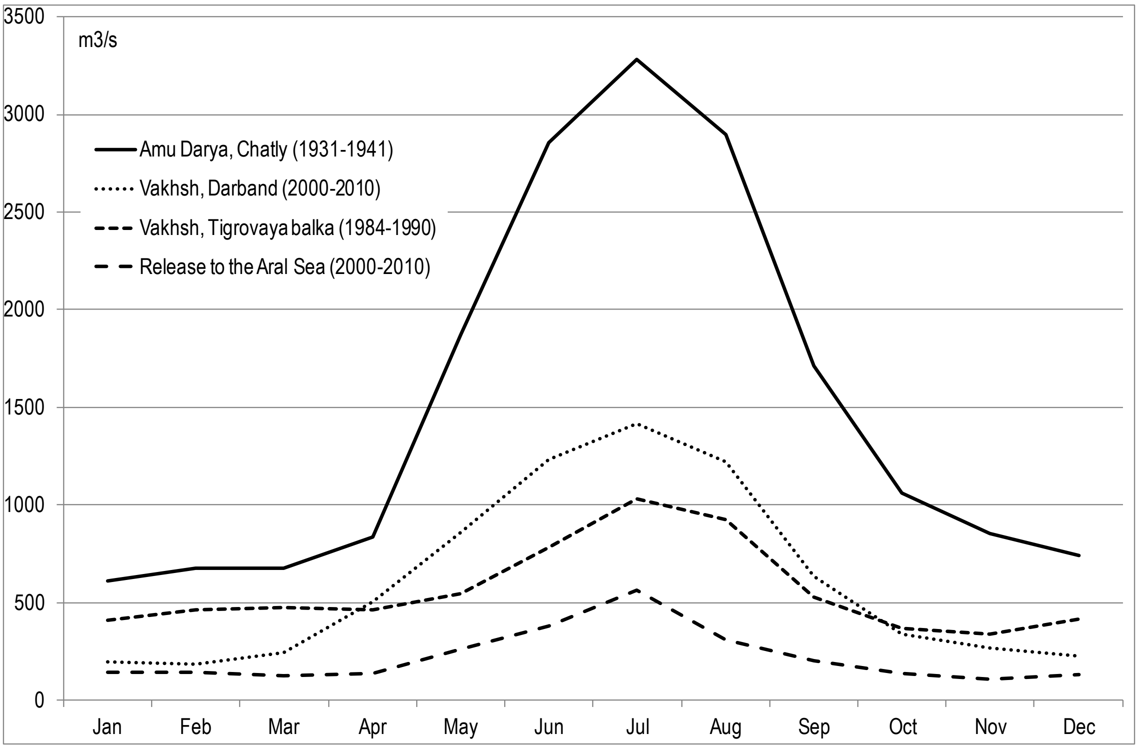


Figure 8-28: Mean natural hydrographs of Vakhsh and Amu Darya rivers

Note: Different periods shown for the different stations

Table 8-11: Amu Darya basin and sub-basins hydrological regime

Station	**average flow m^3/s**	**minimum recorded flow m^3/s**	**average annual lowest flow m^3/s**	**average lowest monthly flow m^3/s**	**average highest monthly flow m^3/s**	**average annual peak flow m^3/s**	**maximum recorded flow m^3/s**
Surkhob (Nurobod)	324	40.3	231	73.1 (Feb - March)	1380 (July)	456	2690
Vakhsh (Darband)	603	125	443	140 (Feb - March)	2050 (July)	709	2590
Vakhsh (Tutkaul)	640	96.5	487	135 (Feb - March)	2170 (July)	782	3500
Vakhsh (Golovnaya HPP)	580	39	425	102 (Feb - March)	2050 (July)	845	3450
Pyanj (Nyijni pyanj)	1010	281	837	281 (Jan - Feb)	3350 (June)	1190	5420
Amu Darya (Chatly)	1352 (1931-1973)	0.00			(July)		> 6000

The assessment of water resources made by BVO brings the following information:

- The total mean annual flow of all rivers in the Amu Darya river basin is estimated about 78.46 km^3; 90% of the annual flows are in a range from 55.1 to 102 km^3.

- 80.2% of Amu Darya flow forms in Tajikistan.
- 7.9% of Amu Darya flow forms in Afghanistan, 6.0% in Uzbekistan, 2.4% in Kyrgyzstan and 3.6% in Turkmenistan.

With 20.1 km^3/yr, Vakhsh river represents 26% of the total flow of the Amu Darya (78.46 km^3), thus being the second largest river feeding the Amu Darya after Pyanj (40% of Amu Darya inflow).

8.8.3 Flow Pattern of Vakhsh River

Vakhsh river has a seasonal flow pattern, with a discharge maximum in July and a minimum in February, as can be seen from the following Figure. River flow is mainly influenced by snow melt, since a major part of the annual precipitation falls during the winter months, in higher areas as snow.

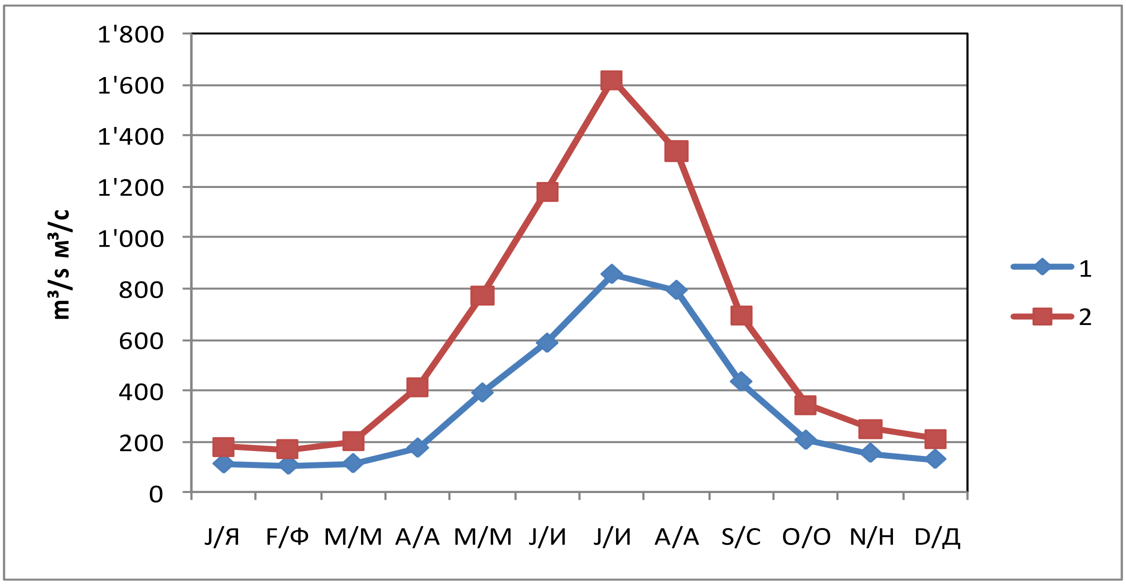


Figure 8-29: Monthly average flow of Vakhsh River

1 = Surkhob river (near Garm) 2 = Vakhsh river at Nurobod (Komsomolobod)

8.8.4 Effect of Nurek

The construction of Nurek from 1961 to 1980, the creation of the 10.5 km^3 reservoir and the commissioning of the hydroelectric station from 1972 to 1979 have resulted in a modification of the Vakhsh River flow pattern to the following extent:

- the filling of the reservoir during nine years from 1972 to 1980 resulted in a reduction of downstream flows equal to the volume of water stored in the reservoir of 10.5km^3, which over the nine years filling duration meant a reduction of 6.8 % of the Vakhsh River flow or 1.5 % of the entire Amu Darya flow;
- the increase of evaporation due to the creation of the reservoir is estimated by HPI (2009) to be 0.052 km^3/yr, i.e. 0.3% of the Vakhsh River flow;

- the modification of the seasonal distribution of Vakhsh river discharge, as a result of the reservoir operation. As can be seen from the following Figure, Nurek had a regulating effect on Vakhsh discharge downstream of the dam, with a marked shift from high flow season to low flow season.

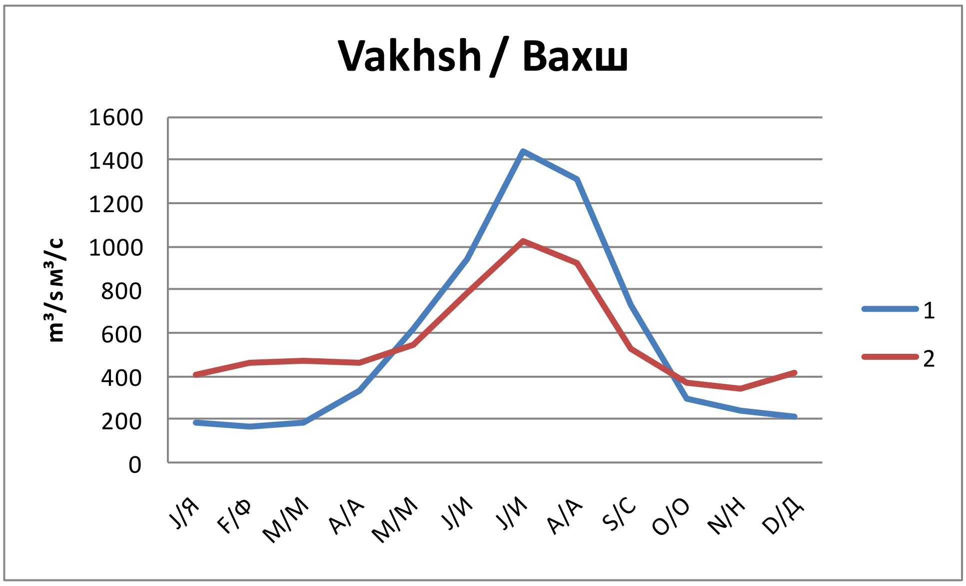


Figure 8-30: Effect of Nurek dam on Vakhsh discharge

Values for Vakhsh-Tigrovaya Balka station:
1 = without Nurek (1960-1962)
2 = with Nurek (1984-1990)

The reservoirs located downstream from Nurek have very limited reservoir capacities. Baipaza has a storage capacity that allows regulation at the week level, while the other HPPs have a regulation capacity that only allows daily regulation, for example for peak production. In practice, this means that hydropower schemes downstream of Nurek have a too small storage capacity to influence significantly water availability in the Amu Darya basin.

8.8.5 Effect of Irrigation

Irrigation upstream of Nurek and Rogun sites, since there is no agriculture between Rogun and Nurek reservoir - is rather limited due to the limitations in availability of suitable land. Furthermore, water for these small scale irrigation schemes is taken from tributaries of Vakhsh river and not directly from the river itself.

The situation is different for the lower part of Vakhsh valley, where there are flat areas suitable for irrigated agriculture. The following Table shows the volumes of water that were allocated by ICWC to Tajikistan in the sub-basin of Vakhsh river from 1992 to 2010, and the volumes that were actually used, compared to the actual flow of Vakhsh river. These figures show that irrigation used in average, over the considered period, 26% of the Vakhsh river flow.

Table 8-12: Water allocated and used by Tajikistan for irrigation from Vakhsh River from 1992 to 2010 (km^3)

unit:km^3	minimum	average	maximum
Allocated	5.9	6.8	7.3
Used	3.2	5.5	6.0
Total river flow	17.1	21.0	26.1

Source: ICWC website

Figure 8-31 provides a layout of the water intakes and return flow canals along the Vakhsh river. Together with Figure 8-32, it shows how complex the network of irrigation canals, drainage canals and natural arms of the Vakhsh river is. These two Figures also show that the lower Vakhsh develops in a wide floodplain formed by ancient sediments, where significant underground flows are possible, depending on the permeability of underground geological layers.

The effect of irrigation on the hydrology of the Vakhsh valley is presently estimated on the basis of multiple flows measurements or calculations:

- flow calculation at the 6 intakes on Vakhsh river left bank: 3 intakes are equipped with a gauging station (water level measurement), 2 intakes are equipped with pumps and their flow is calculated on the basis of the pump work, and 1 intake is equipped with gates for which the flow is calculated using rating curves;
- flow calculation at the 12 intakes on Vakhsh river right bank: 7 intakes are equipped with a gauging station (water level measurement) and 5 intakes are equipped with pumps and their flow is calculated on the basis of the pump work;
- return flow calculations from the 19 drainage canals are determined by the regional water resources services (under the Ministry in charge of water resources management) jointly with Tajik hydro geological and land reclamation survey services.

None of the gauging stations or drainage canals is subject to continuous real-time monitoring. The measurement of flows which by nature is difficult, is even more complex in this context.

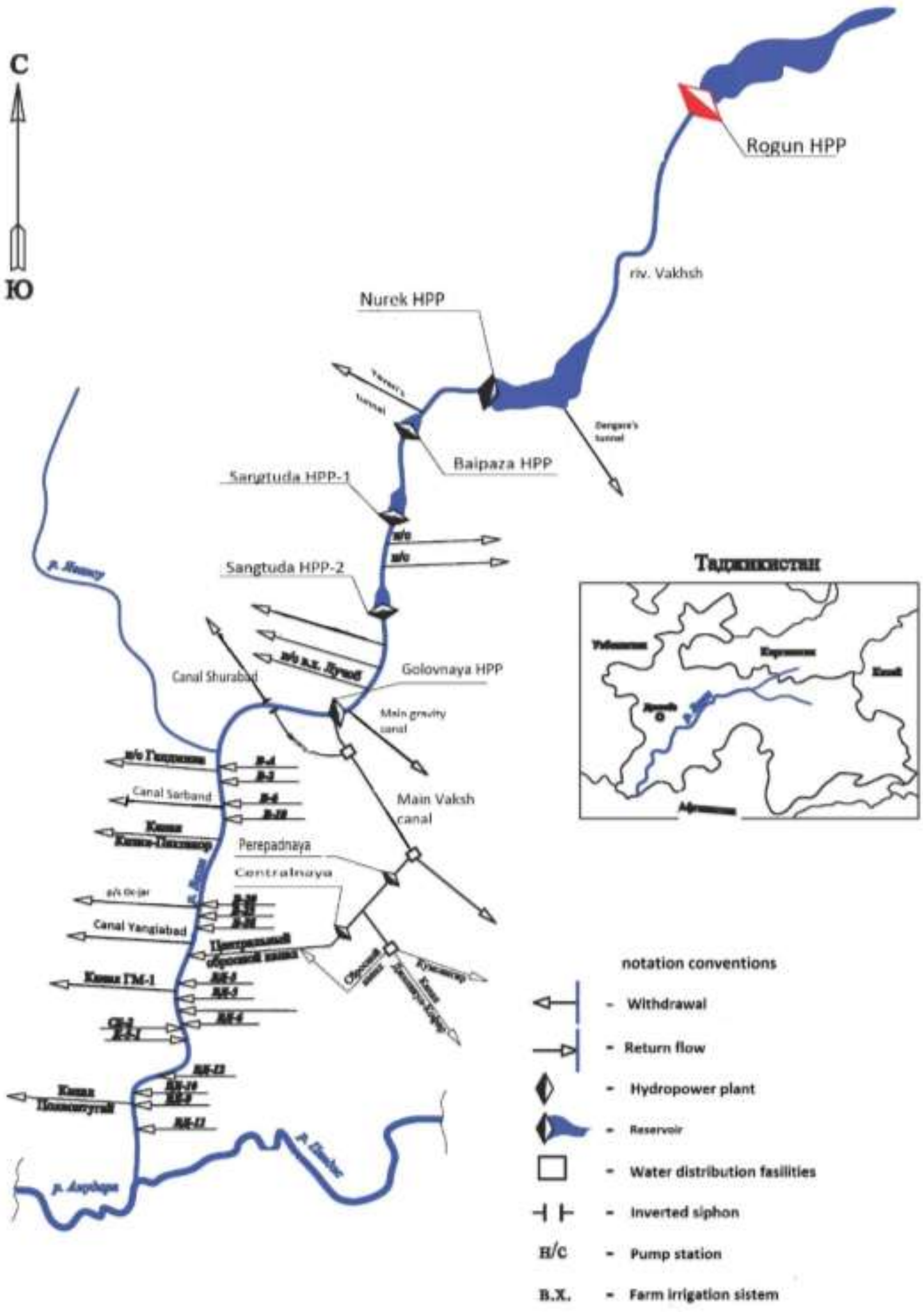


Figure 8-31: Layout of water intakes on Vakhsh River

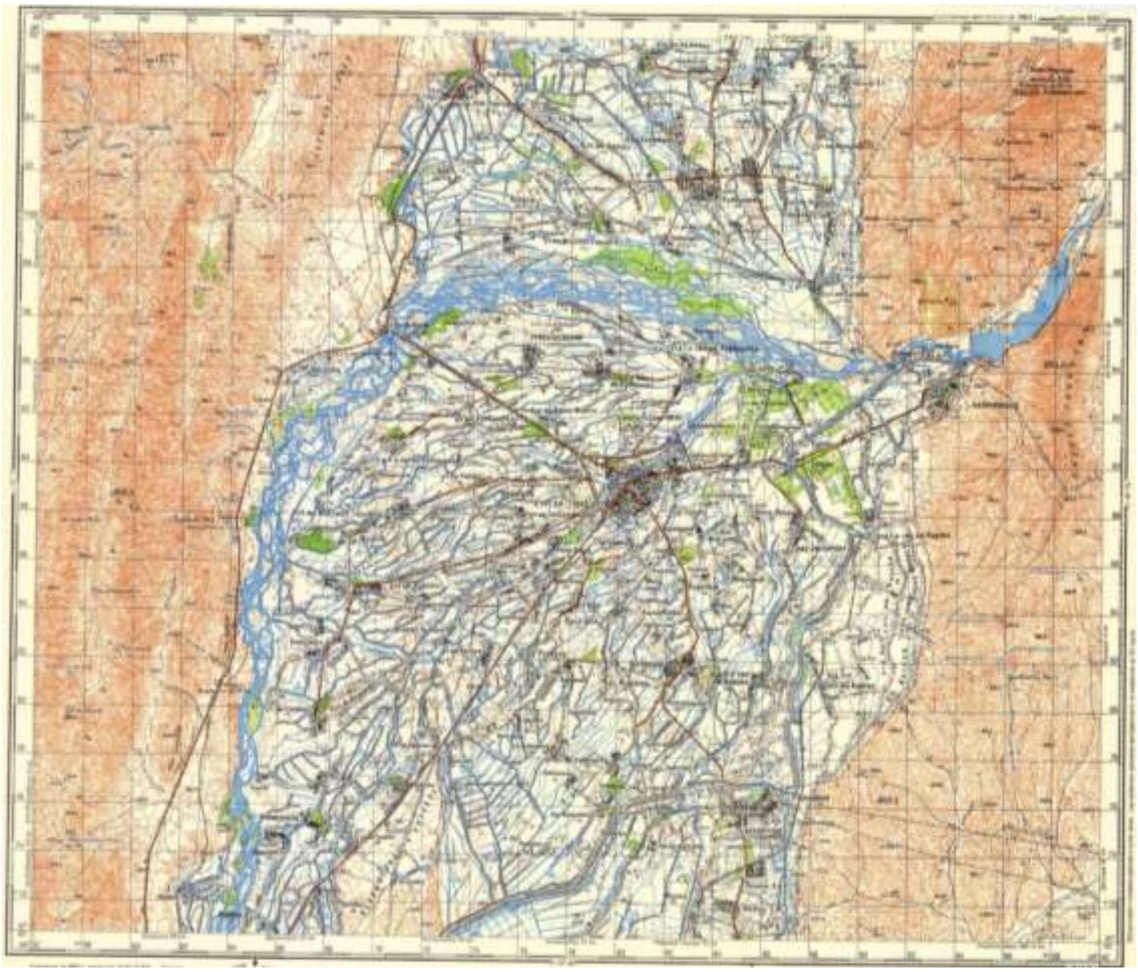


Figure 8-32: Map of the upstream part of lower Vakhsh flood plain

The effect of irrigation on the hydrology, i.e. the actual volume of water used in the Vakhsh basin, can be defined as the difference between inflows (underground and surface water flows + direct precipitations) and outflows (underground and surface water flows + natural evaporation) along the Vakhsh River system. The gauging station immediately downstream of Nurek (Sariguzar) and the one close to the confluence of Vakhsh with Pyanj (Tigrovaya Balka), provide a first estimate of the water used for irrigation This is shown in the following Figure (see also data in more detail in Annex 8).

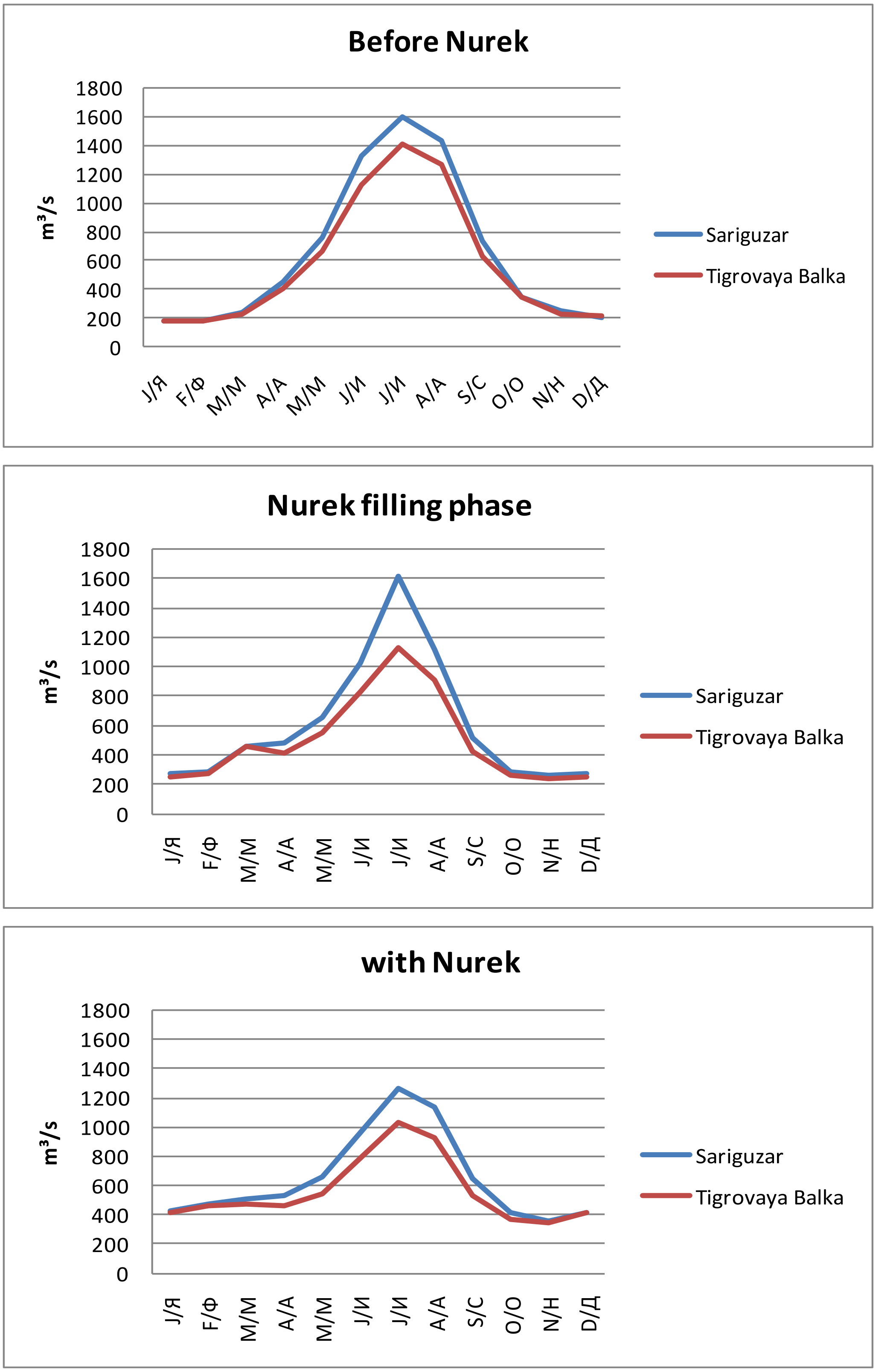


Figure 8-33: Effect of irrigation on Vakhsh river discharge

The Figure shows two things, namely:

- In summer, during the vegetation period, there is a marked reduction in river discharge between these two stations. This corresponds to the water needed for irrigation. However, flow in winter remains almost unchanged, which shows that there is no significant water abstraction during this period, but also no inflow of additional water.
- The effect of Nurek (difference between top and bottom graphs in the Figure confirms what was shown already in Figure 8-30: a reduction of flow in summer and an increase in winter, i.e. a shift from the high flow to the low flow season.

8.8.6 Effect of Nurek on Amu Darya

The effect of the construction of Nurek on the Amu Darya can be summarized in two categories:

- A reduction of flows during the filling period, equal to the volume of water required to first filled Nurek reservoir, i.e. 10.5 km³ over 9 years (1.5 % of the entire Amu Darya flow).
- A shift in the distribution of flows from the Vakhsh river which subsequently influenced the monthly distribution of flows in the Amu Darya. This effect is determined by the operation of Nurek: the operation mode of Nurek was in the Soviet time dedicated in priority to water regulation for irrigation (energy production was a secondary activity). This operation mode was changed after the collapse of the Soviet Union (because previous transboundary water/energy exchange principles were not applied anymore) and Nurek was operated in priority with the objective of winter energy production for Tajikistan.

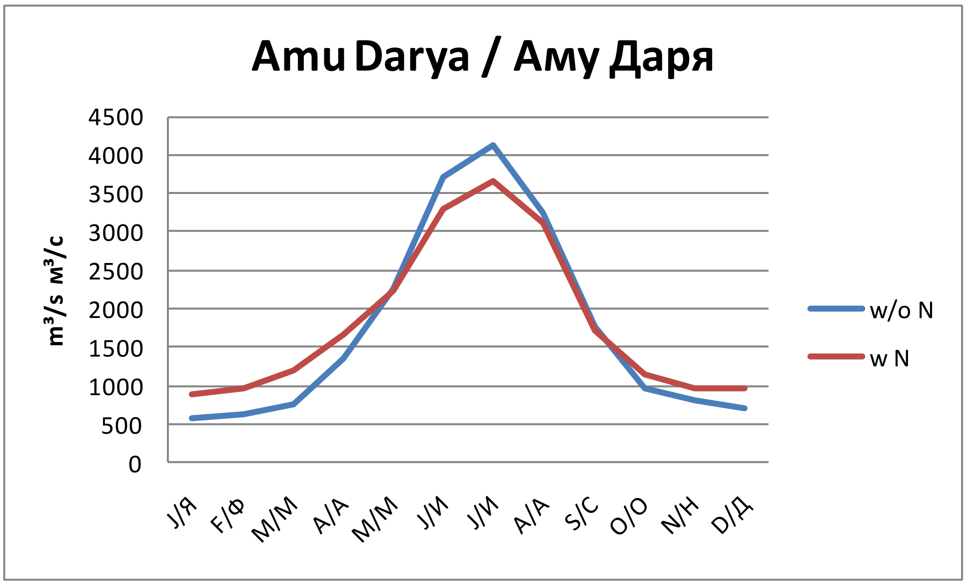


Figure 8-34: Comparison of Amu Darya flow without and with Nurek dam

w/o N = without Nurek
w N = with Nurek

8.9 Residual Flow

8.9.1 Reason for Residual Flow

The daily peaking possibility has not been assessed in the Reservoir Operation Simulation Studies (TEAS, Chapter 5, November 2013), because the simulation time step is monthly. Operating Rogun in peaking mode could be possible within the monthly operation studied. The peaking operation has been taken into account in the economic analysis by dispatching the total energy within a day to fit the demand. Thus Rogun HPP will be operated, at least to some extent, as a peaking power plant, for producing energy during peak demand hours. However, there is certainly the possibility to close the turbines down completely. This would mean that there can be periods with zero flow in the river below the dam. Therefore it is necessary to evaluate the situation and to define the need for a residual flow.

A residual (ecological, minimum) flow is defined as the minimum amount of water which needs to be kept flowing at all times - and especially during times when the turbines are shut down - in order to guarantee a minimum of water in the river on a permanent basis.

The main purpose of defining and maintaining a minimum flow is usually one or both of the two following:

- to maintain the affected part of the river as a habitat, mainly for fish, but also for other aquatic life; and/or
- to guarantee water availability on a permanent basis for water users along the affected stretch of river; this concerns mainly water needs for irrigation or drinking water supply, or for maintaining a sufficient dilution of waste water being discharged into the river.

8.9.2 Specific Conditions

In the case of Rogun, a certain number of specific conditions has to be considered, namely:

- The affected stretch of river, where discharge could temporarily be reduced to zero, is very short, it is only between Rogun dam and the upper end of Nurek reservoir at FSL, a total of approximately 15 km. Further downstream, river discharge is regulated by Nurek, Rogun has no direct effect on that.
- There are no settlements, i.e. no water users, along this affected part of the river.
- The importance of this river stretch for fish is very limited (see Chapter 11). In any case, even if there were fish migrations from Nurek reservoir upstream, these would be blocked by Rogun dam.
- Immediately downstream of the dam there is a left bank tributary (Obishur) which brings a certain amount of water (there do not seem to be any data on its discharge); this means that even in the absence of a residual flow from the dam, this part of the river will never be completely dry.
- One additional condition has to be taken into consideration: there is a plan for an additional HPP, Shurob, between Rogun dam and Nurek reservoir. If this will actually be implemented, there might be no need for a residual flow. The layout

of this plant (FSL, distance to Nurek reservoir) still needs to be defined. The situation for this case, based on presently available information, is shown below.

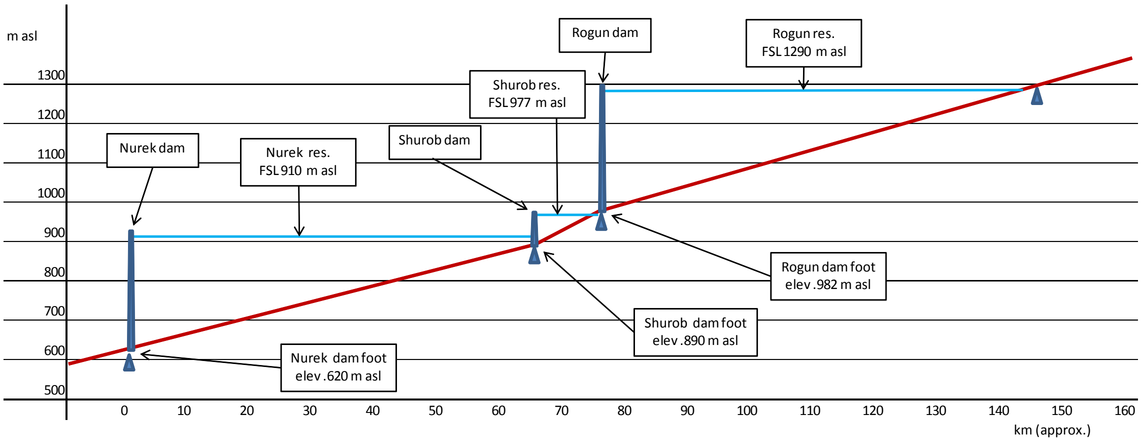


Figure 8-35: Cascade in upper Vakhsh river

Table 8-13: Cascade in upper Vakhsh river

	Unit	Nurek	Shurob*	Rogun
River bed elevation at dam site	m asl	620	890	982
Dam crest elevation	m asl	920	983	1300
Reservoir FSL	m asl	910	977	1290
Dam height	m	300	93	335

* Data for Shurob have to be seen as provisional, not confirmed

If Shurob HPP would be implemented as indicated in the Figure and Table above, the situation would be as follows:

- Shurob dam site is immediately at the upper end of Nurek reservoir (about 65 km upstream of Nurek dam).
- When Nurek reservoir is full (FSL 910 m asl), its water reaches the water outlet of Shurob HPP.
- If the water level of Nurek would be lower (which is not foreseen in the intended operation pattern), there would still be water flowing between Shurob and Nurek reservoir, since Shurob will be operated as run-of-river HPP, with very little regulating capacity.
- Shuorb reservoir has a FSL of 977 m asl, and an MOL of 973 m asl, while the river bed elevation at Rogun dam site is 982 m asl. This means that Shurob reservoir would almost reach Rogun dam; at most, a few 100 m would be between the foot of the dam and Shurob reservoir, in an area where Vakhsh river is highly disturbed by construction and operation of Rogun in any case.

This would mean that with Shurob HPP in place there would be as good as no part of the river left which could run dry in an extreme case. In this situation providing a residual flow would not be required.

8.9.3 Recommendations for Residual Flow

In the absence of a legal basis for determining a residual flow, and given the limited importance of the affected part of the river as a habitat for fish, it is recommended to adopt a residual flow in the order of magnitude of 10 m^3/s, to be reassessed at further stage by taking into account the runoff from the tributaries as well as the morphology of the river reach. This would guarantee a minimum flow of water in this part of the river, which would enable e.g. trouts to move upstream from Nurek reservoir into the few small tributaries between Nurek and Rogun.

It has to be stated that a residual flow defined for Rogun will not influence in any way the river discharge pattern downstream of Nurek, since the regulating capacity of Nurek is large and the discharge in Vakhsh downstream of Nurek HPP is determined entirely by the operation of this latter.

8.10 Floods

Rogun flood issues have been addressed in the hydrology study (TEAS, Chapter 5, November 2013) in two ways: firstly by a frequency analysis of instantaneous and daily peaks; and secondly by an estimation of Probable Maximum Flood (PMF). Flood hydrograph has been defined by analysing three major observed flood events.

8.10.1 General Approach

The short period of records obtained for the Vakhsh river at Tutkaul have not allowed transposition to Rogun dam site to conduct a statistical analysis and estimate flood for large return period (10'000-year). Considering the results of former studies, TEAS has defined regional flood samples transposed to Rogun conditions. The statistical analysis was carried out on three different flood samples of rivers with similar hydrological regime and close mountain range climate conditions. The analysis favoured first time series within the catchment of interest and second, records from reference gauging stations in close climatic and geographic conditions with long time series. The standardisation is made using Francou-Rodier Index, which is defined by the frequency analysis using a regional approach in three steps:

- **First step**: regional sample based on Vakhsh gauging stations;
- **Second step**: first regional sample and transposed floods from Indus (Attock) and Chenab (Benzwar) rivers;
- **Third step**: second regional sample and transposed floods from Syr Darya (Tyumen Aryk).

TEAS studies have adopted the following flood peaks and frequencies for Rogun dam site:

- 2-year flood event: 2360 m^3/s
- 5-year flood event: 2780 m^3/s
- 10-year flood event: 3070 m^3/s
- 20-year flood event: 3360 m^3/s
- 100-year flood event: 4030 m^3/s
- 1'000-year flood event: 4950 m^3/s
- 10'000-year flood event: 5970 m^3/s

The computation of the flood hydrographs was based on three major observed flood events of Vakhsh river at Tutkaul gauging station:

- **July 1953 – the largest flood recorded on the Vakhsh**:
  daily discharge of 3500 m^3/s and peak discharge of 3730 m^3/s;
- **July 1958**:
  daily discharge of 3250 m^3/s;
- **July 1969 – major event in terms of volume recorded on the Vakhsh**:
  daily discharge of 2800 m^3/s.

The a-dimensional hydrograph combines flood peaking issued from July 1953 and July 1958, and flood volume from July 1969, as shown below.

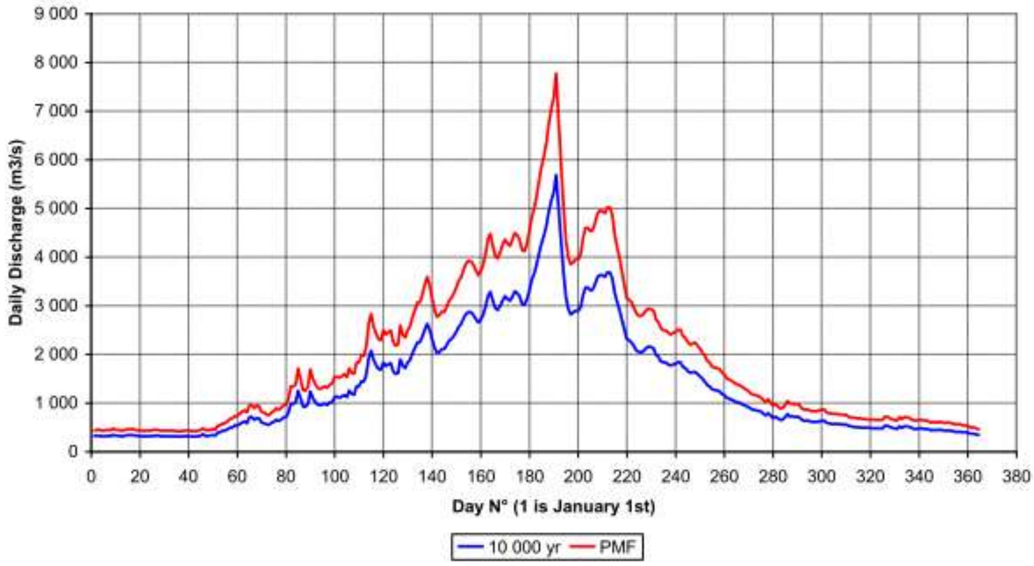


Figure 8-36: Hydrographs for 10’000-year flood event and Probable Maximum Flood

Source: TEAS: Phase II: Project Definition Options – Volume 2: Basic Data – Chapter 5: Meteorology, Hydrology and Climate Change – March 2014

8.10.2 Probable Maximum Flood (PMF)

The Vakhsh river is a snow and glaciers melt influenced river. The high flows are related to the thaw season with main peaks in July and August. Discharge is not correlated to the precipitations. According to TEAS studies, the PMF cannot be assessed by conventional methods of World Meteorological Organisation, applying Probably Maximum Precipitation (PMP). Thus TEAS has studied climate variables controlling the flow regime in the Vakhsh basin:

- **First step**: availability of snow and ice cover, determined by the quantity of the winter precipitation;
- **Second step**: melting process in spring and summer, controlled by solar radiation.

The analysis has led to a daily PMF of 7800 m^3/s associated to an instantaneous peak of 8160 m^3/s.

8.11 Water Quality

8.11.1 Prevailing Situation

8.11.1.1 Chemical parameters

The hydrological station of Nurobod, located in the future Rogun reservoir, is the project's reference station for water quality monitoring. The quality of Vakhsh river in Nurobod has been monitored since 1980 (with disruptions in 1981 and from 1994 to 1997). Due to the weak population density, the scarcity of vegetation, and the absence of large scale agricultural or industrial activity in Vakhsh river basin upstream from Rogun, the biochemical composition of the water is mainly influenced by the geochemical nature and erosion processes of the drainage basin.

Water quality analyses were performed directly in Nurobod until 1994. Since that time, water samples are sent to Dushanbe for analyses at the head office of Gidromet. Six to eight samples are analysed annually. Due to the lack of means, samples are transported in usual plastic bottles or containers, without control of their temperature. Several inconsistencies are observed between data after and before the disruption period 1994-1997. Therefore, the results of the analysis have to be considered carefully, in particular for oxygen related parameters (oxygen itself and BOD are no more monitored).

Water quality analyses made in Nurobod show water with a low nutrient and COD content.

Like most rivers of Amu Darya basin, Vakhsh river in Nurobod has a rather high carbonate concentration ($[HCO_3^-]$ = 105 mg/l). The concentration of sulphate regularly exceeds the Tajik requirements for surface water and the concentration of chlorine is rather high, which all together reflects corrosive water.

Table 8-14: Water quality of Vakhsh and Amu Darya rivers

Parameter	unit	Vakhsh Nurobod 1998-2010 average	Amu Darya Termez 1996-2001 average	Amu Darya Samanbay 1996-2001 average	Tajikistan requirement for surface water
O2	mg/l		10.5	10.8	4.0 in winter 6.0 in summer
	%sat		99.7	98.7	
BOD	mg/l	-	0.8	1.4	3.0
COD	mg/l	0.6	4.5	15.1	
salinity	mg/l		551.4	1170.0	
pH		7.6	7.6	7.6	
PO_4^{3-}	mg/l	0.06	0.75	0.60	
NO_3^-	mg/l	1.6	0.6	0.5	40
HCO_3^-	mg/l	105.4	131.1	142.9	
Cl-	mg/l	85.4	73.3	213.9	300
$SO4^{2-}$	mg/l	169.6	176.6	433.6	100
Temp.	°C	7.6	16.7	13.6	

Source: for Vakhsh river, TajGidromet, for Amu Darya, Crosa et al., 2006

Only two heavy metals are being monitored in Nurobod: Chrome (Cr VI) and lead (Pb). Both show concentrations which are below but close to the normative limits. These high concentrations most probably result from the geochemical characteristics of the catchment rocks, and the intensive erosion processes. The lead concentrations reported in the following table are those measured in 2007-2010: lead concentrations reported by Gidromet for the previous years (2003-2005) are more than ten times higher (average [Pb]= 0.37 mg/l), which Gidromet explains as a reporting mistake. This example shows *(i)* how carefully water quality data are to be used and *(ii)* the need for an improvement of water quality monitoring reliability in future.

Table 8-15: Chrome and lead concentration for Vakhsh River in Nurobod

Station	average annual concentration	maximum annual concentration	EU Directive 75/440/EEC (surface water intended for drinking water production)	Tajikistan requirement for surface water
Cr VI (mg/l)	0.017	0.031	0.050	0.100
Pb (mg/l)	0.025	0.030	0.050	0.100

Source: for Vakhsh river, TajGidromet, for Amu Darya, Crosa et al., 2006
Values for 1980-2010

The Amu Darya river water in its lower reach is characterized by a downward degradation of its quality mainly related to salinity, the major ions being sulphates, chlorine, sodium and potassium:

The longitudinal increase in deoxygenating pollutants can be mainly considered as indicative of the loss of organic matter from the irrigated areas, which, in conjunction with salinization, contributes to the major degradation processes affecting the land resources surrounding the Amu Darya river.

The contribution of urban wastewaters to the overall level of pollution can be considered as non-relevant, since the anthropic density is extremely low and extremely localized. The effects of punctual wastewater contamination, if present, have to be considered not significant, standing the evidenced auto-depuration capacity of the Amu Darya river.

The major factor impairing the water use in the lower part of the river can thus be attributed to the secondary salinization processes originating from the lithological composition of the watershed and which are driven and increased by the return waters and by the irrigation activities.

The relevance of such problems can be summarized by comparing the average annual values of salinity at Kerki, (625.7 mg/l) and at Darganata (1023.7 mg/l) to the average annual value calculated for the up-stream station located at the confluence of the Pyanj and Vakhsh rivers (500 mg/l), these data allow to estimate an increment of 25% and 100% after 350 and 800 km, respectively.

Two main driving forces act in shaping the seasonal variation of the salinity of the Amu Darya River: low natural drainage density of the catchment, which limits the salt loads induced by the natural runoff processes, and the snow and glacier melting in the upper catchment area which promote dissolved salt dilution during the high-flow period (spring and summer). During low-flow periods salinity is strongly influenced by the return waters used for land washing and irrigation. However, as was shown in Figure 8-13, Section 8.4.6.1, this is a procedure applied in the downstream area, in Uzbekistan and Turkmenistan; Rogun HPP will have no influence on this, since the cascade with Rogun will be operated keeping the Vakhsh river flow pattern unchanged.

8.11.1.2 Sediments Load

Due to the intensity of erosion processes in its catchment, Vakhsh river is characterized by a high sediments load. The concentration of suspended solids fluctuates during the year and reaches its maximum during the flood season. TEAS (Phase II: Project Definition Options – Volume 2: Basic Data – Chapter 6: Sedimentation, March 2014) has determined the annual sediment supply into the reservoir to be in the order of magnitude of 62 to 100 hm^3. This range of uncertainty could not be narrowed at the present stage of the studies. As a conservative approach, the value of 100 hm^3/yr has been considered as a representative assumption of sediment solid runoff.

At equal water discharge values, the sediment concentrations are higher during the flood increasing period than during the flood decreasing period. The annual sediment load varies with the hydrology up to a factor of 2.5 (less or more). Bed load is estimated to represent 12% of the volume of suspended solids.

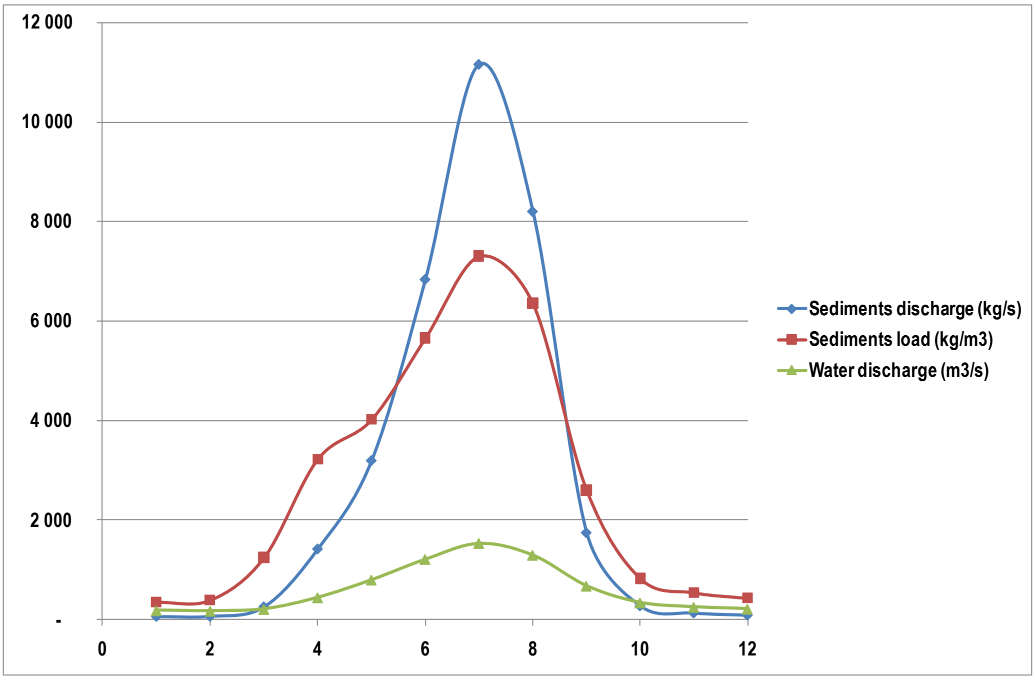


Figure 8-37: Sediment load and discharge in Vakhsh river at Rogun (1949-2007)

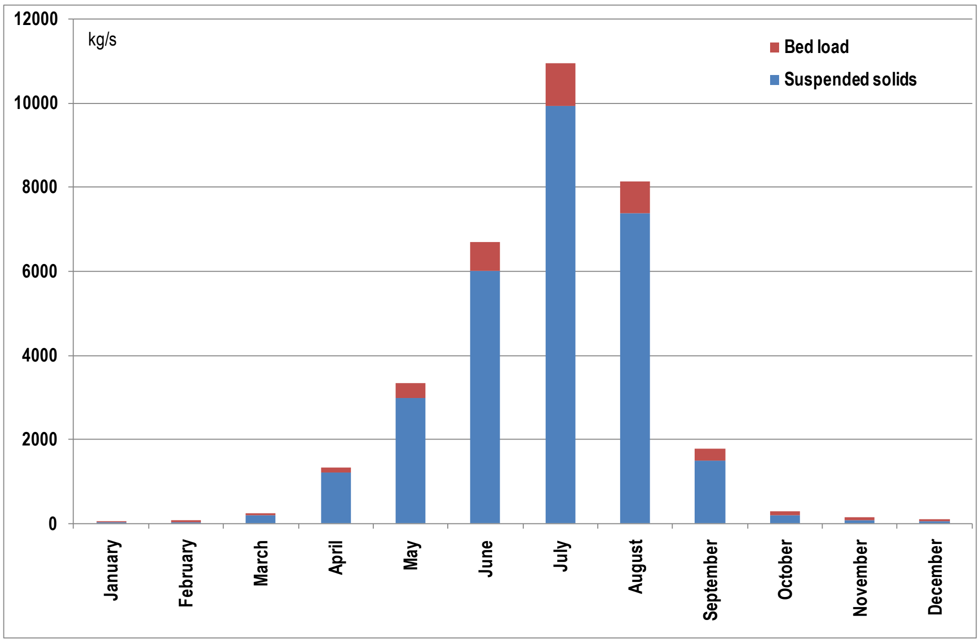


Figure 8-38: Suspended solids and bed load in Vakhsh river at Rogun (2010)

Since the construction of Nurek HPP, the majority of the sediments of the upper Vakhsh catchment does no longer reach the lower catchment but instead is deposited in the reservoir of Nurek. Various estimates of the sediment volume in Nurek reservoir were made, but no bathymetric study has ever been implemented to define the actual figure. During a visit to Nurek in 2011, information was obtained that a bathymetry is planned to be implemented.

The following picture shows the inflow of Vakhsh river into Nurek reservoir. It demonstrates that suspended solids brought by the river sediment quickly and are trapped in the reservoir.

Figure 8-39: Inflow of Vakhs river into Nurek reservoir, showing sedimentation process

As discussed by TEAS, today's sediment supply of the upper Vakhsh river is trapped in the Nurek reservoir, as shown in the above picture. If Rogun would not be built, Nurek will be progressively filled up with sediment. At mid-term, several hydraulic structures will have to be reconsidered. At long-term the project safety will be questioned. Vakhsh river will not have any regulation capacity any longer, which would drastically decrease winter energy output. Furthermore, Nurek's surface spillway capacity is only of 2020 m^3/s, not able to handle the PMF peak of 8160 m^3/s. Construction of Rogun will largely decrease the Nurek filling rate, ensuring the river regulation for a significant additional time period, and delay the need of rehabilitation of the flood evacuation system with respect to the sedimentation issue.

The total reservoir capacity of Nurek is not exactly known. In the Reservoir Operation Simulation Studies (TEAS, Chapter 5, November 2013) values between 7.98 and 10.5 km^3 are indicated. In the framework of the ESIA, Nurek's life span has been roughly estimated considering the same sediment supply as for Rogun and a total reservoir capacity of 9.0 km^3. When Rogun would be built, life span of Nurek (expected to be 90 years without Rogun) might be increased by Rogun's life span.

During the 115 years of operation phase for TEAS recommended Rogun alternative, the full sediment supply will be deposited in the reservoir. While the sediment level keeps rising, the power intakes are progressively raised from their initial level, following the rise of the sediments level and avoiding their early plugging. This system could also be used for fine suspended sediments to be discharged through the turbines. After the life span of 115 years, Rogun will be operated as a run-of-river HPP and Nurek will do the whole river regulation, considering the conservative annual sediment supply of 100 hm^3.

At the final stage of Rogun, the surface spillway is able to operate and ensure PMF evacuation, allowing also solid load evacuation to downstream, always ensuring dam safety issues.

The following graph shows the discharge of suspended solids at Tigrovaya Balka, downstream Nurek HPP, before and after commissioning of the HPP.

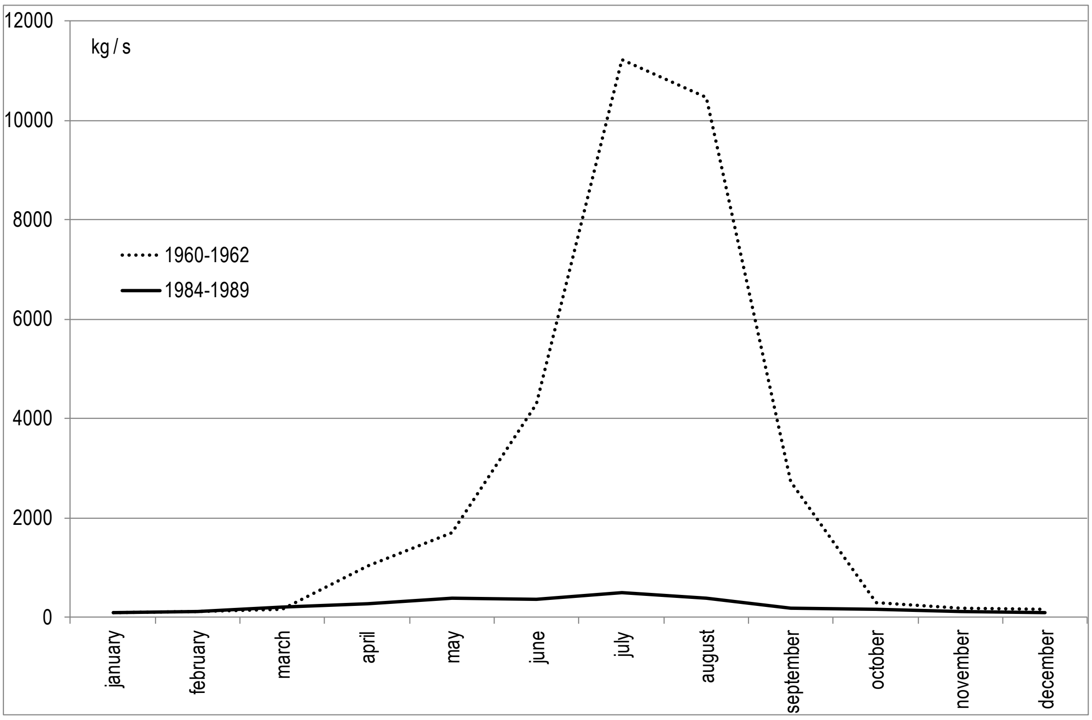


Figure 8-40: Suspended solids - Tigrovaya Balka, Vakhsh, before and after Nurek HPP commissioning

8.11.2 Reservoir Stratification

8.11.2.1 The Stratification Process

Large and deep reservoirs in temperate climates, like natural lakes, usually show a thermal stratification during summer, when water temperature at the surface is rather high, while water in greater depth is much colder.

An empirical dependence of reservoir stratification on residence time (τ) to the maximum temperature difference between the surface and hypolimnion (i.e. water in the deeper areas of the reservoir) was found by Straskraba and Mauersberg (1988; cited after EAWAG 2006) for several reservoirs in the Czech Republic, approximated by the equation:

$$\Delta T_{0\text{-}30} = 20\ (1\text{-}\exp\ (-0.0126 * \tau))$$

whereby ΔT_{0-30} is the difference in water temperature between the surface and a depth of 30 m, and τ is the residence time of the water in the reservoir.

According to this formula, with a residence time (τ) of about 252 days, the temperature difference between surface and hypolimnion would correspond to a maximum of about 19°C. This should not be taken as an accurate value, but rather as an estimate of the upper limit. Nevertheless, this important difference in temperature would indicate a stable thermal stratification. Under the given climatic conditions (hot summers, cold winters) however, this stratification will not persist, there will be a circulation within the reservoir twice a year, in autumn and early winter, when the water at the surface gets cooler, and in spring, when it gets warmer again.

Thermal stratification and circulation in lakes and reservoirs in temperate regions are governed by the following parameters and processes:

- Density of water depends on temperature; it is highest (water being heaviest) at 4°C, lower at both higher or lower temperatures, and lowest when it is in the form of ice. This means that water, when it reaches 4°C, will sink to the bottom, and in a deep reservoir or lake water temperature at the bottom will always be at or close to 4°C.
- In summer, solar irradiation will raise water temperature at the surface; this warmer water, since it is lighter, will remain at the surface. Wind and wave action will mix this warmer water with the cooler water layers below it, however, this affects only the upper layers of the water body. This leads to a stable thermal stratification.
- In autumn the water at the surface will slowly become cooler. Cooler water will start to sink, bringing the warmer water below it to the surface; this is the start of the circulation, which will gradually reach deeper water as the cooling process goes on.
- When the water reaches 4°C over the entire water column, it will circulate freely, since there are no layers with different density any more.
- Further cooling in winter will lead to colder (< 4°C) water at the surface, and thus again to a thermal stratification, the colder water remaining at the surface. When the water starts freezing, the ice will remain at the surface; a closed ice cover will slow down the further cooling process.
- In spring, with a warming of the surface the process will start again (water getting heavier as it approaches 4°C and sinking to deeper layers, spring circulation, and then remaining at the surface as temperature rises.

This situation is illustrated in the following Figure with an example from a reservoir in northern Turkey, under climatic conditions also characterised by hot summers and cold winters.

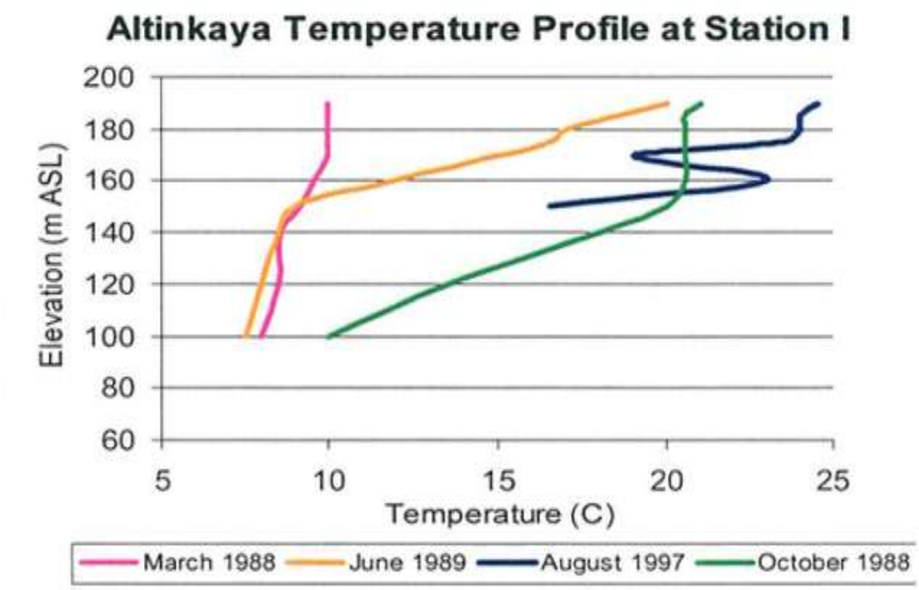


Figure 8-41: Temperature profile in a Turkish reservoir

The Figure shows mainly the following:

- March: more or less uniform temperature over the water column (i.e. from surface to bottom) indicates the spring circulation. Slightly higher temperatures near the surface indicate the beginning of summer stratification.
- June: water temperature at the surface has increased significantly, while in the deeper water it is still as cold as in March.
- August: surface temperature has increased significantly, and temperature generally decreases with depth.
- October: the cooling process at the surface has started, autumn circulation begins.

8.11.2.2 Effects in Rogun Reservoir

Given the climatic situation in the project area, this sequence of stratification and circulation will also occur in Rogun reservoir.

Environmental consequences of this are the following:

- Thermal stratification and water intake for the turbines in deeper (i.e. cooler) layers can lead to the input of very cold water into the river downstream of the power plant, and this in turn can have negative impacts on the river, and mainly on organisms (fish and organisms serving as food for fish). In the case of Rogun, this impact will be negligible, since the water will flow into another reservoir a short stretch downstream, and since the river section between these two reservoirs has very little if any biological or economic importance (see Chapter 11). Colder water flowing into Nurek reservoir will insert itself into the lower water layers of the reservoir, without causing any major change in surface water temperature.

- Circulation twice a year will bring oxygen-rich water from the surface to deeper layers of the reservoir. This, together with the fact that there will be no elevated oxygen consumption, given the small amount of biomass that will be submerged (see following Section), will prevent the risk of anoxic conditions in the deeper parts of the reservoir.

Overall, no negative impacts are to be expected in this respect, and no measures are required.

8.11.3 Oxygen and GHG Emissions

Reservoir stratification is also important with respect to oxygen content of the water. During a stable thermal stratification in summer, oxygen in deeper layers can be depleted if large amounts of organic matter have to be broken down. In the case of a reservoir, this can be the case under two conditions, namely:

- after first filling, if large amounts of biomass (vegetation) were submerged and are now being broken down, and
- in cases where eutrophication of the reservoir happens, i.e. when large amounts of nutrients are being brought into the reservoir, which lead to a high plant (algae) productivity close to the surface, where there is enough light for photosynthesis.

The first condition (submergence of biomass) can lead to anoxic conditions in the reservoir, and this in turn will lead to methane (CH_4) production; methane is a very powerful greenhouse gas (GHG). This is the case mainly in tropical reservoirs, where often very large amounts of biomass are submerged. The risk for such a development in Rogun is calculated with a simple model in the following Table.

Table 8-16: Oxygen requirements in Rogun reservoir

	Parameter	Unit	Rogun
1	Biomass total (soft only)	t	170'000.00
2	Reservoir area	ha	17'000.00
3	Biomass average (soft biomass only)	t/ha	10.00
4	Mean annual river discharge	m³/s	631.00
5	Water in res., total volume	mio m³	13'300.00
6	Annual inflow	mio m³	19'876.50
7	Oxygen in inflow water	mg/l	8.00
8	Oxygen per m³	g/m³	8.00
9	Oxygen total at first filling	t	106'400.00
10	Oxygen total in annual inflow	t	159'012.00
11	Oxygen demand /t biomass	t	1.07
12	Oxygen demand total	t	181'900.00
13	O2 balance 1: O2(1st filling) - O2 demand	t	-75'500.00
14	O2 balance 2: O2(annual inflow) - O2 demand	t	-22'888.00
15	O2 balance 1: % of O2 required available 1st filling	%	58.49
16	O2 balance 2: % of O2 required available yearly	%	87.42

Explanations:
1 = total soft biomass (leaves, twigs) in the reservoir area to be submerged at first filling
2 = reservoir area in ha

3 = soft biomass per ha (estimated in comparison with other sites with similar vegetation
4 = mean annual river discharge at dam site
5 = total reservoir volume at FSL
6 = total amount of water flowing into the reservoir per year
7 = mean concentration of oxygen in inflowing water
8 = total oxygen per m^3 of inflowing water
9 = total amount of oxygen in amount of water required for filling the reservoir
10 = total amount of oxygen flowing into the reservoir per year
11 = amount of oxygen required to decompose 1 to of biomass
12 = total amount of oxygen required to decompose the submerged soft biomass
13 = O2 balance at first filling (meaning that an additional 75'500 t would be required for decomposing all the soft biomass after first filling)
14 = O2 balance after one year (meaning that an additional 22'900 t would be required for decomposing all the soft biomass within one year)
15 = the water after first filling of the reservoir contains 58% of the oxygen required for breaking down all the soft biomass submerged
16 = the water flowing into the reservoir in one year contains 87% of the oxygen required for breaking down all the soft biomass submerged

For additional explanations of the model see Zwahlen (2003)

The result of this calculation shows that there would be an oxygen deficit. However, the following conditions have to be considered in the case of Rogun:

- to be on the safe side, for the calculation, an oxygen content of the water of 8 mg/l was assumed. This is a conservative value, since the water in the inflowing rivers is rather cold and, due to the turbulence in the rives, saturated with oxygen, and therefore content is probably rather around 10 mg/l; if this value is taken for the calculation, O_2 content in the water flowing into the reservoir would be sufficient for breaking down all the organic matter.
- The inflowing water is rather cold (stemming from snow melt), and this means that breakdown of biomass will be slow (much slower as would be the case under tropical conditions).
- The reservoir will not be filled within one year, but the filling process will take a number of years, during which the reservoir will increase in steps (see Figure 21-3). This also means that the biomass will be submerged (and decomposed) during this long period.
- There will be no seasonal regrowth in the drawdown area, this area will be completely bare, as it is the case presently in Nurek reservoir. This means that there will also be no input of organic matter into the water from this zone.

The risk of reservoir eutrophication at later stages is also very low. There is little agriculture upstream of the reservoir, and therefore little input of fertilizers. There are also no large settlements with an important input of waste water, which could lead to eutrophication of the reservoir. Over its 30 years of existence, the Nurek reservoir has developed into a very oligotrophic (low nutrient content) water body, as discussed in Chapter 11.

The conclusion here is that there is no risk of anoxic conditions in the deeper layers of the reservoir, which could lead to considerable greenhouse gas emissions.

8.11.4 Conclusions

As discussed by the TEAS studies (Phase II Report – Volume 1: Summary – Chapter 2.6: Sedimentation, April 2014), mitigation measures to address the long-term sediment impacts shall be considered to demonstrate that dam safety can be assured. A comprehensive sediment management plan shall take into account the whole cascade, making use of the Nurek experiences. Thus, TEAS studies recommend, and ESIA supports this decision, the following additional studies and investigations:

- A thorough analysis of Nurek sedimentation by means of new bathymetric and sediment surveys, including echo-sounding, core sampling, measurement of suspended sediment load as well as particle size distribution;
- A detailed simulation of the Nurek and Rogun sedimentation patterns, including turbidity currents;
- An analysis of potential mitigation measures within the whole cascade scheme.

Once Rogun would be built, a thorough sedimentation monitoring is requested to assess supply processes in the reservoir as well as the efficiency of implemented mitigation measures.

The risk of deteriorating water quality, and especially the risk of anoxic conditions in the deeper layers of the reservoir, which could lead to considerable greenhouse gas emissions, is very low. Still, a monitoring of water quality should be carried out as part of a standard reservoir monitoring and an input for the measures proposed to be taken for fish monitoring and fisheries development (see Chapter 11); a program is proposed in the EMP Report. Likewise, waste water from settlements should be treated in wastewater treatment plants before being reverted to the river; such a wastewater treatment plant is under construction in Darband, the new Hukumat centre which will replace Novobod.

II. THE BIOLOGICAL ENVIRONMENT

This part of the Report deals with the living components of the environment, for practical reasons subdivided in the following Chapters:

- Vegetation and flora: plant life in the project area
- Terrestrial fauna: wild animals living in the project area; the focus is on mammals, birds, reptiles and amphibians.
- Aquatic fauna, especially fish, living in the river and other water bodies in the study area.
- Protected areas, i.e. areas that contain special habitats and/or populations of endangered and rare species, and which could be affected by the Project.

9 VEGETATION

9.1 Key Messages

The reservoir will cover an area of 170 km³, and the vegetation on this surface will be destroyed. Key messages are the following:

- The vegetation types found in the project area are characteristic for valleys in mountainous areas in Tajikistan, and are widespread. No rare or especially valuable natural habitats and no rare or endangered plant species will be affected by the project.
- The vegetation in the entire area has been influenced and changed since a long time by human activities, mainly logging, livestock husbandry and agriculture. While much of the area, in its natural state, would be covered by forests of different types, there are no such forests left in the affected area.
- Overall, the impact on vegetation caused by the project is small and of minor importance.
- There is one type of natural habitat in the directly affected (reservoir) area, namely, two floodplain areas, for which an offset will be required.

9.2 Theoretical Considerations

The biological diversity of an area is made up by the number of species of plants and animals that exist there, and by the number and extent of habitat types which they inhabit and help to form. Furthermore, some areas contain a high number of endemic species, i.e. species that exist only in this area and nowhere else on earth.

A large number of species have become very rare or even extinct through the progressive shrinking of specific habitat types as e.g. primary forests or wetlands, sometimes in combination with other influences like hunting. Species that are rare by nature, as the large predators, especially attractive for one reason or another, as furbearers or “trophy animals”, or that depend entirely on a specific, threatened habitat type as amphibians (wetlands) are especially vulnerable.

Hydropower projects can affect biodiversity mainly in the following ways:

- direct destruction of habitats, mainly by submerging large areas through formation of a reservoir;
- indirect disturbance through improved access to hitherto inaccessible areas or through the resettlement of the people living in the reservoir area to formerly natural areas;
- disruption of a river by formation of a lake (reservoir), by impeding migrations of aquatic species through construction of a dam and by changing the downstream flow pattern in this river.

The first two points affect mainly terrestrial vegetation and fauna, while the third point refers to impacts on hydrobiology (fish and other aquatic life). In addition to these points, the construction phase can have a major impact on specific species, e.g. by increasing pressure on certain plants or animals, mainly by collecting or (usually illegal) hunting carried out by the work force.

9.3 Introduction

In the case of plants, two aspects have to be considered, namely:

- Flora, i.e. the individual species of plants living in the area under study. For impact assessments, emphasis lies on the most important or frequent plants (which constitute a characteristic feature of the area), on plants which are of special importance due to their being used by the local population (as food, construction material, fuel, medicine and/or for economic purposes), and on rare, endangered and/or endemic plants, which are important from a biodiversity conservation point of view.
- Vegetation: these are the plant associations to be found in an area, which determine to a large extent the visual aspect of this area (forests, grasslands, wetlands, steppes etc.) and which also constitute the main component of the habitat of animals. Today, in most places (natural) vegetation overlaps with and is influenced very much by all forms of human land use (agriculture, forestry, pasture, etc.).

The description of vegetation and flora of the area to be affected by the Project will focus on vegetation on the land used for construction and to be submerged at reservoir impoundment, of any other land that might be occupied by the project, and on wetlands in the d/s area that might be affected by changes in river discharge pattern by the Project (mainly Tigrovaya Balka National Park).

9.4 Material and Methods

Part of the work carried was the revision of existing documents. The most important assessment of the vegetation cover of the reservoir area of Rogun HPP has been carried out by “Hydroprojekt” for the main Technical Report, Part II, Chapter 4: Nature resources and nature protection of 1978 (№ 1174 – T19).

Furthermore, several scientific studies (Grigoriev (1940, 1944, 1948, 1951), Nikitin (1938), Zaprjagaevoj (1964, 1970, 1976), Goncharov (1937), Sidorenko (1953, 1956), Sidorenko, etc. (1964), Shukurova (1963, 1970), Kaletkinoy (1961, 1971)) were used to draw a picture of the region. In addition, experts from the Institute for Geobotany AS RT have been interviewed.

Field work has been carried out in the project area, covering 25 characteristic sites within the area of the future reservoir. A plant list indicating the site where the plant was found is provided in Annex 9.

9.5 Prevailing situation

9.5.1 Stratification of the Vegetation in the Catchment Area

The project area is located within the Hissar-Darvaz floristic region, which covers a wide area in the central parts of Tajikistan. Its limits are the ridges of Hissar mountains to the north and the Alai mountains to the south. Westwards it extends as far as the border with the Republic of Uzbekistan.

The region is characterised by a number of ridges (Alai, Hissar, Karategin, Peter I and Darvaz), which extend mainly in a northeast to southwest direction. The elevation is considerable, the highest peaks of the Hissar range reach 5’400 to 5’700 m asl. Due to the general direction of these ridges, winds from southwest bring moisture into the valleys. The area covered by glaciers is relatively small, but still several 100 km².

Summers are hot and dry, precipitation falls mainly in winter and spring; however, overall precipitation is rather high as compared to other parts of Tajikistan. At lower elevations in the Hissar range, between 700 and 1’000 m asl, annual precipitation is 500 to 800 mm, reaching as much as 1’600 mm or more at elevations of 2’000 to 3’000 m asl (Gusharov, Khoja Obigarm). The highest values are reached on the Peter I ridge and on the southern slopes of Hissar.

The foothills generally do not receive snowfall, but at higher elevations snow cover usually reaches 1 m and lasts for 200 to 250 days.

Due to this rather abundant rainfall, vegetation in the Darvaz-Hissar region is the richest and most diversified of all of Tajikistan. It was the object of a considerable number of scientific studies and for that reason it is quite well known.

The zonation of the vegetation according to elevation is described here shortly.

1. Elevations from 700 (1100) - 1500 (1800) m asl - The lower parts of this belt are mainly meadows dominated by wheatgrass (*Agropyron* sp.), in the past they have been in association with a shiblyak (thicket consisting of thorn bushes and small trees) layer consisting of almonds and cherries which mostly disappeared. The upper parts of the belt are covered by mesophilic broad-leaved forest consisting of trees and shrubs; on shadowy northern slopes, these descend as low as 1’000 m asl. Important tree and shrub species within the shiblyak tree layer are *Amygdalus bucharica* (almond), *Crataegus pontica* (hawthron), *Pistacia vera* (pistachio), less often *Acer regeli* (maple), *Celtis caucasica* (Caucasian hackberry), *Zizyphus jujuba* (jujube), and *Cotoneaster racemiflora* (rockspray cotoneaster). Important plants in the herbaceous layer are *Elytrigia trichophora* (wheat grass), *Hordeum bulbosum* (barley), and the viviparous *Poa bulbosa* (bulbous bluegrass). The grasses *Cynodon dactylon (*common stargrass) and *Botriochloa ischaemum (*Turkestan bluestem) dominate on abandoned fields. In the floodplains in this zone *Juglans regia* (walnut), *Platanus orientalis* (sycamore), *Populus* spp. (poplars) and a number of *Salix* spp. (willows) can be found.

2. Elevations from 1500 - 2500 m asl - the belt of mesophilic broad-leaved forest vegetation characterised by junipers (*Juniperus* spp.). Other important species are *Prangos pobullaria, Juglans regia* (walnut), *Acer turkestanicum* (Turkestan maple) and *A. regeli* (maple), *Vitis hissarica* (common grape) and *Platanus orientalis* (sycamore); they are accompanied by a number of smaller tree species like *Prunus divaricata* (cherry plum), *Padellus mahaleb* (cherry), *Malus sieversi* (apple) and *Juniperus zeravashnaica* (juniper).

   Depending on slope and exposure, the composition of the vegetation in this zone can be quite different. On terraces with a northern exposition mesophilic forest with *Juglans regia* (walnut) can be found which are characterised by the shade requiring *Impatiens parviflora*. In valleys and on northern slopes *Juglans regia* (walnut) and *Acer* spp. (maple) forests, often mixed with *Populus* spp. (poplar) occupy a considerable space. Southern slopes are often treeless or show open stands of *Acer* spp. (maple), *Celtis caucasica* (hackberry), *Crataegus sp* (hawthorn), *Amygdalus bucharica* (almond), together with herbaceous species as *Agropyron* sp. (bluegrass), *Eremurus* sp. (desert candles), and *Prangos pabularia*.

On southern slopes of the western Hissar range stands of junipers (*Juniperus* sp.) are well represented. At the central part of the Hissar rage junipers (*Juniperus* sp.) are often association with *Pyrus bucharica* (Bukhara pear) and *Malus* spp. (apple).

The uppermost band of this zone, between 2'300 and 2'500 m asl is characterised by the most heat tolerant tree species as *Juglans regia* (walnut), *Platanus orientalis* (sycamore), and *Juniperus zeravshanica* (juniper). *Acer turkestanica* is a dominant species here, while *Exochorda sp.* (Pearlbush), *Acer regeli* and *Celtis caucasica* usually do not grow here. These open forests with high grasses are often combined with meadows, treeless spaces of significant extent, dominated by *Polygonum coriarium* and other tall meadow herbs. In dry areas open stands of *Juniperus turkestanica* and *J. semiglobosa* mixed with *Acer sp*. (maples) are often combined with a xeromorph ground vegetation dominated by *Ziziphora pamirolaica*, *Dianthus seravschanicus*, *Hypericum scabrum*, *Cousinia pseudobonvalotii* and *Onobrychis echidna*.

3. Elevations from 2800 - 3400 m asl is a belt of subalpine meadows. Due to rainfall and a rather low snow line, this vegetation type develops here at lower altitudes than in other regions of Tajikistan. *Juniperus turkestanica* still grows here, in addition to a high variety of *Lonicera* sp. (honeysuckle). Grass cover consists of *Festuca sulcata*, *Poa relaxa*, *P. litwinowiana*, *Polygonum eoriarium*, *Poa bulbosa* (bluegrass) and *Phlomis* sp. (Jerusalem Sage). Thorn cushion plant formations are noted within this belt in subalpine sections of Hissar-Darvaz, however, never occupying much area. Associations of *Onobrychis echidna*, *Astragalus lasiosemius* as well as *Astragalus nigrocalyx* are rather widespread. Other subalpine meadows are formed by *Eremurus zeravshanica* (foxtail), *Festuca rubra* (red fescue), *Geranium montana*, *Ligularia thompsonii*, *Agrostis canina*, *Zerna turkestanica*, *Allium fedtschenkoanum* and others.

   Steppes occupy a more modest place in the area, they are usually dominated by fescue (*Festuca* sp.) in combination with *Stipa kirgisorum*, *Geranium montana* in moister and *Cousinia stephanophora* in more stony places.

4. Elevations from 3400 - 3800 (4000) m asl - a belt of Alpine meadows. In general xerophytic meadows of different types. Meadows dominated by *Carex* sp. (sedges), *Cobresia pamirolaica* and *C. capilliformis* are the most humid type. Other important species are *Carex pseudofoetida*, *Carex melanantha*, *Potentilla gelida*, *Eremurus zeravshanica* and *Poa karategensis*.

   The dryer steppes are characterised by *Atropis subspicata*, *Festuca coelestis*, *Festuca sulcata* and *Poa litwinowiana*, accompanied by *Hedysarum cephalotes* an *Sibbaldia olgae* and sometimes by the "pillow plants" *Oxytropis immersa* and *O. savellanica*.

9.5.2 Vegetation Cover in the Area Affected by Rogun HPP

The vegetative cover around the projected Rogun water basin is non-uniform and can be subdivided into different belts.

As mentioned above, geobotanically the project area belongs to the Hissar-Darvaz floristic region, which under natural conditions is characterized by mid-mountain mesophilic broad-leaved forest. However, there is also a considerable xerophytic element. Very often the vegetation cover shows a mosaic of these two types, which is explained by different exposures of the slopes.

The vegetation cover changes in a horizontal direction due to unequal distribution of precipitation, which decreases from west to east. So, the vegetative cover of Garm and adjacent with it Romit, Komsomolobod and Tavildara changes from west to east. This is reflected in a gradual reduction of abundance and a deterioration of the development of mesophilic tree species like *Juglans regia* (walnut) and *Acer turkestanicum* (maple). *Exochorda*, a small genus belonging to the Rosaceae family is pinching out and to the east the mid-mountain mesophilic deciduous forest is dominated by *Rosa* spp., which are replacing the *Exochorda* species. Here the vegetation is characterized by a large xerophylisation of the vegetative cover.

The lower border of mid-mountain mesophilic broad-leaved forest belt is located in the average mountain zone, at a height of 1100 to 1500 m asl., and the upper border at 2400 to 2800 m asl. In general the limits of the mid-mountain mesophilic deciduous forest belt are within 1500 - 1800 m asl to 2600 - 3000 m asl.

The mid-mountain mesophilic broad-leaved forest belt vegetation is presented by following types:

1. Black forest (Broad-leaved forest) – Characteristic species of mesophilic broad-leaved thermophilic trees are *Juglans regia* (walnut), *Acer turkestanicum* (maple), *Exochorda* and *Rosa* spp.;
2. White Forest - hygrophilous tree species – *Betula spp.* (birches), *Populus* spp. (poplar);
3. Shiblyak - uniting formations of xerophilic communities – *Amygdalus bucharica* (almond), *Crataegus pontica* (korsh), *Pistacia vera* (pistachio);
4. Juniper forests - formations of evergreen cold tolerant and xerophytic species.

The mid-mountain mesophilic broad-leaved forest belt can be further divided in its vertical direction into two belts: in the lower part, which is dominated by shrubs, (mainly *Exochorda* sp., a species of Rosaceae typical for this association) and tree species (walnut and maple) extending to an elevation of 2300 - 2400 m asl, and the upper part, which is dominated by *Rosa canina* (yellow dog rose) with light maple forests.

The *Exochorda* are the most common species on the left bank of the Obihingou river. They form the basic background of the black forest. *Exochorda* thickets develop depending on the steepness of the slopes: on gentle slopes they can cover areas of 400-500 m. They form a dense thicket at elevations between 1600 m asl and 2700 m asl., and can be found on both flat and steep slopes. In addition to *Exochorda* sp. there are *Acer turkestanicum* (Turkestan maple), *Amygdalus bucharica* (almond), etc. Within the herbal stratum vegetation types dominated by *Exochorda* (on the left bank of the river) are semisavannoid with a dominance *Prangos pabularia, Hordeum bulbosum* (bulbous barley), *Scabiosa dzungarica*, etc.

The upper part of the mid-mountain mesophilic broad-leaved forest belt is dominated by *Rosa* spp. associations, which occur at the left bank of Obihingou river, from the river bank up to 3000 m asl. Characteristic tree species in this belt are *Acer turkestanicum* (maple) and on stony sites individual specimens of *Juniperus zeravashnaica* (juniper).

The herbaceous layer on the left bank of Obihingou river consists of meadows dominated by tall herbs, usually associated with wild roses (*Rosa* spp.) and maples. The wood vegetation is represented basically by maple forest and less often by walnut trees.

Maple forests are in general plantings with a variety of flowering shrubs and grass societies. The maple forests are occupying the lower parts of mid-mountain mesophilic broad-leaved forest belts.

The distribution of *Juglans regia* (walnut) is rather limited, they are represented by small patches among the *Exochorda* vegetation and maple forests, and mainly located on the lower parts of slopes, on river terraces and on river banks slopes. The walnut groves look like parks. The second society is represented by shrubs, like *Rosa canina* (yellow dog rose) and/or *Prunus divaricata* (cherry plum). The grass cover is sparse, shade-tolerant mesophyte plants are predominating, the plant society consists usually of the grass *Poa bulbosa* as well as *Senecio* sp. and *Tanacetum spp.*, etc.

Another vegetation type called shiblyak vegetation is dominated by *Amygdalus bucharica* (almond) and *Padellus mahaleb* (cherry). The highest concentration of almonds is located in the south on gravel and stone-gravel slopes in the lower part of the mid-mountain mesophilic broad-leaved forest belt.

The so called "white forest" is characterized by poplar, birch and willow associations, with a high distribution in the eastern part of the area, mainly located at the lower parts of the mid-mountain mesophilic broad-leaved forest belts at the lowlands and terraces of the rivers and the river bank slopes.

The riparian forest is distributed as small patches in the alluvial valleys of Vakhsh, Surkhob and Obihingou rivers. They form sparse phytocenosis on gravelstone areas, consisting of *Elaeagnus angustifolia*, *Salix purpurea* (purple willow), and *Hippophaë* sp. (sea-buckthorn). The herbaceous layer consists mainly of different grass species (Gramineae) and a variety of herbs (mainly Compositae, Labiatae and Papilionaceae). The ecological uniformity is typical for these societies. The upper societies are represented by mesophytic broad-leaved forest. The herbaceous layer usually has a xerophilous character (increased insolation and evaporation leads to a deficiency of moisture in summer).

Desert and semidesert ecosystem vegetation types occur only in small patches and are mostly degraded. Ephemerous desert vegetation (i.e. plans growing rapidly as soon as suitable conditions, mainly defined by scarce and irregular rainfall) can be found within the catchment area only in the Vakhsh river valley, between the two tributaries Mudshiharova and Obihingou, on a narrow strip on river terraces, occupying a small area. The present situation is that large parts are degraded by ploughing and used for agricultural crops.

Further to the east on the gravelstone terraces of Vakhsh river the ephemerous sage-brush (*Salvia* spp.) association is common. This area is also used for agricultural activities and therefore the ecosystem is not widespread anymore. Therefore only small fragments of this vegetation type persist. Rhubarb (*Rheum praksimovichil*), and buckwheat (*Polygonum* sp.) are growing on stony places, and *Prangos pabularia* is growing in moist spots. This belt is used in autumn by nearby villages as pasture.

Thus, the catchment area is located in a belt of mesophilic broad-leaved forest, which shows clear signs of degradation due to human use (agriculture, pasture); these influences have led to today's situation where actual forests have been eliminated almost completely, with the exception of small patches on steep slopes and difficult to access in elevations above the full supply level of the future reservoir.

There are also differences due to natural conditions. These changes in vegetative cover can be observed both vertically (by increasing elevation) and horizontally, from west to east, related to changes in precipitation. The development and abundance of trees decreases from west to east, where walnut, maple and *Exochorda* are increasingly replaced by associations dominated by wild roses (*Rosa* spp.), which are more xerophytic (tolerant of hot and dry conditions).

The main vegetation types encountered in the project area are shown on the map on the following page.

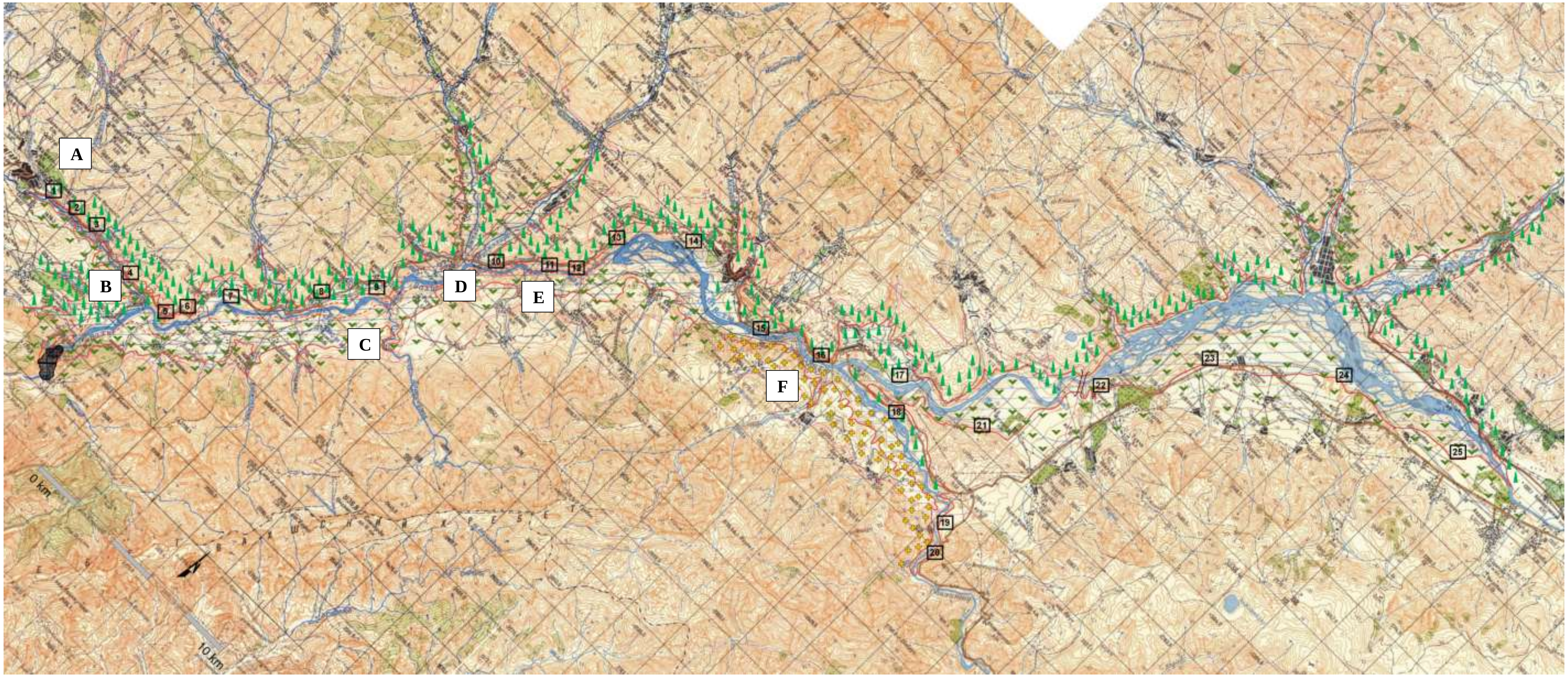


Figure 9-1: Vegetation sampling points and main vegetation types

Shiblyak forest with fragments of several ecosystems (semisavanna, ephemeretum, forb meadows, understock forest composed of narrow-leaved tree species)

Deciduous forest with fragments of several ecosystems (semisavanna, ephemeretum, forb meadows, understock forest composed of narrow-leaved tree species)

Juniper forest with fragments of several ecosystems (semisavanna, ephemeretum, forb meadows, understock forest composed of narrow-leaved tree species)

10 — Survey location

A — Photos of typical vegetation on following page

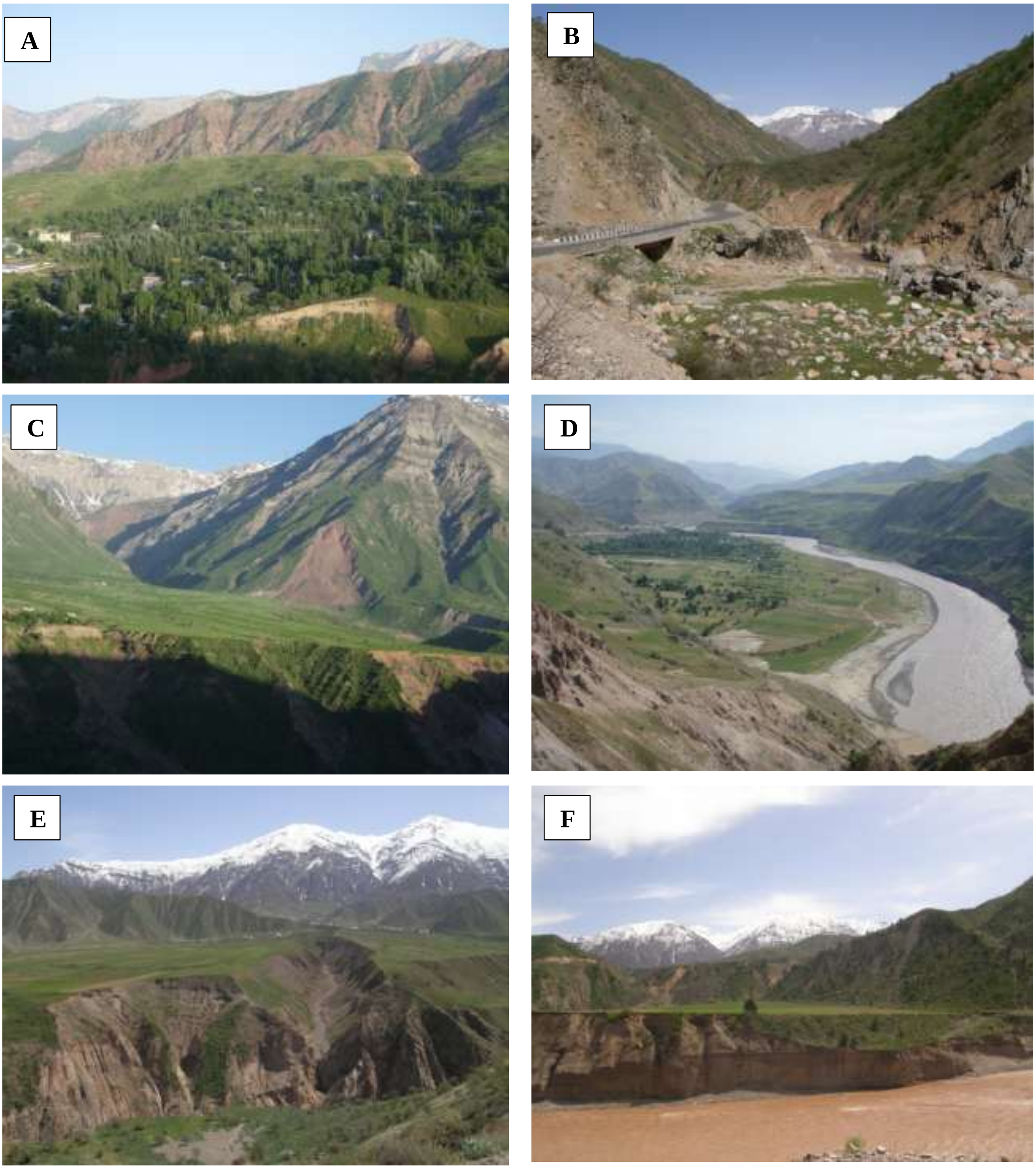


Figure 9-2: Typical aspects of the vegetation in the reservoir area

A: Obi Garm, above reservoir level.
B: Obi Garm valley, just below 1290 m asl. Shybliak forest area.
C: Left bank of Vakhsh river, lower part of terrace below 1290 m asl. Deciduous forest area.
D: Floodplain and river banks near Chorsada; this village will be the first to be submerged.
E: Left bank of Vakhsh river. Deciduous forest area.
F: Left bank of Vakhsh river, near Surkhob-Obihingou confluence. Juniper forest area.

It has to be noted that in the area which is going to be directly affected by the Project, i.e. on the land that will be submerged at the impoundment of the reservoir up to an elevation of 1290 m asl, there is no real forest left, as can be seen in the photos in Figure 9-2 on the previous page. Even if in the description of the vegetation "forests" of different types are mentioned, this should be read as meaning "sites which under natural conditions, uninfluenced by human activities, would be covered by forest". Presently, all these former forests have been replaced by a mosaic of various secondary vegetation types with a more or less steppe character, and single isolated trees of different species can be found there at best. The rests of the shybliak forests are mostly formed by bushes, with some small trees, if any. Only on some steep slopes which are not easily accessible some small remnants of forest can be found, but these are far above 1300 m asl, and even these are stands of bushes and single trees rather than real forests. This degradation is mainly due to the fact that the entire area is rather densely populated, and that all of it is used as pasture. In spite of this, when characterising the vegetation of the area, the term "forest" is being used. The only spots within the project area which sometimes give the impression of being covered by forests are in fact the settlements (see e.g. Photo A in Figure 9-2); however, these partially rather dense stands of trees are all planted, mostly poplar (used as hedges and for timber) and fruit trees, like e.g. mulberry and apple.

Species occurring in the project area which are listed in the Red Data Book of Tajikistan are given in the following Table. None of these species is restricted to the project area, and, within the project area, none is restricted to the area which will be submerged by the future reservoir; the project will not endanger any of them.

Table 9-1: Red Data Book species found in the project area

Scientific name	English name	Russian name	Distribution [m asl]
Campanulaceae			
Ostrowskia magnifica		ОСТРОВСКИЯ ВЕЛИЧЕСТВЕННАЯ	1100-2800
Crassulaceae			
Rosularia lutea		РОЗЕТОЧНИЦА ЖЕЛТАЯ	2800-2900
Iridaceae			
Iris darwasica		ИРИС ДАРВАЗСКИЙ	1500-2800
Iris Hoogiana		Ирис Гуга	1500-3500
Juno baldshuanica		ЮНОНА БАЛЬДЖУАНСКАЯ	1600-2000
Liliaceae			
Allium Suworowii		ЛУК СУВОРОВА	900-2300
Petilium Eduardii		ПЕТИЛИУМ ЭДУАРДА, РЯБЧИК ЭДУАРДА	1200-2100
Tulipa linifolia	Slimleaf Tulip	ТЮЛЬПАН ЛЬНОЛИСТНЫЙ	1300-1800
Tulipa praestans		ТЮЛЬПАН ПРЕВОСХОДЯЩИЙ	1000-2000
Paeoniaceae			
Paeonia intermedia		ПЕОН СРЕДНИЙ	2000-3000
Rosaceae			
Rosa longisepala		РОЗА ДЛИННОЧАШЕЛИСТИКОВАЯ	2200-2500

9.6 Impacts

9.6.1 Impact of construction

First of all it needs to be mentioned that the construction already started in the 1980ies. Thus, the vegetation cover within the construction area is already degraded due to the past construction activities, the clearance of the dam site and appurtenant structures like camp sites, access roads, etc. have been carried out a long time ago. Therefore the additional impact is estimated to be negligible, as long as additional dumping sites outside the future reservoir area are kept as small as possible; any excavation material, e.g. from additional tunnelling, should be used for the dam construction, whenever possible. Strong efforts needs to be taken to reduce the erosion (see Vol. III: ESMP).

9.6.2 Impacts on Flora

The largest part of the area to be submerged is land which originally was covered with mesophilic broad-leaved forest; and which by now has been converted to agricultural land, orchards or pasture (see Table 9-2). As has been shown above, there are no plant species, including the species listed in the Red Data Book of Tajikistan, which are restricted to this area and would therefore disappear from the wider area of the Hissar-Darvaz floristic region. It should also be noted that within the reservoir area there are no real forests left; what is referred to here as "forest" are in reality, as mentioned above, areas whit forest potential, i.e. areas which would be covered by forests in absence of human interference. Under prevailing conditions, these areas are strongly degraded by human use (logging and use as pasture). Only single trees, often stunted, remain as indicators of former forest cover.

Given the fact that no particular and unique species or habitat types have been identified in the affected area, and that the plant species growing inside the reservoir area can also be found around the reservoir and in other parts of the country, the impact on vegetation can be qualified as rather small. The magnitude of the impact is obviously related to the area which will be inundated.

9.6.3 Impact on Vegetation and Land Use

At an FSL of 1290 m asl Rogun reservoir will submerge 170 km^2. A 70 km long stretch of floodplains including the riverbank vegetation and the walls along the river will be submerged. Two floodplain habitats are located within that area, one between Chorsada and Nurobod (Komsomolobod), the other between the origin of Vakhsh river at the confluence of Obihingou and Surkhob, stretching along the latter to the upstream end of the reservoir. Some remnants of mesophilic broad-leaved forest, now reduced to shrub, which grow mainly on the steep slopes of the tributaries to both sites of the Vakhsh river, and a rather large part of meadow (pasture) area will be submerged.

The following Figure and Table show impacts of the project on vegetation types and land use.

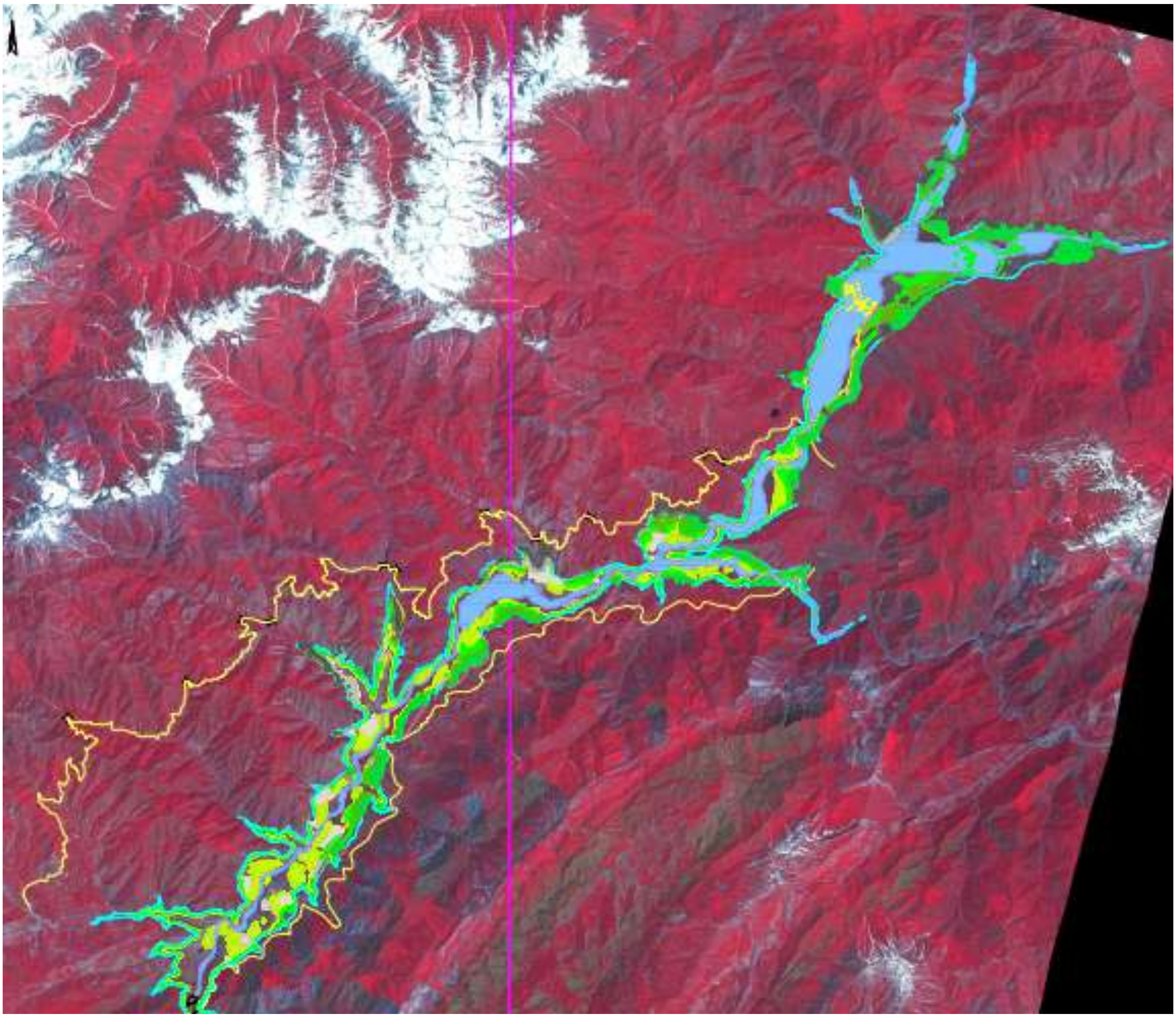


Figure 9-3: Affected land use types in the reservoir

Legend:

Land use type	**FSL 1220**	**FSL 1255**	**FSL 1290**
River and floodplain			
Cultivated land			
Settlements			
Degraded habitats, pasture	not shaded		

Note: this evaluation was made for the three different reservoir levels (see Figure 3-3) which were analysed as potential project alternatives. As explained in Chapter 3, the TEAS recommended alternative is FSL 1290.

The following Table shows the land use types that will be affected by the project.

Table 9-2: Habitat and land use types submerged at reservoir impoundment

Land use / vegetation type	**FSL 1220**		**FSL 1255**		**FSL 1290**	
	km²	**%**	**km²**	**%**	**km²**	**%**
River and floodplain	20.6	30.3	34.2	30.0	42.2	24.9
Agriculture (fields)	9.3	13.7	17.2	15.1	31.6	18.6
Settlements (orchards)	3.1	4.5	5.8	5.1	14.5	8.5
Pasture	35.0	51.5	56.8	49.8	81.7	48.1
Total	**68.0**	**100.0**	**114.0**	**100.0**	**170.0**	**100.0**
In percent of 1290 FSL reservoir		**45.8**		**70.3**		**100.0**

Determination of land types was done on the basis of the satellite picture and the ground truthing carried out during the field survey of the vegetation. A short description of the land use and vegetation types follows:

- River and floodplain: almost a third of the area to be submerged is today "river bed", i.e. an area dominated by the river and its natural dynamic, including land which is flooded only during the peak flow season. This included some major floodplains. Human interference here is rather small.
- Cultivated land: this includes agricultural land, but also land used for producing hay for the livestock. These areas are used very extensively, there is as good as no natural vegetation left.
- Settlement: this is all the land within settlements, i.e. including buildings and streets. The larger part of this area, however, is made up by house gardens, which are characterised mainly through a high number of fruit trees, which sometimes give them an almost "forest-like" aspect.
- Pasture: this comprises all the remaining areas and makes up roughly half of the total area to be submerged. There are no really natural habitats left in this area, vegetation is mostly strongly degraded due to its use as pasture.

One important point is the fact that the largest reservoir, i.e. the recommended alternative (FSL 1290), does not only occupy the largest fraction of settlement land in absolute terms, but also in percent. This is due to the fact that in the upper part of the reservoir the valley is generally wider, with gentler slopes, and therefore more densely populated.

When comparing these figures with the ones provided in Chapter 13, Table 13-22, some discrepancies become immediately apparent. This is presumably mainly due to the fact that different categories were used. While the State Land Committee, from where the figures in this latter Table stem, concentrated on types of land use (which is the relevant criterion in Chapter 13, which deals with socio-economic aspects of the project area), here the focus is on habitats. As mentioned, there are no natural habitats of critical importance in the affected area, however, the floodplains were identified as the most important type of natural habitat to be found here. For this reason, it was important to have here a separate category identified as "river and floodplain"; this is presumably included in the broad category termed "other" in Table 13-23, a category which probably also contains some land which here is included under pasture.

9.6.4 Impact of New Access Roads

One additional project impact will be caused by the new access roads; the road sections to which reference is made here are shown in Figure 3-5.

The following Table shows the land use of the new access road on the right bank, lower part of the reservoir (road #5).

Table 9-3: Land used for access road on left bank, lower part of reservoir

Land use type	Length (m)	Area (ha)
Reservoir / creeks	844	1.01
Agriculture (fields)	8'373	10.05
Settlement (orchards)	5'682	6.82
Pasture	35'462	42.55
Total	**50'362**	**60.43**

This road, of a total length of 50.4 km, will have an average width of 12 m (carriageway of 4.5 m, with a shoulder of 1.75 m and on average 2 m of berms or cuts on either side).

This road is required since the existing access to the villages on the left bank, which is granted mainly by small foot bridges crossing Vakhsh river, will be submerged. It will greatly improve access to these villages.

Road #5 will be required irrespective of the dam alternative chosen, since in this area the reservoir will submerge existing access roads (or rather: paths) irrespective of its final level, therefore there is no difference in land occupation between the three alternatives.

This is different for the new access road along the right bank of the upper part of the reservoir (called road # 4, see Figure 3-5). Here, the alternative will have a very decisive effect on the required length of new (or upgraded) road, as can be seen in the following Table.

Table 9-4: Land use for access road on right bank, upper part of reservoir (ha)

Vegetation and land use type	Unit	Reservoir FSL		
		1220	**1255**	**1290**
Agriculture (fields)	ha	0.00	2.40	2.40
Settlements (orchards)	ha	0.60	0.60	0.60
Hay land	ha	1.08	1.08	1.08
Pasture	ha	37.92	45.72	75.72
Mountain (rock outcrops)	ha	7.20	10.80	19.20
Total	**ha**	**46.8**	**60.6**	**99.0**
Use/upgrading of existing roads (km)	km	9	13	16
Total length of new road	**km**	**33**	**53**	**99**

This road leads through topographically very difficult terrain, and for this reason only small parts of it are cultivated or inhabited. The largest part is again pasture (i.e. degraded habitats of different types, like mountain meadows and forest relics); in addition to that, some areas, here identified as "mountain", are naturally unproductive habitats, mainly rather steep slopes, in part rock outcrops; this latter is a habitat type with is extremely widespread in the entire project area, especially above reservoir FSL.

Here again, road #4 is required for granting access to villages which otherwise would lose their access due to the reservoir. Obviously, the length of required road is in direct proportion to the size of the reservoir.

The impact of the roads in terms of occupation of land and impact on vegetation is small. However, like every road built in this area, they can trigger erosion, which can locally become quite massive. Measures will have to be taken for stabilising the berms and slopes in order to minimise erosion.

9.6.5 Indirect Impacts

Additionally, future resettlement areas will have also a small impact on the flora since they will partly use land which has not been occupied until now, but these areas are rather small compared to the inundation area. Resettlement carried out so far was done in areas largely used for agriculture until now, and no valuable habitats were affected.

Another indirect impact could result in the surroundings of the reservoir, and this will mainly depend on how many people will be resettled (i.e. relocated outside of the project area) and how many will stay in the region. The question here is whether the carrying capacity of the remaining land will be sufficient for the number of people and their livestock. This question will have to be addressed in the course of preparation of the Stage 2 RAP.

9.6.6 Effects of Submerged Biomass

An additional important point to be considered in the framework of an ESIA for a hydropower project is the amount of vegetation submerged in the reservoir at first filling, which will then decompose. As the decomposition of plant material consumes high quantities of oxygen, this can lead to anaerobic conditions in water deeper than 5-10 m. This in turn can produce problems when this water is used for power generation and then discharged downstream, as it can contain toxic substances (mainly H_2S). Furthermore, it needs to be mentioned that under anoxic conditions, the ongoing breakdown process of the biomass leads to the production of methane (CH_4), which is one of the major greenhouse gases. These problems arise mainly in the case of reservoirs in the humid tropics, where very high quantities of biomass can be present in the reservoir area. Mitigation for this problem in such cases consists in a thorough pre-impoundment reservoir clearing. This topic is addressed in Section 8.3.4, which clearly shows that in the case of Rogun, given the small amount of biomass to be submerged, this type of problem will not arise.

While the estimates made show that oxygen depletion due to submerged biomass will certainly not be a problem, it is still recommended to carry out a pre-impoundment reservoir area clearing. This, however, will be restricted to cutting the trees growing in the settlement areas, with the main aim to make use of timber and other useful wood (e.g. fuelwood) growing in the reservoir area. This is a valuable resource which would otherwise be lost due to reservoir impoundment. Trees should be cut before submersion and wood that can be used should be removed from the area.

Rogun reservoir will be filled in stages (see Figure 21-3). The pre-impoundment clearing will have to be in coordination with this staged filling, with the aim of clearing areas as shortly before impoundment as possible, in order to prevent regrowth. In the last stage, for reaching the final FSL, care will have to be taken not to cut any trees, and not to burn any vegetation above this level.

9.7 Mitigation Measures

With one exception, the floodplains to be submerged, specific compensation measures are not required, since otherwise no habitats of value will be affected. Still, some measures for protecting the vegetation especially during the construction period are recommended:

- Logging by the work force must be strictly forbidden, in order to maintain the vegetation above the FSL as intact as possible. The contractors will have to provide heating in worker's quarters as well as fuel for cooking in order not to create a requirement for fuel wood.
- Areas located in the vicinity of the construction site, but not directly designated for a specific use, should be fenced off, and their use - including the occasional driving on such areas with vehicles and construction machines - must be forbidden.
- Wherever construction activities, e.g. for new roads, take place above the future water level of the reservoir, appropriate measures should be taken for preventing or limiting erosion. This can include the planting of suitable trees on slopes etc.
- In suitable areas above the future FSL of the reservoir, trees should be planted, preferably local species like poplars, apricot, apple and mulberry, for replacing such trees that will be lost to submersion. This would also be a benefit for the population in settlements which will not be relocated.
- The project will not affect or destroy any forests, since no forested land is present in the project area. For this reason, no reforestation is required as mitigation measure for the project.

On the other hand, trees within the reservoir area should be felled before impoundment, mainly for making use of the wood, which can be used for construction purposes or fuel wood. Since impoundment will occur gradually over the entire construction period of 15 years, this removal of trees should be done accordingly.

Concerning mitigation for the floodplains mentioned above, see Section 10.6.3).

Furthermore, a watershed management and monitoring plan (see Section 24.5) is required by the ESMP. This would include reforestation and other possible measures to minimise the erosion of the slopes, but also to increase productivity of pastures and forests. Such a plan would need to take into account the human activities (agriculture, pasture), training of the population concerning sustainable farming and husbandry (correct plantation, seed selection, irrigation, plant pests, etc.). This cannot be seen as a mitigation of project impacts caused by Rogun HPP, but would rather have to be part of a regional development plan. It has to be pointed out, however, that such a program would have positive effects on Rogun HPP, mainly by helping to decrease the amount of sediment being washed into the reservoir.

10 TERRESTRIAL FAUNA

10.1 Key Messages

This chapter deals with the impact of the project on terrestrial fauna. The following are the key messages.

- Fauna depends mainly on its habitats. As explained in the previous chapter on vegetation, all habitats in the project area are strongly influenced by human use, and therefore changed and degraded. No especially rare and valuable habitats can be found in the area.
- The project will not negatively affect any endangered, rare or protected species of wild animals.
- There is one type of natural habitat, two floodplains located within the future reservoir, for which an offset will be required.

10.2 Theoretical Considerations

The statements made in the Chapter on Vegetation on biodiversity aspects in dam projects are largely valid for the terrestrial fauna as well, since animals largely depend on their habitats.

One specific issue that often needs to be considered is the potential impact of a project on migrating species (especially birds). This is insofar of importance that a specific site - as is the case for many wetlands - can be of high importance for the survival of animal populations and species even if they do not live there permanently, but use this area only at specific times of the year, e.g. as resting and feeding places during migrations or as overwintering areas.

10.3 Introduction

In the framework of an EIA, it is never possible to study all the animal groups living in the study area. The efforts have to concentrate on groups of animals which can more or less readily be identified and whose habitat requirements are known well enough, and which can therefore serve as indicator organisms for the state of their habitats. As for plant species, the emphasis lies on either economically important species (food or other uses, pests) and on rare, endangered and/or endemic species. The most important groups in this sense are mammals and birds, and reptiles and amphibians. For the entire aquatic fauna, fish serve as indicator organisms.

10.4 Material and Methods

Important initial work was the revision of existing documents. Background information on fauna in the region was extracted from articles and books from researchers like I. Abdusalyamov, V. Stalmakova, Isakov, Popov, and others.

In addition, the report of the Technical Project for Rogun HPP on the Vakhsh river (Part Two, Volume 4-I), "study on species composition of birds and terrestrial vertebrates", carried out by the Research Institute "Hydroproject" in 1978 has been reviewed.

In 1978 147 bird species representing 15 orders were detected, which have been referenced to the vegetation zones; a complete list was not included in the technical report. The information on reptiles and mammals seems to be rather complete.

The Study carried out in 2009 by Hydroproject concentrates on the species composition of mammals and birds listed in the Red Book of the Tajik SSR (Dushanbe, 1988).

This data have been verified with following literature:

- “Birds of the USSR”, Dementiev et al, 1954;
- “Birds of the USSR”, Flint et al, 1968;
- “Fauna of the Tajik SSR, Birds”, Abdusalyamov, 1973;
- “Nature and Wildlife in Central Asia”.

10.5 Prevailing situation

During the work for this report, two species of amphibians, 12 reptiles, 37 species of mammals and 154 species of birds have been identified in the project area (see Annex 10).

Birds and amphibians have been identified with reference to their habitats (ecosystems). Many bird and mammals (mainly carnivores) occupy a wide range of habitats. Some migrate depending on the season from one habitat to another and others visit the project areas only during their seasonal migrations.

Five main vegetation zones have been identified in the project area. The following list gives a short summary on the habitats concerning the number of animals which occur in each habitat (See Annex 10 for species lists):

1. The floodplain of the Vakhsh river and riparian vegetation are particularly important. Both amphibian species and 5 reptiles can be found in the floodplain area. The *Vipera lebetina* (Blunt-nosed viper) is categorised as endangered species by IUCN. Just 9 species of mammals have been identified for the floodplain; *Lutra lutra seistanica* (Eurasian otter) is one of the key species in the floodplain habitat and is categorised by IUCN as near threatened; however, its presence in the two floodplains affected by the project has not been confirmed. 44 bird species are representing the floodplain habitat, 26 of them are nesting in that habitat, and 18 species, mainly water birds (ducks, goose, little egret, grey heron etc.), can be counted as migratory species for spring or autumn.
2. Elevation from 700 (1’100) up to 1’500 (1’800) m asl. The lower parts of this belt are mainly meadows dominated by wheatgrass (*Agropyron sp.*), while its upper parts are sparsely covered with trees. Most of the species, which can be found here prefer wide and open areas with clusters of woody vegetation. It is the habitat with the highest number of reptiles (10 species). Furthermore one of the two amphibian species occurs in that region and at least 51 bird species, among them one endangered species, *Neophron percnopterus* (Egyptian vulture), and two near threatened species, *Aegypius monachus* (Cinereous vulture) and *Coracias garrulus* (European roller). Almost all species of larks are found in this habitat and it is used by several birds of prey as feeding territory, among them all kinds of scavengers. The migration routes of many birds pass through this belt, even those of species which during the nesting period prefer completely

different biotopes like plovers, twits and re-capped finches. The most noticeable birds of this zone are rose-coloured starlings, mynas and field sparrows.

Mammals are rather well represented (26 species) in this habitat in view of species composition. There are hedgehogs, and 10 kinds of chiropterans, frequently using dwellings in settlements as habitat. The Himalayan brown bear, which is listed as endangered species by the IUCN Red List, as well as the wolf and the fox visit this zone occasionally. All three carnivores are listed by CITES, the first two in Annex I and II, the fox in Annex III. Furthermore steppe cat, badgers and weasel occur in this habitat.

3. Elevation from 1500 up to 2500 m asl. This belt is dominated by trees and shrubs, characterised by junipers (*Juniperus spp*.); another important specie is *Prangos pobullaria.* In this zone the amphibians almost disappear, and the number of reptiles is reduced to 7 species. However, the number of mammals increased to 28, the Central Asian lynx can be added for the carnivores and some of the rodents changed. The number of nesting bird species increased up to 52. However, such groups like larks are disappearing, and meanwhile mainly forest species appear - starlings, grosbeaks and green linnets. It is necessary to note hawks from birds of prey, as well as hobby. None of the threatened bird species appears in this belt, since the vultures nest higher and are foraging in areas with less vegetation.
4. Subalpine meadows in the project area are located between 2800 up to 3400 m asl. They are characterised by heaths, thorny grass and juniper elfin wood (*Juniperus sp.*). No amphibians occur anymore in that height, the reptiles are keeping the number of species stable, the mammals decreased to 14 species and the birds to 44 species. Insectivores and chiropterans are not anymore existent in that height, carnivores are represented by six species, two of them are in the category of endangered species (Himalayan brown bear, snow leopard). Furthermore the ibex, tolai hare, pika, marmot and some species of voles can be found. Three of the species among the birds of prey are in the Red List of IUCN: *Neophron percnopterus* (the Egyptian vulture) is endangered, *Falco cherrug* (the Saker falcon) is vulnerable, and *Aegypius monachus* (the cinereous vulture) is listed as near threatened. In this zone migrants are practically absent.
5. Alpine short grass meadows, heaths and thorny grass, as well as cushion plants are located from 3400 up to 3800 (4000) m asl. Just three reptiles can be found in that altitude. The number of bird species is reduced to 11 and the number of mammals as well. Five of the eleven species are bird of prey and six of the eleven mammals are carnivores.

10.6 Impacts on Fauna

10.6.1 Impact of Construction

The main impacts on the terrestrial fauna resulting from the construction of Rogun HPP will be the disturbance caused by noise and the presence of a high number of people, which includes the risk of illegal hunting. It should be mentioned that this situation is not new since the construction of Rogun HPP already started in the 1980ies, but the workforce will increase when the construction of the main dam starts. It will also be restricted to the immediate surroundings of the dam site and along roads, while the remaining area around the future reservoir will not be affected by construction activities in any way. There is no indication of the presence of any wildlife around the construction site.

10.6.2 Impact of Rogun HPP

The prevailing situation describes five important ecosystems, the floodplain habitat is a special habitat passing through the four belts (altitudinal zones). Rogun HPP will have a direct impact on all the species within the reservoir area up to its full supply level, since this area will be submerged and the habitats will disappear. Furthermore, it will have an indirect impact on the area above FSL. The indirect impact will be caused due to a higher pressure on those habitats from human activities (overgrazing, fuelwood collection, hunting etc.).

The reservoir will submerge 170 km^2. A 70 km long stretch of floodplains including the riverbank vegetation and the walls along the river will be submerged. Two rather special floodplain habitats are located within that area, one between Chorsada and Nurobod (Komsomolobod), the other between the origin of Vakhsh river at the confluence of Obihingou and Surkhob, stretching along the latter to the upstream end of the reservoir.

A rather large part of the meadow area will be submerged. The indirect effect could strongly increase depending on how many people will be resettled and how many will stay in the region and if the area is capable for the amount of people and the livestock.

The directly affected habitats are the floodplains with the riverbank vegetation, which is the habitat of the two amphibian species and of *Lutra lutra seistanica*, the Eurasian otter, and the walls along the river, which are composed of river sediment, gravel and loess/silt. These walls are used by several birds like European Bee-eater (*Merops apiaster)*, Common Kingfisher (*Alcedo atthis*), Common Myna (*Acridotheres tristis*) sparrows, pigeons and doves, etc. as breading areas. Protected carnivores (brown bear, wolf, fox) also appear in the area, but since their distribution is from 700 up to 3800 m asl, and they generally avoid the vicinity to settlements, it is unlikely that there will be any significant impact.

The second area directly affected will be the belt were the lower parts are mainly meadow and dominated by wheatgrass and were the upper parts or the areas with a steeper slope are partly covered with trees and shrubs. Most of the larks, shrikes and wheatears are breading here, and the birds of prey use this area for foraging.

Part of this area, all above either 1110 m asl or 1290 m asl might be indirectly affected by a higher human pressure.

Overall, given the strong degradation of directly affected habitats by human influence (see Chapter 9), the impacts on fauna will be small.

10.6.3 Mitigation Measures

Given the type of project the impact on fauna within the reservoir cannot be mitigated, but since the wellbeing of the fauna is strongly related to their habitats it should be forbidden to destroy additional areas due to dumping of construction material. The excavation material should be deposed whenever possible in an already degraded area and should be re-used for the construction of the dams.

Logging needs to be forbidden for the workforce and Rogun HPP will be responsible for adequate heating, of their living quarters, which does not use wood as energy source.

Additional measures will consist in training the workforce in both construction and operation phases to protect vegetation, and to prevent hunting in the entire project area.

The floodplains (two of which will be affected by the reservoir, a smaller one near Komsomolobod, a larger one further upstream, near Nurobod) have been identified as important habitats for wildlife. This type of habitat has become extremely rare in many parts of the world, and especially in highly developed countries, where river training and other regulation measures, mainly for the purpose of flood protection and for gaining agricultural land, have led to their almost complete destruction. This is not (or not yet) the case in Tajikistan, where this habitat type can be found along all major rivers. This means that there are sufficient habitats of this type around to ensure the survival of the species living there.

This leads to the conclusion that these floodplains are not critical natural habitats in the sense of OP 4.04. However, both of these floodplains, which will both be completely submerged with the 1290 FSL alternative, have to be considered as natural habitats for which OP 4.04 requires an offset if avoidance of the impact is not possible, in spite of the fact that they have been degraded to some extent by human interference. As Figure 3-3 and Table 9-2 show, avoidance of the impact is not really an option. With FSL 1255, only a small part of the upper (larger) floodplain would remain intact, and even FSL 1220 (which is not considered to be a viable alternative) would submerge up to a third of this and all of the other, smaller floodplain. For this reason, the following steps are proposed for being carried out before impoundment:

- pre-impoundment survey of both floodplain areas (covering vegetation and fauna) and, based on its results,
- formulation of an offset plan.

Presently, the Consultant recommends measures to be taken in the Tigrovaya Balka area as offset for this impact, and this for the following reasons:

- Tigrovaya Balka is a floodplain on the same river (Vakhsh), although in lower lying areas. It is a different type of floodplain (so-called Tugai), which however, unlike the affected floodplains, is a type of valuable and increasingly rare habitat.
- Tigrovaya Balka will not be affected by Rogun HPP, however, it has been affected by Nurek HPP; providing measures to improve the situation there could therefore be a way for compensating at least to some degree, the cumulative impacts of the Vakhsh cascade.
- Tigrovaya Balka is a critical habitat in the sense of OP 4.04: area legally protected on the national level, type of rare habitat with high importance for biodiversity conservation). Unlike floodplains affected by the project Tigrovaya Balka is also an IBA (Important Bird Area) according to Birdlife International, (http://www.birdlife.org/datazone/country/tajikistan/ibas).

A description of this habitat is provided in Chapter 12, and an outline of the proposed offset measure in Section 12.5.

11 AQUATIC FAUNA

11.1 Key Messages

The focus of this chapter is mainly on fish, and on the effects the project could have on them. Key messages are:

- No long range fish migration presently takes place in Vakhsh river. If earlier there would have been any, they were definitely interrupted by the construction of Nurek dam.
- Given this fact, Vakhsh river, including the section directly affected by Rogun HPP dam and reservoir, is not considered as a natural habitat.
- The river in the project area, with its very high sediment load, is not a very good habitat for fish.
- The fish fauna is very poor, both in terms of species and in terms of numbers. Fish do not have any economic importance for the local population.
- Fisheries developed rather well in Nurek reservoir after impoundment, but catches diminished after a few years. In this period, a number of species were introduced to the reservoir, most of which have not become permanently established.
- Rogun dam will have a negative impact on the local fish fauna, but this will be of minor importance.
- Rogun and/or Nurek reservoirs might have a certain potential for commercial fisheries, e.g. for fish cage aquaculture. It is recommended to study this potential once Rogun will have been built; however, the introduction of exotic species is not recommended.

11.2 Theoretical Considerations

The main effect of a dam and reservoir project on fish populations is often the fact that the dam will constitute an obstacle to migration. Many species of fish carry out migrations, and some of them depend on these migrations for reproduction.

A second effect on fish is the fact that a part of the river will change from river to lake conditions. While some species can adapt easily to this type of habitat, others cannot and will therefore diminish in numbers or will disappear altogether from this area.

A third potential effect on fish can be caused by a change in river flow pattern d/s of the dam, e.g. in cases where seasonally flooded areas serve as breeding grounds, and when this flooding no longer takes place due to the regulating effect of the dam.

Finally, fish populations can be affected by the indiscriminate introduction of exotic species (which is sometimes done as mitigation measure for a dam project, but very often independently of that), e.g. by introducing the exotic rainbow trout, a good sport fish, to European and Asian waters, often to the detriment of native species.

11.3 Prevailing Situation

The ESIA for Rogun has to take into consideration that Nurek dam was built about 30 years ago approximately 70 km downstream of Rogun dam site. This means that any long range fish migrations that might have occurred here from Amu Darya or the lower parts of Vakhsh river to its headwaters have already been interrupted. In any case, Vakhsh river with its exceptionally high sediment load (up to 4000 g/m³) does not favour fish migrations. Coarse moving sediment can cause damage to fishes, and the fine suspended solids negatively affect gill functions.

In the upper part of Vakhsh (Surkhob) river, in the region of Jirgital and further upstream, there is a number of small lakes which are connected to the river, and in this area there are populations of Amu Darya trout (*Salmo trutta oxianus*), brown trout (*Salmo trutta fario*) and common marinka (*Schizothorax intermedius*). Fish species present in the river system upstream of Nurek dam still carry out short range migrations, e.g. between Vakhsh river and its tributaries.

When describing the fish fauna of Vakhs river, it also has to be mentioned that a number of exotic species of fish were introduced into Nurek reservoir. The following Table provides a list of fish species from the wider area, with some indications on distribution.

Table 11-1: Fish species of central and northern Tajikistan

Family **English name**	**Russian name**	**Scientific name**	**Occurrence**
Acipenseridae (sturgeons)			
	Лопатонос сырдарьинский	*Pseudoscaphirhynchus fedtschenkoi*	Syr Darya
	Щип Аральский	*Acipenser nudiventris*	Syr Darya
Salmonidae (salmons, trouts)			
Amu Darya trout	Форель амударьинская	*Salmo trutta oxianus*	+ Vaksh
Rainbow trout	Форель радужная	*Oncorhynchus mykiss (S. gairdneri)*	+ e
Brown trout	Пресноводная форма Аральского лосося	*S. trutta fario*	-
Coregonidae			
	Пелядь	*Coregonus peled*	- e Nurex
Cyprinidae (carps)			
	Маринка обыкновенная	*Schizothorax intermedius*	- Nurek
	Храмуля самаркандская	*Capoeta capoeta heratensis*	-
	Быстрянка пёстрая	*Alburnoides taeniatus*	+ e Nurek
	Толстолобик белый	*Hypophthalmichthys molitrix*	+
	Толстолобик пёстрая	*Hypophthalmichthys nobilis*	+
Carp	сазан (карп)	*Cyprinus carpio*	+
Cobitidae			
Tibetan stone loach	Тибетский голец	*Triplohysa stoliczkai*	+ Vaksh
	Гребенчатый голец	*Paracobitis malapterura*	+
	Таджикский голец	*Iskandaria kuschakewitschi*	+

Siluridae (catfish)			
Turkestan catfish	туркестанский сомик	*Glyptosternon reticulatum*	+ Vakhsh

Notes:
+ / - = presently found / not found in river or reservoir
e = exotic, species introduced to Nurek reservoir
Scientific names updated acc. to http://www.fishbase.org/Nomenclature/ScientificNameSearchList

11.3.1 Experience with Reservoirs in the Area

Dams are usually built, and reservoirs created, for generating hydropower and/or for providing water for irrigation. However, reservoirs can also be used for fishing and fish farming.

In the Sukhd region, on Syr Darya, two reservoirs have been built, Farkhad, with an area of 4.8 ha, in 1947, and Kairakkum, with an area of 52’000 ha in 1956. Originally, these waters were inhabited by 18-20 species of economically interesting fish. Therefore, fisheries in these reservoirs was organised in the early days of their existence. In Kairakkum reservoir, рыбпромхоз (fisheries management) started to be organised in 1962 and has yielded 300-400 t of fish annually since then. It has to be pointed out that Kairakkum is a large, shallow reservoir (maximum depth 18 m) without a very considerable drawdown; its productivity in terms of fisheries therefore is much higher than that of Nurek reservoir, which is a narrow and very deep reservoir with a very important drawdown.

Before the creation of these two reservoirs on Syr Darya, two endemic fish species, the Syr Darya shovelnose sturgeon (сырдарьинский лжелопатонос, *Pseudoscaphirhynchus fedtschenkoi*) and the Aral schip or fringebarbel sturgeon (аральский щип, *Acipenser nudiventris*) lived in this river. After the construction of the power plants, these two species gradually disappeared. However, the reservoirs proved to be a suitable habitat for other species, which developed well and created a good basis for fishing. In addition, a number of species were introduced to this area.

In 1973, Nurek reservoir was created, with a surface of 98 km². Other than Kairakkum reservoir, Nurek is a mountain reservoir, narrow, with steep slopes, a maximum depth of almost 300 m, and a normal yearly drawdown of up to 50 m. Inflowing water is cold even in summer. At the surface of the reservoir, water temperature in summer reaches 22 to 23°, and below a depth of 10 m temperature does not exceed 10°C, indicating a stable thermal stratification of the reservoir. These conditions, together with a low nutrient content, make the reservoir unfavourable for fish.

Many fish species carry out up-or downstream migrations. The purpose of these migrations is either the search for food, for suitable spawning or wintering sites. Most of the time however, 9-10 months out of 12, such movements are in search of food. Before the construction of Nurek dam, there probably were some species which carried out migrations from the Amu Darya upstream into Vakhsh river beyond Nurek and Rogun sites. However, a check of the scientific literature did not yield any confirmed information on such migrations. In any case, such long range migrations would have been interrupted by Nurek dam.

Some information is available on the development of Nurek reservoir. In the first two years of the filling phase, it was rather sterile, with very low nutrient contents of the water. Gradually, with the submersion of additional areas and the vegetation covering them, nutrient content in the water increased. This led to the growth of algae (phytoplankton) and zooplankton, and this in turn was a food basis for some fish species. This was sufficient for maintaining a good fish population (and corresponding fisheries) during a period of 10 years. This population consisted mainly of common marinka, Samarkand khramulya, Turkestan catfish, Amudarya trout etc. However, once the reservoir had reached its full supply level, the input of organic material stopped, and nutrients were washed out of the reservoir. Productivity went down again. For this reason, over the last 20 to 25 years the fish species mentioned above have disappeared almost completely from Nurek reservoir. One species, the peled or Northern Whitefish (*Coregonus peled*), a pelagic plankton feeder, had been introduced to Nurek reservoir at the beginning of the filling phase. The population grew over the first few years, but after the end of the filling phase, due to the development of more oligotrophic condition (lack of nutrients), it then died out again. A number of other species were introduced as well (see below), mostly with limited success.

11.3.2 Field Work

A first part of field work was done in the period of May 5-9, 2011. Working conditions were rather difficult in this period, due to heavy rainfall during most of this time. This also lead to rather muddy water in all rivers, a situation which does not facilitate sampling of fish or their food organisms. During this period, the section of Vakhsh river between Obi Garm and Chorsada was examined, including tributaries along this part of the river (a small lake and Obi Garm near the village of the same name, Lufirarf, and Mudzhiharv and Hakimi near Chorsada). Water temperature was around 12 to 13.5°C. Main aim was to identify species of fish living in this area, as well as obtaining information on feeding places and preferred food. For this purpose, benthos was sampled, and stomach content of caught fishes were examined. Places with different substrate (rocks, gravel, sand) were examined.

Additional field work was carried out July 18-23, 2011, in the Rogun reservoir area, and September 12-27, 2011; this latter period concentrated on Nurek reservoir.

11.3.3 Benthos

During field work, in addition to fish, benthic organisms were sampled and determined; these organisms are important since they are the main food for river fish species.

The following Table lists the benthic organisms found during the different field work periods.

Table 11-2: Benthic organisms found in Vakhsh river (Rogun area)

№	Species	Frequency in samples (%)	Maximum quantity per m²
	Acaridae		
1	*Acaridae* gen. sp	13	40
2	*Agrionecta aquatica*	13	40
	Oligochaeta		
3	*Nais bretscheri*	25	40
4	*N. behningi*	13	80
	Trichoptera		

5	*Hydropsyche* sp.	13	25
6	*Rhiacophila jbsura*	25	40
	Ephemeroptera		
7	*Oligoneurella renata*	13	40
8	*Baetis* sp.	13	40
9	*Iron reophilus*	13	40
10	*Ephemerella submontana*	13	40
11	*Ironopsis* sp.	13	
12	*Cloen dipterum*	13	
	Diptera fam. Chironomidae		
13	*Chironomus salinarius*	25	80
14	*Cryptochironomus javanensis*	25	80
15	*Tanytarsus longipes*	25	280
16	*Parachironomus* sp.	13	40
17	*Eukiefferiella* sp.	13	40
18	*Diamesa thenemanni*	13	80
19	*Orthocladiinae* gen.sp.	50	80
19	*Tanytarsus gregarious* K	25	80
20	*Prodiamesa* sp.	25	40
21	*Procladius nigriventris*	13	40
22	*Cryptochironomus defectus*	13	40
24	*Tanytarsus medius*	13	40
	Mollusca (snails)		
25	*Limnaea auricularis*	13	

The following list provides information on important benthic organisms identified and on the frequency of their consumption by the fish caught in the area:

- 2 species of oligochaetae worms; eaten by marinka (found in the stomachs of 40% of caught specimens).
- 2 species of caddis flies; used by 100% of marinka and Turkestan barbel.
- 6 species of mayfly larvae; used by 100% of marinka and Turkestan barbel.
- 12 species of chironomid larvae; since they live on or within the sediment, they are eaten only by the Turkestan catfish (found in 25-30% of specimens).
- 1 species of molluscs; not consumed by more than 5% of the fish.
- Algae growing on stones (aufwuchs) are eaten by 100% of the fish.

As can be seen from this, main food for fish caught in Vakhsh river feed on sessile algae (growing on stones) and on benthic organisms (worms and insect larvae).

11.3.4 Fish Fauna in the Project Area

The fish fauna in the project area includes common marinka, Turkestan catfish, Amudarya trout, rainbow trout, brown trout, Tibetan stone loach, and crested loach (обыкновенная маринка, туркестанский сомик, амударьинская форель, радужная форель, аральский лосось, тибетский голец, гребенчатый голец) (see Table 16 in Annex 11 for a list of fish species with scientific, Russian and English names).

Carps were not caught during this period, but according to local fishermen rather large carps are sometimes caught; these are then sometimes sold in local markets. The carp is not a migratory fish and thrives in lakes and ponds.

Fish stocks in Vakhsh river in the project area are estimated to be 120 fish per km, with an average weight of 250 g; this amounts to 30 kg of fish per km. The reservoir will submerge about 100 km of river (main river and main tributaries), changing the conditions there. Assuming that the part would be lost as fish habitat, this would mean a loss of 3000 kg of fish.

11.3.5 Observations on Fish Biology

Most migrations are carried out in search for food; this is done year round with the exception of a short pause in winter. Spawning migrations are carried out mostly in spring, for some species in fall.

Characteristics of the most frequent species:

- **Amu Darya trout (*Salmo trutta oxianus*):** body length 23-32 cm, weight 240-560 g; a female produces 1200 to 6800 eggs. The specimens caught in May did not have eggs, their spawning period is autumn (September to December), when it carries out spawning migrations. The species was found in Mudzhiharv creek, where the water was relatively clear. Local fishermen confirmed the suitability of this tributary for this species. Amu Darya trout is endemic to Central Asia, where it can be found in most rivers in mountain areas.
- **Aral salmon (*Salmo trutta aralensis*):** until the first half of the 20th century this species lived in the Aral sea, migrating into the headwaters (Vakhsh among others) for spawning. Populations which did no longer return to the Aral sea finally developed into a distinctive river form (*Salmo trutta aralensis* forma *fario*, or *S. t. fario*, the brown trout). A population of this river form also lives in upper Vakhsh, upstream of Nurek reservoir isolated from other populations by Nurek dam, and it will continue to live there once Rogun reservoir will be in place. This species can reach a considerable size, specimens of more than one metre and over 14 kg were recorded; fishermen from upper Vakhsh valley even report specimens with a weight of up to 18 kg. This species is still carrying out migrations, moving upstream into the headwaters of tributaries for spawning. Rogun reservoir will not affect the population of this species in a negative way, and depending on reservoir operation there might even be a positive effect.
- **Common Marinka (*Schizothorax intermedius*):** frequent in all tributaries and in the Vakhsh itself. Size is 17-52 cm, weight up to 1600 g. This is the most frequent species in this area, and most important one for fishing. The fishing gear used most often to catch it is a local type (sabat), a screen woven from twigs with a narrow, cone-shaped inlet. The reproduction period is June, when it migrates to smaller tributaries for spawning.

- **Turkestan catfish (*Glyptosternon reticulatum*):** this is a rather small (maximum length 18-20 cm, weight 90-100g) bottom dwelling fish with a flattened head and body. It feeds on benthic organisms, algae and organic sediment. It is widespread in Central and South Asia. Once Rogun dam built, it will continue to live in all the tributaries.
- **Loach (*Nemachilus stoliczkai*):** small fish (6-12 cm) living in rivers and creeks with gravel grounds. A rather stationary species, not carrying out any longer migrations. As the Turkestan catfish, it is of no direct economic value, but it forms a considerable part of the diet of the two trout species.

Figure 11-1: Fishermen with brown trouts caught in the Rogun area (1980)

Table 11-3: Characteristics of caught fish

Scientific name	English name	Виды рыб	Number caught	Length (cm)	Weight (g)	Age (years)
Schizothorax intermedius	Common marinka	Обыкновенная маринка	5	12.5-15	57-70	2+
Salmo trutta oxianus	Amudarya trout	Форель амударьинская	3	13.3-26.5	76.6	2-3+
Glyptosternon reticulatum	Turkestan catfish	Туркестанский сомик	4	7.2-14.1	35.0	1-4+

11.3.6 Fish in Nurek Reservoir

The construction of the 300 m high Nurek dam was finalised in 1973, creating a reservoir with a length of approximately 70 km, width of 2-5 km and a surface of approximately 100 km². Given the seasonal flow pattern of the river, the reservoir itself also shows a seasonal cycle. In October, the reservoir is full (FSL = 910 m asl). During winter, the reservoir is being drawn down by 50 to 60 m. In April, when river flows start to increase, the filling of the reservoir starts, and it reaches FSL again in October.

Surface temperature varies considerably during the year. It is usually at 8-11°C in February/March, and can reach 28°C in July.

Phytoplankton concentration is about 0.04 g/l, zooplankton 0.09 g/l. Benthos reaches hardly 0.5 g/m²; the very considerable drawdown makes the development of an aquatic vegetation along the shorelines impossible, and also limits the development of benthos. Overall, Nurek reservoir can be characterised as an oligotrophic (clean, nutrient poor) mountain lake.

After filling of the Nurek reservoir, the number of fish in the reservoir increased considerably. In an attempt to make best use of this resource, a number of exotic fish species were introduced in the reservoir. However, after a few years, once the additional nutrients gained from the submerged soils and vegetation were decomposed and flushed out, productivity decreased, and most of the introduced species disappeared again.

Table 11-4: Fish species in Nurek reservoir

Family	**English name**	**Scientific name**	**1979-1982**	**2011**
Salmonidae	Amu Darya trout	*Salmo trutta oxianus*	frequent	rare
	Brown trout	*Salmo trutta fario*	frequent	rare
	Rainbow trout	*Oncorhynchus mykiss (Salmo gairdneri)*	introduced	rare
Coregonidae	Peled	*Coregonus peled*	introduced	absent
Cyprinidae	Marinka	*Schizothorax intermedius*	frequent	absent
	Khramulya of Samarkand	*Capoeta (Varicorhinus) capoeta*	frequent	absent
	Carp (sazan)	*Cyprinus carpio*	introduced	present
	Silver carp	*Hypophthalmichthys molitrix*	introduced	present
	Spotted silver carp	*Hypophthalmichthys (Aristichthys) nobilis*	introduced	present
	Chebachok of Amur	*Pseudorasbora parva*	introduced	present
	Striped bystranka	*Alburnoides taeniatus*	introduced	present
Cobitidae	Tibetan loach	*Triplohysa (Nemacheilus) stoliczkai*	frequent	present
	Crested loach	*Paracobitis (N.) malapterura*	frequent	present
	Tajik loach	*Iskandaria kuschakewitschi (N. pardalis)*	frequent	absent
Sisoridae	Turkestan catfish	*Glyptosternon reticulatum*	frequent	absent
Gobiidae	Amur goby	*Rhinogobius similis*	Introduced	absent

Scientific names updated according to http://www.fishbase.org/Nomenclature/ScientificNameSearchList

In the first years after impoundment, the development of fish stocks allowed commercial fishing activities, fish being sold on local markets. Some details follow:

- **Amu Darya trout:** was quite frequent, reaching 300 g (and exceptionally up to 870 g) at the age of two years. Spawning took place in Vakhsh and its tributaries, adults spent the rest of the year in the reservoir for feeding. Today, it is very rare in Nurek reservoir.

- **Brown trout:** similar life cycle a Amu Darya trout. No longer frequent in Nurek reservoir.
- **Rainbow trout:** a species introduced from North America; it was introduced to many rivers in temperate regions all over the world, and it is also bred in fish ponds. In Nurek reservoir, it reached up to 700 g and a length of 39 cm in 2 years., and up to 1400 g at the age of 3. In the early 1980ies, a cage breeding program started with this species in Nurek reservoir, introducing fingerlings and providing additional food for them; the fingerlings reached a weight of 250-300 g in 6 months.
- **Peled:** 5 million larvae were released in Nurek reservoir in 1978, reaching a weight of 600-800 g. Acclimatisation was first very successful, however, 20 years later the species had disappeared completely, apparently not having found suitable conditions.
- **Carp:** this is a species frequently bred in ponds and lakes, and it easily adapts to different conditions, although it prefers nutrient rich waters. It was introduced to Nurek reservoir form different fish breeding stations in the country, and quickly reached considerable numbers. It is still present in the reservoir.
- **Silver carps:** were also introduced from fish ponds and developed quite well. They are still being caught in the reservoir.
- **Marinka and Khramulya:** these two autochthonous species first multiplied greatly in the reservoir, then the populations crashed. Since about 5 to 10 years they have not been found there any longer.

Today, none of the species still present in Nurek reservoir is frequent. The conditions in the reservoir are not suitable for the development of fish stocks. The massive drawdown is a severe limiting factor.

11.4 Effects of Rogun Dam

Rogun will be built mainly for generating electricity, and possibly for regulating water for irrigation; however, no water will be diverted directly from Rogun reservoir for irrigation purposes. It will, however, have some negative impacts on the fish fauna of the river.

The most important effects will be:

- Change of a part of the river from river to lake conditions: the fast flowing water with temperatures of 5-6°C in winter and 12-13°C in spring will change to stagnant water with a thermal stratification, and temperatures near the surface of up to 20°C or more.
- This change in conditions will also have effects on organisms which serve as food for fish. The river benthos, the main source of food for the fish, will disappear. Here, much depends on the operation pattern with will be chosen. Should there be a considerable drawdown of the reservoir, this would create unfavourable living conditions for such organisms, in this way limiting food resources for fish.

- The dam will be an obstacle to migrations; however, it has to be seen that major migrations, if there were any , have already been interrupted by Nurek dam 30 years ago. Still, any migration that might still occur from Nurek reservoir upstream, from fish species still occurring there, will be no longer possible. The river stretch between the water outlet from Rogun HPP and Nurek reservoir will not be a suitable fish habitat due to the large fluctuations in river discharge as a consequence of peaking production in Rogun.
- Given the intended operation scheme for the entire Vakhsh cascade, which will remain within water allocation practices agreed upon among riparian states, the river flow pattern, and especially the seasonal distribution of the flows downstream of Nurek HPP will not be changed by Rogun HPP (see Section 21.3.3 for details).

It is highly probable that a similar development will take place as described above for Nurek, with an increase in productivity in the first years after impoundment, followed by a drastic reduction in productivity due to scarcity in nutrients. With Rogun dam in place, migrations from the reservoir into the tributaries and within the remaining part of the rivers will still be possible. The operation pattern intended to be with a massive drawdown of several 10s of metres, like presently in Nurek, will have an important influence (see Section 11.5.2).

11.5 Measures and Recommendations

Overall, given the present situation the impact of Rogun HPP on fish fauna and fisheries in the upper Vakhsh will be rather small. Still, two types of measures should be envisaged, namely (i) managing natural fish stock in order to preserve the species which still live in this river system, and (ii) exploring the potential for developing fish stocks and fish production in the reservoir.

For any of these activities, first of all a fish monitoring program would be required.

11.5.1 Fish Monitoring and Management of Natural Populations

The monitoring program will have to be carried out according to the following conditions:

- 2 monitoring phases per year, with a total of 4 days field work each (one day of which for Nurek reservoir), 3 days for sampling sites in rivers in the area of the future reservoir; at least one of these sites will have to be located upstream of the reservoir area. The sites will have to be chosen in a way as to take into account the gradual filling of Rogun reservoir.
- The field work should cover fish as well as benthos and plankton (in Nurek reservoir and, after start of filling, also in Rogun reservoir).
- The program should start as soon as possible, i.e. as soon as the decision to go ahead with the project will have been taken.
- The program will have to be carried out during the entire construction period (15 years) and for a number of years after commissioning of Rogun HPP, until the results indicate a stabilisation of the situation in the reservoir (estimated at 5 years, but to be decided then). This brings the duration of the program up to an estimated duration of 20 years.

- All records from field work and laboratory analysis will have to be kept in store.
- A short report will have to be prepared after each field campaign. This should focus on the results of the reporting period. Where useful, cumulative tables should be used (i.e. tables where one column is added for each field campaign, putting the results in the context of previously obtained results).
- The fish monitoring will have to be coordinated with the water monitoring program, which will have to be carried out over the same period.
- At the end, a comprehensive report including all the material collected will have to be prepared. This report will also have to contain a detailed program and recommendations for further measures to be taken (be it for management of natural fish stocks, artificial restocking or aquaculture). Obviously, it is not excluded that some such measures will already be recommended and started during the filling phase of the reservoir.

A cost estimate for this monitoring program is provided in the following Table.

Table 11-5: Cost estimate for fish monitoring

Annual costs for fish monitoring		**Unit cost**	**Unit**	**N**	**USD**
1. Field work per year (2 phases @ 4 days each per year)					
	Expert / team leader	150	day	8	1'200.00
	Field assistants (2)	60	day	16	960.00
	Car hire	100	day	8	800.00
	Boat hire	100	day	2	200.00
	Per diems (3 pers)	20	day	24	480.00
	Accommodation	30	day	24	720.00
	Fishing gear	300	lumpsum	1	300.00
	Various field material	200	lumpsum	1	200.00
	Subtotal field work per year				*4'860.00*
2. Laboratory work and reporting					
	Expert	150	day	10	1'500.00
	Assistants (2)	60	day	12	720.00
	Various lab. material	500	lumpsum	1	500.00
	Subtotal lab. work and reporting per year				*2'720.00*
Total yearly costs					**7'580.00**

The cost estimate is based on 2013 costs.

For the entire duration of 20 years, including the final analysis and report, the total cost for fish monitoring will be approximately 170'000 USD.

The detailed program, including choice of timing of field campaigns and sampling sites, will have to be prepared by the expert in charge of the monitoring, and approved by PIU; this latter will also be responsible for carrying out a close follow-up on this program (supervision of timely implementation of the program, checking and approving reports, funding).

11.5.2 Development of Fish in Rogun Reservoir

Rogun reservoir has the potential to support fishery because of the extensive areas of shallow waters in the upper part of the reservoir. However, the reservoir would need to be maintained at a constant level in order to develop this potential. The intended operation pattern for the cascade is based on using Rogun reservoir for seasonal regulation, and therefore with a considerable drawdown, while Nurek reservoir will be kept near to its FSL throughout the year. This implies that, as described above, conditions for fish development in Rogun reservoir will not be optimal. On the other hand, the situation for fish and fishing could improve in Nurek reservoir, although this has not the same potential as Rogun reservoir.

Artificial restocking of one or both of the reservoirs might still be required (will have to be determined by the monitoring program). However, it is recommended to give preference to autochthonous species and to introduce any exotic species only after a very careful assessment of risks associated with such a measure (especially risk for local species).

11.5.3 Fisheries and Resettlement

As mentioned, under the intended operation regime, i.e. seasonal regulation being done with Rogun reservoir, this will have a limited potential for fishing at best. If it were possible to develop a commercial fishing activity in Rogun reservoir, this could be linked with the resettlement effort, in the sense that fisheries might provide an alternative livelihood for some households located in vicinity of the reservoir. In the case that such a development could take place in Nurek reservoir, a direct link with resettlement is not probable; at least for the time being, no resettlement of people living in the area affected by Rogun to the Nurek reservoir area is foreseen. Still, if the proposed programs should identify fish stock development in Nurek as economically attractive, it would still be good to develop this resource.

11.5.4 Summary of Recommendations

The analysis has shown that the project area is not very suitable for fish and fisheries. Still, with Rogun dam in place, there might be a certain potential for managing fish stocks. It is recommended to investigate the feasibility of fish stock management, possibly including the introduction of fish to suitable sites. If this should be envisaged, it is strongly recommended to use primarily local species, and not, or only after careful identification of potential risks, to introduce exotic species. Before this is implemented, a monitoring of conditions and fish stocks should be carried out for providing the necessary data base.

12 PROTECTED AREAS

12.1 Key Messages

The following are the key messages concerning impacts of the project on protected areas:

- There is no protected area in the area affected by dam and reservoir.
- One important protected area, Tigrovaya Balka, is located downstream of the Rogun-Nurek cascade, in the floodplain of Vakhsh river near its confluence with Pyanj. It is one of the few remaining Tugai ecosystems, a habitat type which was originally widespread along the major rivers in Central Asia. It was negatively affected by the construction of Nurek dam, and mainly by the fact that river dynamics in the floodplain, with high flows and occasional floods in spring/summer and low flows in winter, was changed.
- Rogun HPP will not have a negative effect on this protected area. It, or the Rogun-Nurek cascade, could however contribute to its improvement, e.g. by occasionally releasing higher amounts of water, in this way imitating natural flood events. This would have to be planned and implemented very carefully in order to prevent damages to cultivated areas and settlements.
- Several protected Tugai sites exist along the entire course of the Amu Darya outside of Tajikistan. They were all degraded due to increasing use by the human population, but mainly due to changes in water regime and availability. There will be no significant impact of Rogun on these areas.

12.2 Theoretical Considerations

Impacts of a project on protected areas have to be evaluated very carefully, mainly for the following reasons:

- Protected areas have a legal protection status, and interference with them in any way that is not in compliance with this legal protection therefore has to be considered as an illegal activity.
- Protected areas have been declared as such because they contain some exceptional values (e.g. in terms of biodiversity) which need to be protected. Impacts of a project might contradict the main protection aims of such an area, e.g. by interfering with habitat conditions on which the biodiversity of this area depends.

For both reasons, potential project impacts need to be identified, and mitigation measures need to be taken in case of adverse impacts.

12.3 Protected Areas in Tajikistan

Article 13 of the Constitution of the Republic of Tajikistan states: “Land, its minerals, water, air, flora and fauna and other natural resources are the exclusive property of the state and the state guarantees their effective use in the interests of the people. “

In accordance with the Law of the Republic of Tajikistan "on specially protected natural territories" there are the following categories of protected natural areas:

1. state natural reserves, including state biosphere reserves;
2. state national parks of the republic (national parks) and parks of local importance (provincial parks);
3. state nature reserves of the republic and of local importance;
4. public monuments of nature of the republic and of local importance;
5. environmental and ethnographical zones:
6. dendrological parks and botanic gardens;
7. natural, therapeutic areas (health resort zones);
8. natural recreational areas.

Protected areas include natural complexes and objects that possess exceptional environmental, historical, cultural and recreational value of national importance

According to UNDP/GEF (2011, see Figure below), the following nationally protected areas were officially listed in Tajikistan: four state nature reserves (заповедники, in red in the Figure), three national parks (among which the Tajik National Park; brown hashed), and 13 nature reserves (заказники, green).

The total surface of the protected areas is 3.1 million hectares, of which the Tajik National Park, located in the Pamir mountains, accounts for 84% (2.6 million ha). The area of all nationally protected areas comprises 22% of the country.

Figure 12-1: Protected areas of Tajikistan

Source: UNDP/GEF 2011; Rogun reservoir added

In the wider project area there is one state nature reserve, Tigrovaya Balka (No. 1 in the Figure above), and one species management area called Nurek Species Management Area (No. 17), both downstream of Rogun HPP.

12.4 Nurek Species Management Area

The Nurek Species Management Area (No. 17 in the Figure above) is located on both sides of the upper part of Nurek Reservoir. It was created in 1984 and has a size of 30’000 ha. The State Department for Forestry is in charge of the Species Management Areas.

This reserve was an offset for the impact caused by Nurek reservoir on the terrestrial ecosystems in the reservoir area; since this part of the valley, with its rather steep slopes, was not inhabited, the submerged area consisted mainly of natural habitats, or at least habitats with little human influence. The purpose of the reserve is to protect local juniper and other forest types, and in this way to provide a suitable habitat for the species of wildlife found in this area. Among others, the following species can be found there: Tien Shan brown bear (*Ursus arctos isabellinus*), Central Asian otter (*Lutra lutra*), Turkestan lynx (*Felis lynx isabellina*), snow leopard (*Uncial uncia*), mountain sheep or urial (*Ovis vignei bochararensis*), as well as a number of bird species like vulture (*Neophron percnopterus*), golden eagle (*Aquila chrysaetos*), bearded vulture (*Gypaëtus barbatus*), saker falcon (*Falco cherrug coatsi*), and others. (See information on website “Экология Таджикистане” (Ecology of Tajikistan), http://eco.tj/nature/eco-20.html .

Since Rogun project, although not located far from this area, will have no effect on it, neither directly nor indirectly, no additional work has been carried out on this object.

12.5 Tigrovaya Balka State National Reserve

The Tigrovaya Balka State National Reserve (No. 1) is located in the lowermost part of the Vakhsh river basin, down to its confluence with Pyanj river (where these two rivers from Amu Darya), close to the border with Afghanistan. It was created by decree No. 1163 of the Tajik SSR on November 4, 1938. Its main objective was the conservation of the unique tugai complex and of the animals living in it. Tugai is the name of a specific type of floodplain habitat in desert areas of Central Asia; it is characterised by a groundwater level close to the surface, which conditions a specific vegetation type composed of a number of specialised tree species, reeds etc. It is also a habitat for many species of animals. Tugai systems have come under increased pressure through intensified human use of these floodplains.

The reserve, with an area of 49’786 ha, is located about 200 km south of Dushanbe. It is of great importance for the conservation of the Tugai ecosystem and its unique fauna and flora; It was the last place where the Caspian tiger lived, which finally disappeared around 1950. Human pressure on this area reached its maximum after the collapse of the Soviet Union and the ensuing civil war. Illegal and uncontrolled logging, hunting and fishing led to a sharp decline of many species of animals - the Bukhara deer, black and golden pheasant, gazelles, the striped hyena and other species.

The climate is continental and arid. The average annual temperature is +14 to +17°C, the temperature of the coldest month (January) is + 2°C, the one of the hottest (July) 32 to 38°C Temperature in July sometimes reaches up to 48°. Length of frost-free period is

250-310 days. Winters are short and mild, which is typical for dry subtropical zones. Precipitation is distributed unevenly throughout the year, up to 70% falling in winter and spring months, usually in the form of rain.

The reserve contains about 20 lakes of different size; their water is poorly mineralised, with about 1.92 to 4.67 mg/l. Besides 438 species of vascular plants, within the reserve there are about 30 species of reptiles, 34 species of mammals, 2 species of amphibians and 150 species of birds. It is one of the few remaining habitats of the Bukhara subspecies of the red deer or Hangul (*Cervus elaphus bactrianus*).

Main threats for the reserve are the massive development of land adjacent to its borders, the lack of buffer zones, poaching, regular forest fires, reduced water levels in the Vakhsh and illegal logging.

As every floodplain habitat, it depends directly on the dynamics of the river forming this plain, i.e. in this case Vakhsh river. These river dynamics are made up by the amount of water flowing, but to a very great extent also by the seasonal distribution, and especially by seasonal floods. The area is of concern for the Rogun ESIA, since this Project can influence the river discharge pattern in this area, which in turn would have an effect on this fragile system. For this reason, it was included in the study.

12.5.1.1 Floodplain Dynamics

Floodplains like Tigrovaya Balka are ecosystems depending on a meandering river and its dynamics. These dynamics are conditioned by the variation in river flow, by regular seasonal variations as well as by rare and extraordinary flood events. The following main conditions determine the composition of the species living in such an ecosystem:

1. Low flows in winter: a large part of the soil is dry, water only in the river itself and in lakes (oxbows); in cold climates, soil and vegetation is exposed to frost. This eliminates all plants which cannot tolerate longer dry periods and frost.
2. High flows in summer: a large part of the floodplain is under slow flowing or almost stagnant water. These inundations can last for a few days or for longer periods, up to several months. The water brings sediments (fine sediments in the form of suspended solids in moving water, which will slowly sediment when the water is stagnant. These floods eliminate all plants that are not tolerant of prolonged inundation (i.e. dryland species). At the same time, normal high flows tend to erode the river bank on the outside of bends, while at the inside, where flow is less strong, sediments are being deposited.
3. Extreme floods: "catastrophic" events characterised by large amounts of water and high flow speed. Under such conditions, the meandering river can change its bed, destroying the vegetation in its course. An old river bend, which by this process will be cut off and no longer be part of the river, will then be transformed into one of the floodplain "lakes".

This means that such a floodplain is a system which is highly dynamic and is maintained by the ever changing conditions dominated by the river: seasonal flow variation, successions of dry and wet years, and extreme flood events.

The development at the local level is governed by different processes, some of them slow and gradual, other short and violent:

- An oxbow which is cut off from the river will develop a typical pond vegetation, with a succession of reeds and other water plants. Occasional marginal flooding will still bring some sediment from time to time. This, and the dead and decaying plant material, lead to a gradual filling in of this oxbow. The free water surface diminishes, and over time it disappears altogether, even if the structure as such may still be visible for a long time given a difference in vegetation. This is a very slow process, which can take tens of years.
- The meandering river gradually changes its bed by the process of erosion and sedimentation in the bends described above. This is usually a slow, gradual process, which however can be accelerated momentarily during higher than average floods.
- Exceptionally high floods, of the order of a one in 50 years flood or higher, can occasionally bring about very considerable changes in very short time (hours): the river might deposit large amounts of sediments in some places, possibly blocking its own bed, and then breaking through and excavating and entirely new bed, destroying the vegetation on its way and carrying away large amounts of sediments, to deposit them somewhere further downstream. If a river bend is cut off in the process, a new oxbow was created, and the river has a new bed surrounded by smaller or larger areas of bare soil (gravel, sand or silt depending on the situation). These are sites where so-called pioneer plants (plants able to grow rapidly on bare soils often poor in nutrients) and their associated fauna can develop.

All this means that a set of specialised plants which are tolerant to these often extreme conditions - or, more exactly, adapted to the specific conditions in specific parts of this ecosystem - will grow here; many of these plants are limited to such sites, i.e. they will not grow in places which do not offer these specific conditions. Likewise, the vegetation formed in this way will be the habitat for a set of animal species which are adapted to - or which depend on - the conditions of this special habitat, characterised mainly through seasonal changes in water level and flow velocity. Since habitats of this type are limited in extent and number, many of the specialised species living there are rare, and as a consequence endangered if their habitat is negatively affected.

Obviously, this does not apply to Tigrovaya Balka only, but also to similar floodplains further downstream in the Amu Darya basin (or in any other river basin).

Figure 12-2: Section of Trigrovaya Balka showing floodplain characteristics

The picture shows the present river bed of the Vakhsh river in this part, a number of "lakes" (oxbows) which all have the characteristic curved shape of former river bends, and also a number of former river beds which are completely dry by now, but still clearly visible.

12.5.1.2 Effects of River Regulation on Floodplain Ecosystems

River regulation, as caused e.g. by a large storage reservoir like Nurek upstream of such a floodplain, has the following main direct effects on floodplain dynamics:

- Shift of water from the wet season (summer) to the dry season (winter); this effect of Nurek was clearly illustrated in Figure 8-30. This means that normal summer flooding will on average reach lower levels than it did before, and with higher winter flows less land will be dry during this period.
- Reduction in frequency and severity of high floods: a large reservoir has, among other effects, also an effect of reducing flood peaks, in this way providing flood protection to downstream areas. This means that the effects of such flood events as described above will be less marked.

These direct impacts on the floodplain dynamics influence the vegetation mainly in the following way:

- Areas no longer flooded regularly in summer become gradually colonised by dryland species which would not be able to grow under flood conditions, but which replace floodplain species in the absence of such floods. It is also possible that people start cultivating areas which are flooded only very exceptionally.

- Erosion as well as sediment accumulation processes is slower, and events where the river actually destroys vegetation occur more rarely or not at all any longer; this means that pioneering plants find no suitable habitats any longer.
- The "lakes", i.e. the old oxbows, continue to be filled in and disappear over time; if no new such lakes are formed due to the river changing its bed, this means that over time there will be no such lakes left any longer.

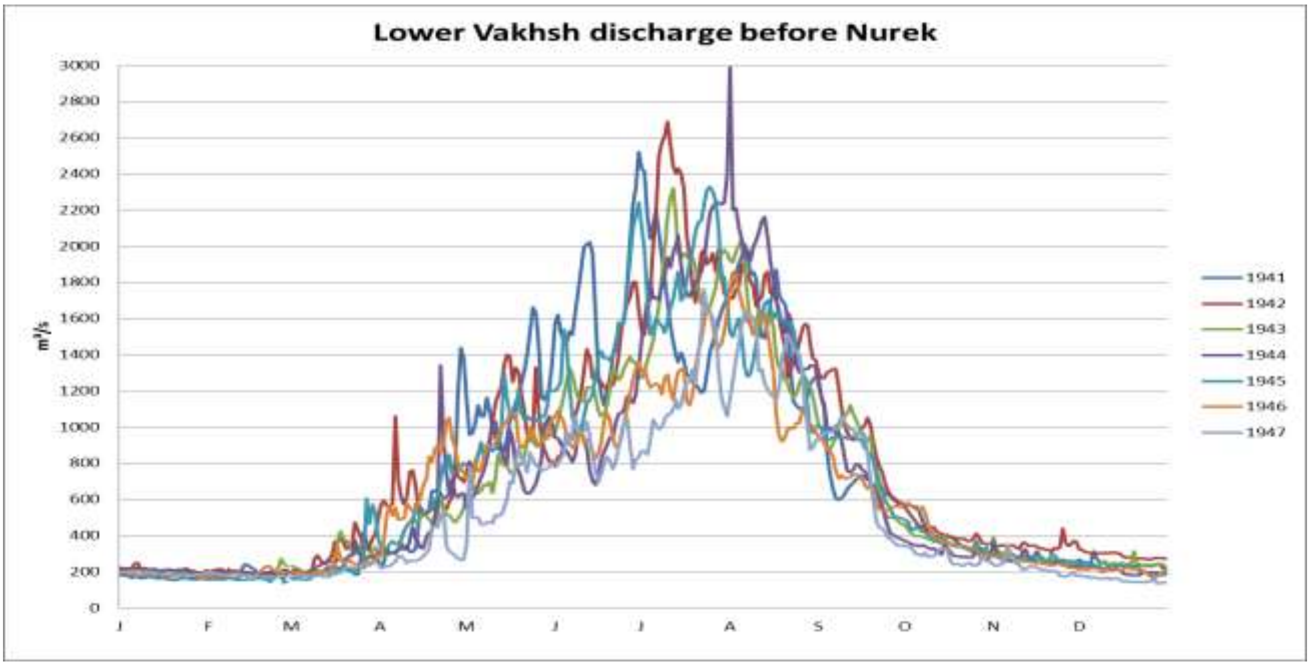
The entire process can lead to a more uniform habitat where many of the very specialised species of plants and animals cannot live any longer. In addition to that, the inflow of drainage water from irrigation schemes in the surroundings leads to the input of salts, fertilisers and agrochemicals, which all contribute to changing the situation in this ecosystem.

12.5.2 Effects of the Vakhsh Cascade

The first HPP (Perepadnaya HPP) on the Vakhsh river was put in operation in 1959, followed by Golovnaya HPP, Central HPP, Nurek HPP and Baypazin HPP. Nurek HPP, which is operating since 1972, had the strongest impact on the discharge regime of the Vakhsh (see Section 8.8), the other power plants are ROR schemes with little regulating capacity and therefore little influence on river flows. The discharge pattern of the cascade has changed the natural discharge regime of the Vakhsh river from a highly variable to a more uniform flow, and, as has been shown earlier, has reduced the peak flow in summer. Furthermore, the sediment was trapped behind the dams (again mainly in Nurek), and this can typically cause a number of adverse effects in the downstream area such as bed and river bank erosion, morphological changes within the river bed, and lowering of ground water tables. In addition to the impact of the HPP cascade water from the Vakhsh river is used for irrigation and as drinking water. This cumulative impact has led to a reduction of overall water quantity, and especially of summer flows, and to a lowering of the groundwater table. In addition, the reserve received drainage water from irrigated areas contaminated with fertilizers and pesticides, and the salinity of the soil increased.

Summer floods are essential for the dynamics of floodplains and for maintaining the highly specialised ecosystem, which is adapted to these condition. Floods flush out the soil, which is leading to a desalination, they bring new alluvions, they destroy periodically a part of the vegetation, which is important for maintaining the characteristic pioneer vegetation types, and they prevent the invasion of plants from surrounding drier areas, which otherwise would outcompete the characteristic tugai vegetation. Under present conditions, this dynamic is no longer maintained. The main visible effect, due to lowering of the groundwater table and lack of inundation, was the continuous decrease of the water in the characteristic lakes of Tigrovaya Balka (which are in reality old parts of the river bed which were cut off from the main stream).

The Figures on the following page show the effect of the cascade on Tigrovaya Balka.



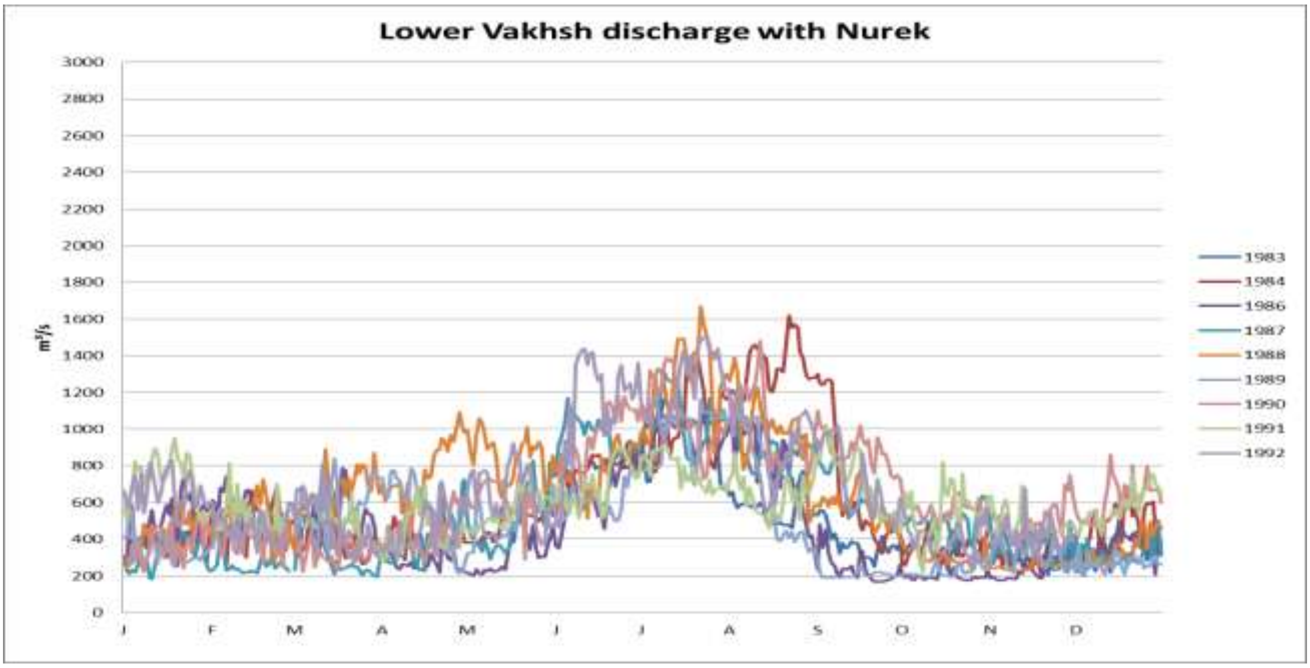


Figure 12-3: Daily flows in lower Vakhsh without and with Nurek

The upper graph shows recordings from Tutkaul, a hydrological station that was located approximately at Rogun dam site and no longer exists. The flow values here are probably a good approximation of the water flow in Tigrovaya Balka before any hydropower stations or irrigation schemes were built on Vakhsh river. The lower graph shows recordings at Tigrovaya Balka with Nurek, the lower Vakhsh cascade and irrigation in place.

The two illustrations show clearly what has happened in Tigrovaya Balka and illustrate the effects discussed above. The main points are:

- Average total flow was 100 m^3/s higher in the period of 1941-1947 as compared to 1984-1991 (no complete records for 1983 and 1992).

- Summer flows are much lower in the "with Nurek" case. This is the case for average flows, but mainly also for peak flows. This means that summer floods in Tigrovaya Balka were reduced, which leads to less area flooded regularly, smaller areas affected by exceptional floods, and less dynamics caused by floods.
- Minimum flows were about the same (although very rarely below 200 m³/s since Nurek is in operation), but overall winter flows are considerably higher and more variable with Nurek in Place. This means that less land falls dry and is exposed to frost in winter.

This, together with the effects of change in sediment transport and water quality mentioned above, has led to the changes in the tugai ecosystem in Tigrovaya Balka.

12.5.3 Management Projects in Tigrovaya Balka

In 1975, due to the changes in the natural runoff, a special resolution was taken to develop measures to preserve and improve the protection of fauna and flora in Tigrovaya Balka. Several scientific and management projects started in Tigrovaya Balka in the 1980ies. These projects came to a halt after the end of the Soviet Union.

The first project with WWF participation started in 1998. The recent project "Integrated River Basin Management and Nature Protection in Tigrovaya Balka" funded by WWF – Norway started 2007. The main aim of the project is to establish long-term plans to conserve and restore the tugai ecosystem of Tigrovaya Balka. The main tasks are

i. strengthening environmental governance,

ii. conservation and restoration of the tugai freshwater ecosystem of Tigrovaya Balka and

iii. develop strategies for sustainable use of Tigrovaya Balka providing sustainable livelihood.

The work for point ii) includes among other things, to ensure that the floodplain receives the water necessary to recover as far as possible. Canals between the lakes have been cleaned, additional canals have been built and lock and pump stations have been implemented to allow the water to pass from one lake to the next and to provide water with low salinity from the Vakhsh river to enter into the ecosystem.

The map on the following page shows the main actions taken by the WWF to recover the ecosystem.

The pictures in Annex 12 show the effect of these measures. The water level of the same lake from the same position in the Tigrovaya Balka before and after implementing the first measures (cleaning of canals).

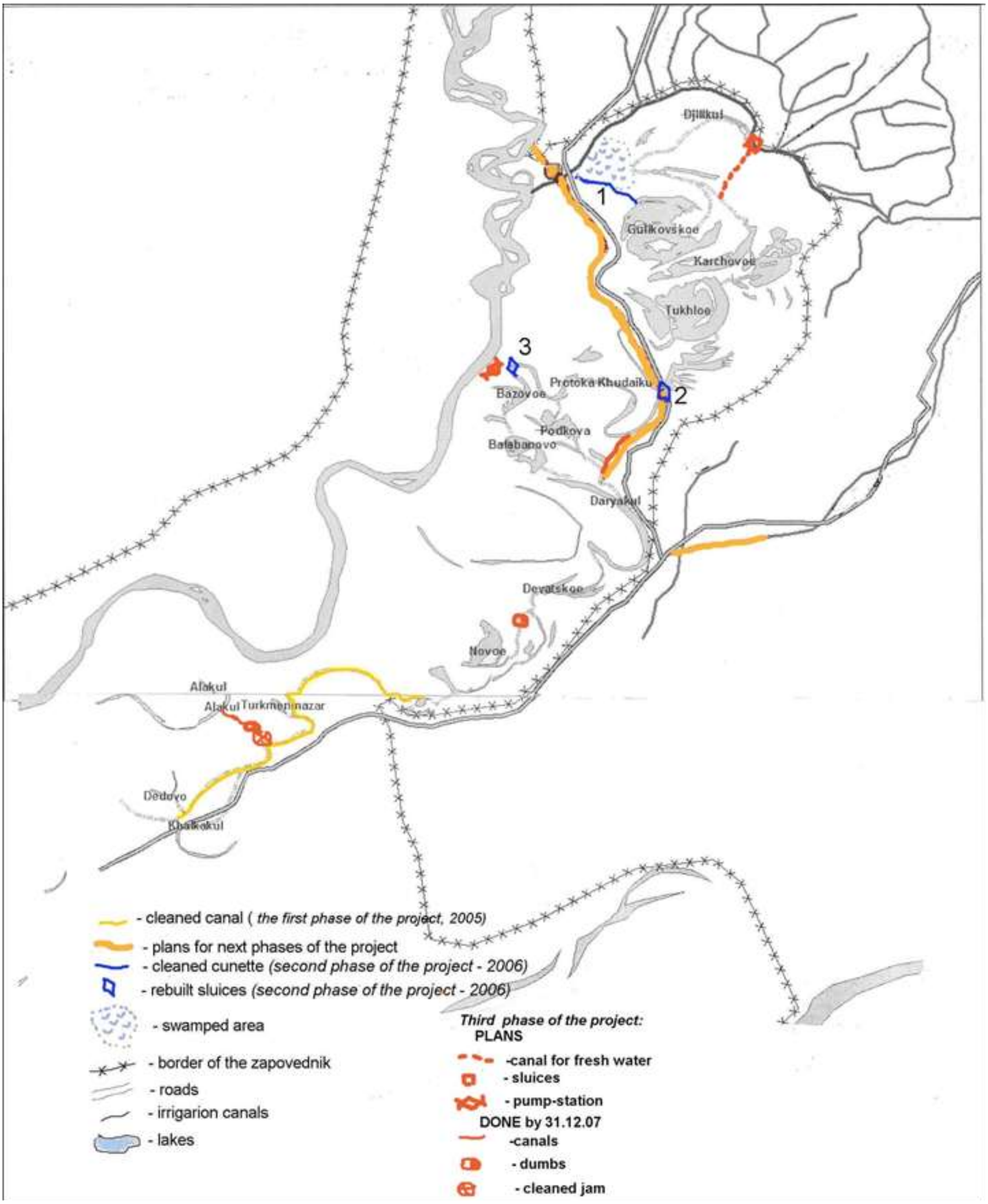


Figure 12-4: Actions taken by the WWF to recover the tugai ecosystem

Source: WWF Russia

12.5.4 Proposed Mitigation Measures

Since Rogun HPP will be operated in a way as not to change river discharge or sediment transport downstream of Nurek any further, it will not have any negative effect on Tigrovaya Balka.

Even so, Rogun HPP could contribute in two ways to an improvement of the situation in Tigrovaya Balka, namely:

- by financing measures aiming at restoring some ecosystem functions in the way done by the WWF project described above; and
- by restoring some of the natural dynamics through creating occasional floods.

This would be a potential offset for the impact of Rogun HPP on floodplains in the upper reaches of Vakhsh river, which will be submerged by the reservoir (see Section 10.6.3).

12.5.4.1 Restoration Measures

Measures similar to those described above (WWF program) will have to be carried out again sooner or later, or additional measures (e.g. dredging of a drying lake) could be envisaged.

Obviously, such measures need to be carried out in the framework of an overall management plan for the area and cannot be done in an uncoordinated way. Therefore it is suggested that Rogun HPP contributes to maintenance and management works in this area, while the planning of the measures to be taken and the implementation of the works has to be done by the managing authority of the nature reserve.

It is proposed to earmark a sum of USD 100'000.00 for this purpose. This is a preliminary estimate which will need to be refined based on a detailed plan for specific measures.

12.5.4.2 Artificial Floods

As mentioned above, floods occurring naturally are a decisive component of floodplain dynamics. In order to restore some of the natural dynamics here, an assessment should be carried out to determine if and under what conditions extraordinary peak flows could be released from Rogun/Nurek during the period where such floods occur naturally, i.e. in early summer.

The advantages of such floods would be:

- occasional filling of the entire floodplain with water;
- elimination of invasive plants;
- flushing out of salt, thus reducing salinisation of the soils;
- depending on magnitude of flood, possibly also occasional creation of new oxbows.

This should preferably be done in extremely wet years, when enough water is available. Obviously, such floods would have to be carefully planned and managed in order to maximise the beneficial effect and to avoid negative impacts. Mainly, the peak flows would have to dimensioned in a way as to prevent flooding and damage in inhabited areas.

12.6 Protected Areas Along Amu Darya Outside of Tajikistan

12.6.1 Locations and Description

The following Table lists the protected areas in the Amu Darya basin outside Tajikistan and provides a short description; only wetland areas are listed here, protected desert and mountain sites are not mentioned.

Table 12-1: Protected areas in Amu Darya basin

No.	Name	Coordinates	Country	Description
	Tugai Reserves			
1	Amu Darya Reserve	39.826°N, 62.530°E	TKM	Tugai reserve on Amu Darya.
2	Kyzylkum Protected Area	41.025°N, 61.967°E	UZB	Tugai Reserve on Amu Darya.
3	Badai Tugai	41.990°N, 60.360°E	UZB	Tugai Reserve on Amu Darya, d/s of Tyuyamuyun reservoir.
	Other Reserves			
A	Denghizkul	39.115°N, 64.15°E	UZB	Lake, only Ramsar site of Uzbekistan; not directly related to Amu Darya.
B	Yangibazar Natural Monument	40.41°N, 62.31°E	UZB	No information on type of protected area; not directly related to Amu Darya.
C	Karakir Lake	39.721°N, 63.613°E	UZB	Lake; not directly related to Amu Darya.
D	Sudoche Lake	43.481°N, 58.532°E	UZB	Former lake in Amu Darya delta; greatly reduced due to lack of water. D/s of Tyuyamuyun reservoir.

Source : GEF-MSP Tugay; Mr. M. Anstey, and GIZ, Mr. S. Michel, March 2013

For the locations of these sites see map on following page.

Tugai is a Turkic word to describe the globally unique desert flood-plain forests, occurring in the Central Asian arid steppes and lowlands. Though "tugai" is generally accepted as referring mainly to the forested areas it is, in ecological terms, a more complex feature incorporating the transition from open water to sand or mud banks and shoreline, reed formations (*Phragmites* and *Typha* sp.), dense gallery forest (*Populus* and *Salix* sp.), fringe shrub (*Tamarix*), and finally desert (*Haloxylon*, *Carex*). This diversity of habitats is matched by a corresponding diversity of flora and fauna from the Eurasian, Indian and African realms and a number of species or sub-species which are restricted only to tugai habitats and are entirely endemic to limited areas of Central Asia (such as the highly endangered Bukharan Deer - *Cervus elaphus bactrianus*).

Three tugai sites are protected outside of Tajikistan, namely Amu Darya Reserve in Turkmenistan, and Kysylkum Protected Area and Badai Tugai in Uzbekistan. They are conditioned by the same dynamic processes as was described above for Tigrovaya Balka, and therefore they suffer from the same impacts: reduction in water flow, change in seasonal flow pattern, invasion of plants not adapted to tugai conditions, and encroachment by human use.

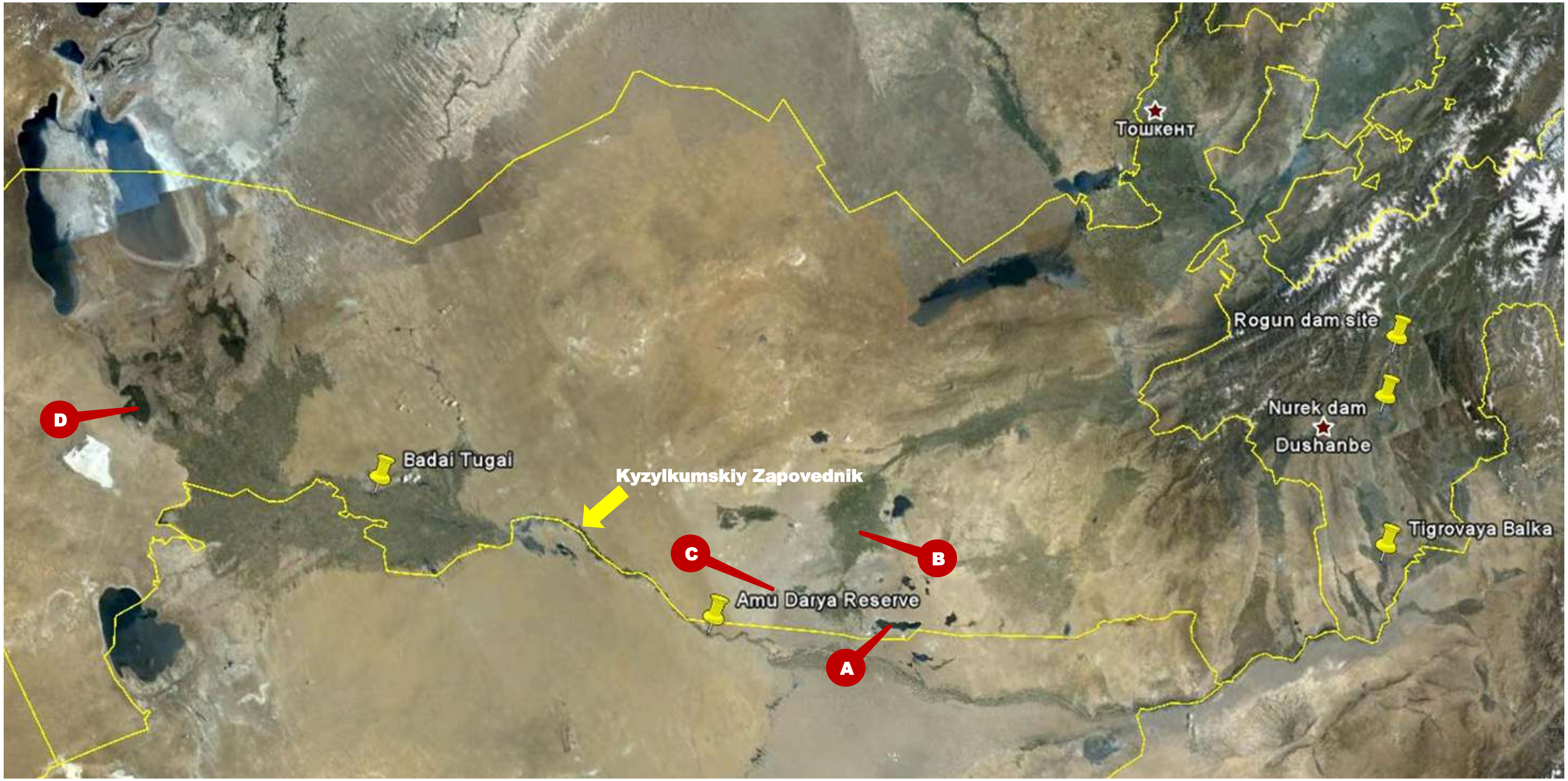


Figure 12-5: Protected Tugai sites in Amu Darya basin

The four tugai sites along Amu Darya:

1. Tigrovaya Balka (Tajikistan)
2. Amu Darya reserve (Turkmenistan)
3. Kyzylkumskiy Zapovednik (Uzbekistan)
4. Badai Tugai (Uzbekistan)

Four nature reserves not influenced directly by Amu Darya

- A: Denghizkul
- B: Yangibazar Natrue Monument
- C: Karakir Lake
- D: Sudoche Lake

All along the Amu Darya, small patches of this ecosystem remain outside protected areas; not being protected however does not mean that they have no ecological value, they are basically a habitat for the same set of plant and animal species as the protected parts.

Effects could arise due to changes in water regime of the river. This also means that the same measures as proposed for Tigrovaya Balka would prove beneficial for them, and mainly the creation of artificial floods. However, quite obviously the water coming from Rogun, unlike in the case of Tigrovaya Balka, constitutes only a small part of the total amount of water (naturally) flowing here, and flow conditions are not mainly controlled by Rogun HPP, but by the other numerous hydraulic structures along the course of the Amu Darya. For this reason, just as the influence of Rogun HPP on these downstream sites is marginal, measures taken to improve the situation in Tigrovaya Balka will have only a marginally beneficial effect in Badai Tugai.

12.6.2 Potential Impacts

The expected effects of Rogun HPP on these areas depends on the impact Rogun will have on Amu Darya river water level and consequently on underground water levels (the water table is fed by the river).

During the Rogun filling period, this impact can be summarised as follows:

- Amu Darya Reserve, Turkmenistan: The Amu Darya river flow at the Amu Darya Reserve more or less equals the inflow to Tyuyamuyun reservoir, i.e. around 35 km^3/yr. The retention of water to fill Rogun will represent 0.83 km^3/yr for the recommended FSL option of 1290 m asl. The respective relative reduction of the Amu Darya flow is 2.4%. These variations will not create unprecedented conditions in the Amu Darya river close to the Amu Darya reserve. This flow reduction also equals the consequence of Tajikistan using in future its full share of water allocated to it by ICWC for other purposes such as irrigation. Artificial floods, which might be used as a maintenance measure for Tigrovaya Balka, would have only a very small effect due to distance and other influences on water discharge in the river. However, complementary releases from Rogun that would be agreed between the Amu Darya basin countries during exceptionally dry years would positively impact the Amu Darya Reserve.
- Kyzylkum Protected Area, Uzbekistan: same situation as for Amu Darya Reserve.
- Badai Tugai: this site is part of the Lower Amu Darya Biosphere Reserve. As the entire Amu Darya delta, it is located downstream of the large Tyuyamuyun reservoir (live storage 5.4 km^3; Wegerich and Warner, 2010). This reservoir has already stopped natural water flow further downstream, and it regulates water availability in the Amu Darya delta. Since (i) the unused water share of Tajikistan largely flows through Tyuyamuyun reservoir and ends up in the Aral Sea, and (ii) around 35% of water from Tyuyamuyun is diverted to Turkmenistan, one can calculate that the retention of water to fill Rogun will represent the same loss in Amu Darya downstream and upstream of Tyuyamuyun in terms of volume (0.78 km^3/yr for the recommended FSL option of 1290 m asl), but a higher, although still small, relative reduction of the Amu

Darya flow of 3.5%. The same comments apply here as to the Amu Darya reserve.

What was said for Amu Darya and Kyzylkum protected areas is also true for all the smaller and larger remaining tugai areas outside of protected areas.

Under the intended operation scheme for Rogun HPP, there will be no change in Vakhsh flow downstream of the cascade neither during filling nor during operation, with the only difference that in the future, with or without Rogun, Tajikistan will use its full share of water allocated to it by ICWC (see Chapter 8 and 21 for a discussion of these issues). This means that Rogun will not have any impact on these reserves, since the "flow pattern preservation" principle shall be applied. Still, should Tajikistan and the downstream countries agree on complementary releases from Rogun in exceptionally dry years (see Section 21.4.4) this would positively impact these reserves.

Overall, it can be concluded that Rogun HPP, under the operating regime defined, will not have any noticeable negative effects on the Tugai ecosystems outside of Tajikistan. It will certainly not have any effect on the reserves located outside the floodplain directly influenced by Amu Darya.

III. THE HUMAN ENVIRONMENT

This Section deals with the human population and its activities and living conditions. It will be the basis for the Resettlement Plan.

13 LOCAL POPULATION AND SOCIO-ECONOMY

13.1 Key Messages

Impact on the population in the project, and on the socio-economic situation in the entire area, is one of the major topics to be addressed in this ESIA. Key messages of this chapter:

- The economic situation in the area is very difficult. Unemployment is very high. Most families are involved to some degree in agriculture; livestock is important. The only major employer in the area is Rogun HPP, and the only alternative is seeking work as migrant labour, mainly to Russia.
- Construction of Rogun HPP, once it will start for real, will bring a considerable number of jobs to the area, although most of them will be limited to the construction period of about 16 years.
- As shown in Chapter 22, Rogun HPP is the best way for closing the gap in winter energy supply in Tajikistan. This is the major benefit from the project, which will contribute to improving the living and socio-economic conditions of the population of the entire country.
- Construction of Rogun HPP will also bring some social risks that will require careful management. Such risks include the need to resettle communities, social change due to the influx of large numbers of workers and public health and safety issues associated with construction activities including in non resettled villages.
- The project will require the relocation of about 42'000 persons who presently live in the area of the future reservoir.
- Resettlement started in the 1980s, when construction of Rogun HPP started. This process came to a halt when Tajikistan reached independence and was resumed recently. Presently, only the so-called "Stage 1 resettlement" is ongoing, which is the relocation of six villages directly affected by construction activities and one village which will be submerge as soon as reservoir filling begins. However, for more than 30 years people in this area live with the awareness that they will eventually have to move, and with the uncertainty about when this will happen.
- The resettlement program is intended to ensure that people who are adversely affected, whether they are relocated or not, have their socio-economic status restored or improved.

13.2 Basic conditions

13.2.1 Theoretical Considerations

Large scale HPPs have many important implications for the social conditions within a project’s area of influence. Large scale projects can deliver important social benefits especially electricity supply, flood mitigation, improved infrastructure as well as the promise of jobs and other economic stimulus to the project area. At the same time large scale HPP bring certain risks associated with the need to physically resettle communities and households, social changes due to the influx of large numbers of workers, and other public health and safety issues associated with large scale construction projects.

The physical footprint of large-scale HPPs and their extensive geographic area of influence present particular challenges for designing effective social mitigation and management programs. Typically, a project’s social area of influence can be quite different than its environmental area of influence and as a result social impacts can be experienced far from the project site and may be related to the operation of the dam with potential social impacts in downstream areas. Furthermore, since HPP require a long time horizon for planning and construction, many social impacts involve long-term problems such as job creation, ensuring sustainable livelihoods for affected communities and managing social risk which are likely to change over the life span of a project.

Finally, it must be noted that social impacts of large scale HPP are not uniform within communities and impacts may be experienced in significantly different ways by different sub-groups. Within affected communities the impacts and needs of vulnerable groups such as women and girls, youth, the elderly or the disabled can be quite different and should be taken into account when planning long term social mitigation measures.

Involuntary resettlement triggered by development projects has become a topic of increasing importance. While such a resettlement can be caused by different kinds of projects, it is often of special importance in dam projects, due to the fact that reservoirs often occupy a considerable area, and that human populations have a tendency to be concentrated along rivers. The main reasons for these concentrations are the presence of fertile alluvial soils in river valleys, as well as the fact that rivers provide water, food (fisheries), and transportation routes (directly, in case of navigable rivers, or by roads following the valleys). This can create major conflicts between projects and the interests of the local population.

The World Bank played a major role in formulating policies as guidelines for such resettlement efforts. The core point of all such policies consists in the principle of fair compensation for lost assets. The aim of any resettlement program must be to prevent project affected persons (PAP) from impoverishment due to the project. As a minimum, after resettlement such persons should be at the same (economic) level as they were before, and if possible their situation should improve (benefit sharing). These principles are by now generally accepted standards.

In the following Sections, the prevailing socio-economic situation in the project area is described, and project impacts are identified. The Outline Resettlement Plan for Stage 2 is then described in Chapter 19; Stage 1 Resettlement is the objective of a separate report, and this is not repeated here.

13.2.2 Overview of Potential Socio-economic Impacts

For the purposes of this report the Rogun HPP “social area of influence” comprises communities, households and individuals that: (i) are living within the reservoir area that will need to be physically relocated; (ii) are directly affected by the construction of civil works, presence of work camps and influx of workers; (iii) will act as host communities for resettled households; (iv) that may be affected by the long–term operations of the Vakhsh cascade principally by changes to water availability downstream of the dam(s); (v) may be indirectly affected by economic development triggered by Rogun HPP; (vi) will receive the direct benefit of assured electricity supply after the project is completed.

In this Section, a first list of potential and/or expected project impacts on the population and on the socio-economic situation is given, short comments are made on possible, probable or expected effects, and cross-references to where in the document these issues are addressed are provided.

It should be noted that this Chapter deals with socio-economic effects of the project on the country, and very specifically on the project area itself. One important category of potential impacts, positive as well as negative, namely, project impacts on downstream riparian countries, are not discussed here. They are addressed in Chapter 21 of this report.

1. **Project induced effects outside of the project area;** these are effects which will not be restricted, or not manifest themselves, within the area directly affected by the project, and will have an effect on the population at the national level in general.
    a. Improved electricity supply. This is the main purpose of the project, and here again mainly the improvement of winter energy supply, and Rogun will have a very positive effect on the population of the entire country. The beneficial effects will begin to accrue three years after river diversion, when the reservoir will reach its stage 1 level and the power plant will start producing electricity.
    b. Improved electricity supply will not only improve the living conditions of the population (lighting, heating), it will also improve the general conditions for overall economic and social development, in this way having a positive effect on the national economy.
    c. Potential for selling electricity: once at full generation level, the project will produce a very considerable amount of summer energy, for which there is a high demand in neighbouring countries. The project will thus offer the possibility to sell this electricity, in this way creating revenues for the country.
    d. During the construction phase, a large number of jobs will be created, directly related to construction, but also indirectly in supply firms etc. Although this effect will be limited in time, given the fact that the construction period will last for about 16 years still means a considerable boost for the local as well as for the national economy (see discussion of this topic in Section 13.10).
    e. The project will interrupt the existing national road Dushanbe - Obi Garm - Rasht to Gorno-Badakhshan on the one hand and to Kyrgyzstan on the other hand. This road needs to be replaced, and work on it has already started (see Section 3.5.2.5). The result will be improved transportation through the region.
2. **Direct impacts in the project area.** These are mainly the impacts caused by the fact that the project already occupies an area of about 20 km² (construction site including quarries, borrow and dumping areas, etc.), most of which is located within the reservoir and will in the end be submerged, and that the reservoir will cover a total area of 170 km². Main direct impacts are:

a. Relocation of 77 villages with a total of about 42'000 people. Main issues to be addressed for the planning and implementation of this resettlement tasks are the following:

   i. To guide this effort, given the special situation of Rogun HPP (see Sections 13.2.3 and 13.2.4), a Resettlement Action Plan (RAP) for Stage 1 is being prepared to guide ongoing efforts.

   ii. Staged resettlement: a Resettlement Policy Framework (RPF) will be in place for guiding the preparation of subsequent site specific RAPs for Stage 2. The construction period will last for about 16 years, and the reservoir will be filled gradually during this period. Resettlement will have to be done in line with, and always a little bit ahead of, progress of the impoundment. This means that the entire process needs to be planned carefully and will need a high degree of commitment over a long period. A Resettlement Unit is in place since 2009, and this unit will continue to work.

   iii. Replacement of land I, house plots: all houses in the affected villages have a house plot where a considerable amount of food for consumption by the HH is produced, and some of which is also sold. Each HH and, in the case of multiple families within a HH, each of these families, is entitled to receive a house plot in the new relocation site (see Sections 13.7and 19.4.1).

   iv. Replacement of land II, agriculture: some of the HH, besides the house plot, also have farmland. According to legal procedures, any HH wishing to receive farmland (independent of the fact whether they were farming before or not) is eligible for receiving land at the new site and will then be allocated such land for agriculture (see Section 13.7.3.3).

   v. Replacement of land III, pasture land: most HH in the project area have livestock. Not all sites identified for relocation have pasture land readily available. At the moment of choosing the site PAPs want to relocate to, they also make a choice on whether or not in the future they will continue with livestock husbandry as before. All affected persons are aware of this situation before they decide (see Section 13.7.3.2).

   vi. Replacement of houses: compensation needs to be made for each house that will be lost. According to Tajik legislation, replacement is made "at market value", this clearly being understood not as the market value of the house, but of the new material and the cost of labour required to build a new house.

   vii. Replacement of immovable assets: before relocation, an inventory is made which covers not only the house, but also other immovable assets; among these, fruit trees are of special importance. These assets are also compensated.

   viii. Transport to the new site: all movable belongings including animals of the affected HHs need to be transported to the new sites. Sufficient transport capacity needs to be available (see Section 19.4.4).

ix. Special assistance to vulnerable groups: vulnerable groups have to be identified and special provisions as may be required need to be offered (see Section 19.4.5).

x. Public consultation: including PAPs in all stages of the resettlement is important; a specific public consultation process needs to be established, and specialised staff has to be engaged for this purpose (see Section 19.8.2).

xi. Grievance process: such a process needs to be established and communicated to the PAPs (see Section 19.8.4).

xii. Relocation of graves and sacred sites: clear procedures have to be established for dealing with this issue (see Sections 9.7.1 and 9.7.2).

xiii. A Witness NGO will have to be engaged as an outside observer of the resettlement process (see Section 19.8.5).

xiv. Livelihood restoration: specific programs will have to be prepared and implemented in order to restore - or improve - the livelihood of the PAPs (see Section 19.4.2 and corresponding sections in the Stage 1 RAP).

b. Impact on infrastructure:

i. Roads: besides the replacement of the national road mentioned above a number of local roads and some small bridges will be lost due to impoundment and need to be replaced (see Section 13.8.1).

ii. Electricity grid: transformers and transmission and distribution lines within the reservoir area will have to be removed before reservoir filling (see Section 13.8.2). Replacement will be made in the new villages.

3. **Indirect impacts in the project area:** these are impacts other than those on the population that needs to be relocated.

a. Effects on villages that do not need to be relocated: Villages located above reservoir FSL will not have to be relocated. However, they will require some specific measures like e.g. replacement of access in cases where existing access will be lost due to impoundment, or additional infrastructure like schools or health services. This will have to be planned in detail along with the progress of the project and resettlement implementation (see Section 13.9.3). It cannot be excluded that in some cases such villages will opt for being relocated, if for instance they will find themselves in a too isolated situation due to the fact that all neighbouring villages will have moved away. This issue will have to be addressed in the respective Stage 2 resettlement planning.

b. Effects on host communities such as potential for social conflicts among host communities and resettlers, pressures on existing social services, lack of sufficient community infrastructure and competition for scarce community resources such as agricultural land will be addressed by the following measures:

   i. Public participation: host communities have to be included in the public participation process mentioned above.

   ii. Land: in the resettlement sites chosen so far, host communities do not have to give up land for the benefit of the resettlers, as there is sufficient land available. Should a host community actually suffer any direct loss, compensation would have to be made.

   iii. Infrastructure: wherever possible, host communities should also get benefits from improved infrastructure (e.g. better access roads, electricity supply, etc.).

c. Influx of workers: up to 13'000 of workers will be required for the construction of Rogun HPP, some of whom will come from outside of the project area. This presents a number of risks that will have to be addressed (see 13.10.3).

   i. Recruitment: it is important that local inhabitants will be given preference in recruitment; specific efforts might be required, as e.g. offering vocational training, for ensuring that they can also get qualified jobs.

   ii. Housing: so far, workers are housed within the construction site, and this practice will be maintained. Adequate facilities will have to be prepared.

   iii. Risk of conflicts with local population: needs to be addressed, necessity to have special community liaison staff on site.

   iv. Risk of spreading of communicable diseases and related community health risks. This will have to be addressed as part of the owner's and the contractor's Environment, Health and Safety (EH&S) Management Plan (see ESIA Vol. III, ESMP).

d. Influx of other population: the project will also present a considerable opportunity for the creation of indirect jobs, i.e. jobs not directly related to construction, and a high number of these will be in the project area, mainly in Rogun town. This could lead to an influx of people to this area. A direct effect will be that Rogun town will grow considerably, given the need for additional living quarters and adaptations in infrastructure (schools, health services, water supply etc.). A development plan for Rogun town will have to be prepared for coping with this situation. This will be a task mainly for the town authorities, and they will require input from Rogun OSC (see Section 13.10.3.2).

e. Public health issues: the large work force and the influx of a considerable number of other people can present some public health risks. These risks must be addressed by the corresponding EH&S plans, the medical service on site for the work force, and the health services in neighbouring towns, especially Rogun town, which will have to be upgraded.

   i. Public health issues as mentioned above, like risk of increase in tuberculosis and other communicable diseases, brought from outside and easily spread in close confinement conditions like e.g. worker's quarters.

ii. Malaria: as explained in Section 13.6.2.2, this is not a risk in the project area, no specific measures are required.

iii. Risk of accidents: increase in traffic to and from the site, and the work on site increase the risk of accidents. This requires measures on work place safety (accident prevention), training in first aid and providing adequate medical services on site, to be addressed in the EH&S plans and other related plans (see ESIA Vol. III, ESMP).

13.2.3 Specific Situation of Rogun HPP

As already mentioned, Rogun HPP is a special case especially where social impacts and resettlement are concerned, mainly due to the following facts:

- The project was developed during Soviet Union times, and construction started in the late 1980ies.
- Resettlement started at the same time, a part of the affected population was resettled then.
- At independence of Tajikistan the work was interrupted.
- During the civil war following independence and the following years, structures already built were damaged to some extent. During this period, there was a considerable amount of uncontrolled population movement; a part of the people already resettled returned to their place of origin.
- In recent years, Tajikistan started efforts to resume the project. A Resettlement Unit (RU) was created and started to work. Presently, resettlement is an ongoing process.

This means that basically since more than 30 years the local population lives with the situation of a yet unfinished project, and with the prospect of being resettled sooner or later. This uncertainty puts a great deal of stress on the PAPs, and the present report should also help in clarifying the situation for them.

At the beginning of the construction phase, and therefore of the resettlement process, still during the time of the Soviet Union, a ban on construction of new houses and on major improvements in existing ones within the area of the future reservoir was proclaimed, and this is still being followed today. According to RU, there are no records of ignoring this rule, of which the inhabitants of the area are well aware. Inevitably, this is reflected in the generally bad condition of the houses, and in the fact that very often more than one family lives in one house, usually grown up children who married and started their own family, but continued to live in the house of their parents.

This special situation has to be kept in mind when analysing the socio-economic situation of the project area, and for all aspects of resettlement planning.

13.2.4 Resettlement in Stages

Given the situation described above and in view of the anticipated development of the project, it was decided to carry out the resettlement in two major stages, namely:

- Stage 1: this includes the villages which are in the so-called risk zone, i.e. located within the construction area, and those which will be submerged in Stage

1 of project development, when reservoir impoundment will start and reach an FSL of 1100 m asl. This stage includes a number of 7 villages, namely Kishrog and Mirog (located downstream of the dam, but within the construction site), Tagi Agba, Talchakchashma, Sech, and Tagi Kamar (all of them located upstream of the dam, above an elevation of 1100 m asl, but within the construction site) and Chorsada (located at an elevation of 1100 m asl and therefore the only village to be affected by the Stage 1 impoundment).

- Stage 2: includes all other villages which will be affected by reservoir impoundment to the final FSL of 1290 m asl.

For the ESIA for Rogun, a Resettlement Action Plan (RAP) is being prepared for the Stage 1 villages, while for Stage 2 an outline of the resettlement process as it will be guided by the RPF is to be prepared. The reason for this is mainly the fact that resettlement of Stage 1 villages is under way, since these villages have to be relocated now, in order not to be affected too much from construction activities. On the other hand, resettlement of the Stage 2 villages will be carried out in line with project development, i.e. will have to take place in the time between year 3 (filling reservoir to 1100 m asl) and year 15 (reservoir reaching final FSL) of the construction period. This means that for Stage 2, there is still ample time for planning and implementation, and resettlement there will be planned and carried out in steps according to project progress. Detailed resettlement plans for Stage 2 will be prepared stepwise.

The present Chapter, and other Chapters related to it in this report, deal with the Stage 2 population. The RAP for Stage 1 is a separate document, and the villages included in this stage are not covered here in detail; however, some data from the Stage 1 HH survey are provided as a comparison with the situation of the Stage 2 population. Resettlement for Stage 1 is presently under way, while resettlement for Stage 2 (which had already started to some extent) is stopped for the time being, awaiting decisions on final project design, layout and schedule. The following Table provides an overview of the actual situation of overall resettlement as of May 1, 2014.

Table 13-1: Status of resettlement, May 1, 2014

District		Families in process of house construction				Installed in new sites	Total families
origin	moving to	not started	ongoing	finished	total		
Nurobod	Nurobod	171	50	138	359	40	399
Nurobod	Tursunzade	148	50	194	372	80	452
Rogun	Tursunzade	148	30	100	199	24	223
Nurobod	Dangara	43	15	198	256	128	384
Nurobod	Rudaki	75	18	168	261	56	317
Rogun	Rogun	176	19	0	195	0	195
Total		**682**	**162**	**798**	**1642**	**328**	**1970**

Source: RU Monthly Report to GOT, May 2014

The Table only indicates districts of origin and destination, without specifying the villages. Moving to Nurobod basically means people who moved from the old district centre to the newly built one (Darband).

The Table shows that so far, a total of 328 families have been installed in the new relocation sites, out of which 80 Stage 1 families (56 from Chorsada to Rudaki, 24 from different villages to Tursunzade). The other 248 families stem from Stage 2 villages, and they were moved before the agreement with the Bank to temporarily suspend Stage 2 resettlement. All these 324 families stem from Rogun and Nurobod districts, so far nobody from Rasht district was resettled.

It also has to be noted that there are different concepts of resettlement phases. While in the ESIA TOR Stage 1 covers the 7 villages in the risk zone and Stage 2 all the remaining ones, the definition originally used by RU was different: here, Stage 1 included the same 7 villages plus Sicharog, a village located nearby, but not directly affected by construction activities. Stage 2 covered villages in Nurobod District, while there was a Stage 3, for villages in Rasht District (where, so far, no resettlement activities have started yet).

Throughout the ESIA and related documents and studies, the definition of resettlement stages is as follows:

- Stage 1: 7 villages in which resettlement is ongoing (Kishrog, Mirog, Tagi Agba, Talkhakchashma, Tagi Kamar and Sech located within the construction site, Chorsada to be submerged at stage 1 of reservoir impoundment.
- Stage 2: all other villages affected by impoundment and to be relocated in the three districts Rogun, Nurobod and Rasht (see Tables 13-3 to 13-6 for figures on population).

13.2.5 Socio-economic Situation of the Country

The socio-economic status in Tajikistan as a whole is presented shortly in Annex 13, with social and economic indicators shown; this should be borne in mind when comparison is made with the socio-economic status of the population in the project area.

The UNDP Human Development Report 2010 has been used to illustrate the general social and economic indicators of the country. Another data source is the Millennium Development Goals from the World Bank eAtlas website. In Annex 13, Table 17 the important indicators are shown.

The country lies at 112th position on the Human Development Index (HDI) and this is a big improvement since it became independent in 1991, given all the problems it faces as an independent country. In 2009 Tajikistan had a HDI value of 0.688 and was ranked 127th in the world. Development seems to have slowed down after Tajikistan's break away from the Soviet Union. Rogun HPP was a Soviet design and the PAPs have experienced promises of having to relocate because of the construction of Rogun HPP. This may have contributed to their present socio-economic status – the uncertainty, civil war, the choice of where to relocate to and when, and the return of resettlers to original villages, among others.

Tajikistan has a population of about 7 million people with a large number of the people living in rural areas. The level of poverty is quite high in the rural areas and with the World Bank's atlas method the poverty headcount ratio living on USD 1.25 per day as of 2009 is at 6.6%, while UNDP's Human Development report puts it at 22% for the same year. The poverty is multidimensional as it touches the three sectors of education, health and living standards, implying that there is severe deprivation in any of these three dimensions. Some socio-economic indicators are shown in the following Table 13-2 and additional information is found in Annex 13.

In terms of gender the national level of education for those who are 25 years and older, the females with secondary education is at least at 93.2% and for the males this stands at 85.8%. These are quite high proportions, but when compared to the level of education of people in the project area it is quite the contrary, with lower education levels of the females, and the males' education levels are also not as high as at the national level. This is understandable as education facilities are lacking in the remote areas and one has to get to large towns or district centres to continue a higher level of education beyond the primary level.

Table 13-2 Basic indicators on Tajikistan

Country Indicators	Value
GNI per capita, Atlas method (current US$)	$730 (2009), $800 (2010)
GDP growth (annual %)	7.9% (2009), 3.8% 2010
Population, total (millions)	6.9 (2010), 7.0 (2011)
Poverty headcount ratio at $1.25 a day (PPP) (% of population)	14.7% (2007), 6.6% (2009)

Source: http://povertydata.worldbank.org/poverty/country/TJK

13.2.6 Approach to Data Collection in the Project Area

The Consultant has analysed available documents (see list of references in Vol. II). In addition, discussions and meetings with the RU and local government authorities were held, and with villagers; these were in the form of Focus Group Discussions (FGD). In autumn 2011 sample HH surveys were carried out in villages in Stage 2, in parallel to a full-fledged socio-economic survey in Stage 1 villages (see RAP).

Field work for the socio-economic survey and the description of the situation of the local population was carried out in parallel for the Stage 1 RAP and for the Stage 2 area. It was done mainly during the period from April to November 2011 (when the bulk of field work for all aspects covered in the ESIA was carried out.

The following main work was done:

- Collection of available data (though agencies involved in the work, from national ministries, local authorities etc.
- Meetings and discussions with local authorities (see list of meetings in Vol. II, Annex 1.2).
- Household survey: this covered all the HHs in Stage 1 villages (N = 288, with a total of 2048 persons) and a sample in Stage 2 villages (N = 246, with a total of 2023 persons); the survey was carried out in June to August 2011. The selection of HH in the sampled villages was discussed with the aim of having a representative sample of HH, mainly concerning the economic situation (e.g. avoiding a selection of mainly poor or mainly not so poor HHs). However, at times the question of availability of interview partners (usually the HH head) had to be considered.

- Focus group discussions: a number of such discussions were held. Focus groups were usually either women, men or young people; in some cases, discussions were held with mixed groups, and there were a number of village meetings whit too many participants as really to be called focus groups. Women are somewhat over-represented in these discussions, since they were often more readily available, many of the men being absent, e.g. as migrant labour to Russia or working on the Rogun construction site. This was however not considered as a disadvantage, since men usually have more possibilities for voicing their concerns.

The results from interviews and discussions in Stage 1 villages are described and discussed in detail in the Stage 1 RAP, which is part of the ESIA studies, but a separate document. Only some of the data are included here, mainly in order to provide a comparison with the situation of the Stage 2 population.

13.3 Study Area

The study area for social impacts of the Project are the three districts in which the reservoir will be located, namely Rogun, Nurobod and Rasht (see following Figure).

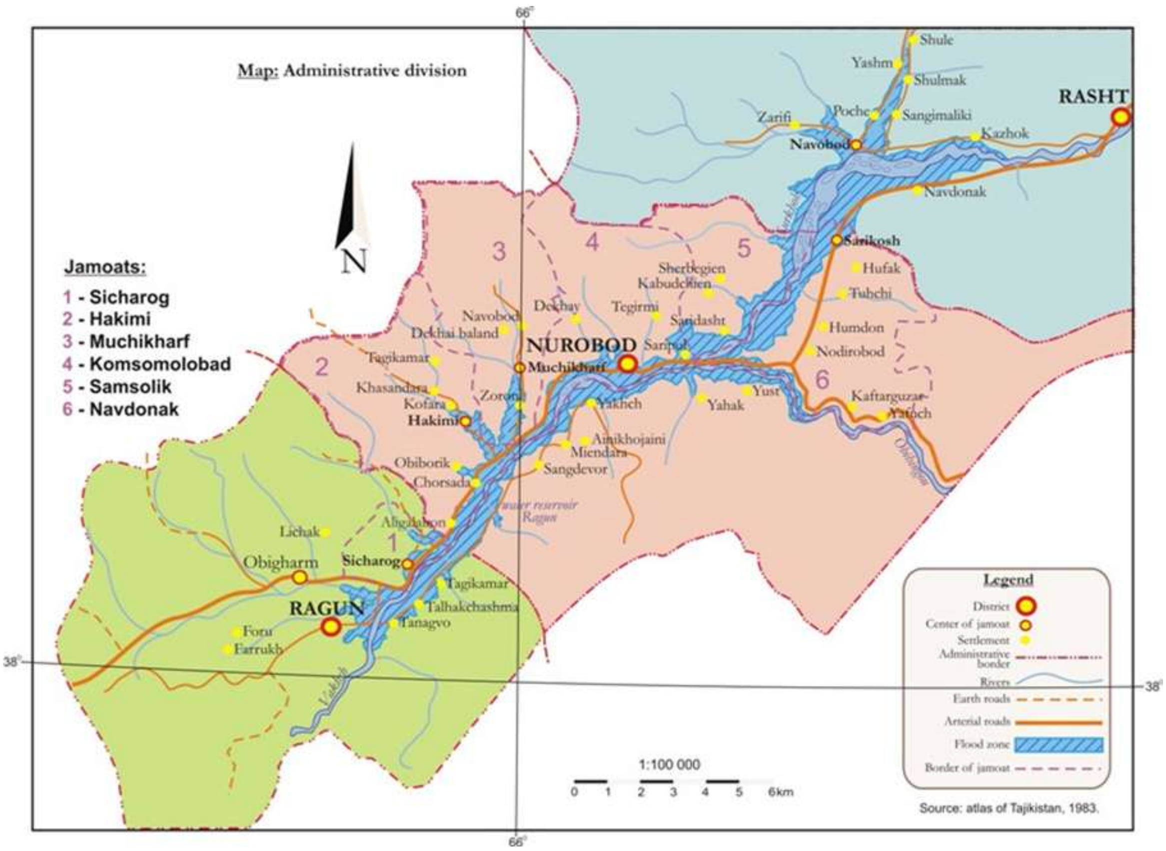


Figure 13-1: Study area for the social impact assessment

As mentioned above, when it came to actual field work, i.e. carrying out the socio-economic survey, the focus was as follows:

- Stage 1 villages, i.e. those in the "risk zone", in immediate proximity to the dam and within the construction site, or to be submerged during Stage 1 reservoir filling; for these villages, a RAP had to be prepared, and for this reason the baseline was included in the RAP Report, which is a separate document.
- Stage 2 villages, i.e. those settlements which will be relocated gradually over the period of dam construction and reservoir filling.

In the Stage 2 area, a sample survey was carried out, for providing a baseline on the present socio-economic condition of the affected population. This situation is described here.

13.4 Affected Settlements and Population

Overall, the project will require the physical relocation of a total of 77 villages in the three districts of Rogun, Nurobod and Gram (Rasht), with 6'065 households (HH) and 42'591 persons; for details see Tables 13-3 to 13-6 and Annex 13 (Vol. II). Distribution of this population on the two stages is as shown below.

Table 13-3: Popuation affected by the two stages

Stage	No. of villages	No. of HH	No. of persons
Stage 1	7	289	2'048
Stage 2	70	5'743	40'219
Total	**77**	**6'065**	**42'591**

From this Table it is clearly visible that the lion's share of the PAPs falls within Stage 2, whereas Stage 1 deals with a comparatively small number of persons.

The following Tables provide information on villages, number of households and number of persons for the three districts Rogun, Nurobod and Rasht. When considering the number provides in these Tables it has to be taken into account that resettlement stages and districts overlap: not all the affected villages in Rogun district are part of the Stage 1 resettlement, and this latter includes also one village (Chorsada) from Nurobod district.

Table 13-4: Affected villages, HH and persons, Rogun district

District	Village name	Название кишлаков	No. of HH Число домохозяйств	No. of persons Число людей
Rogun	Tagi-Agba	Таги-Агба	7	71
	Talkhakchashma	Талхакчашма	47	400
	Sech	Сеч	6	48
	Tagi Kamar	Таги Камар	37	266
	Sicharog	Сичарог	33	324
	Kishrog	Кишрог	31	243
	Mirog	Мирог	6	41
	Luguri poyon	Лугуры поён	27	138
	Kodja Valisho	Ходжа Валишох	19	201
	Total Rogun District (9 vill.)		**213**	**1'732**

Table 13-5: Affected villages, HH and persons, Nurobod district

District	Village name	Название кишлаков	No. of HH Число домохозяйств	No. of persons Число людей
Nurobod	Chorsada	Чорсада	155	979
	Obi borik poyon	Оби борик	42	276
	Surkhob most	Сурхоб мост	106	891
	Shekho	Шехо	6	34
	Aligalaboni poyon	Алигалабони поён	14	124
	Komsomolabad airport	Комсомолабад аэропорт	37	311
	Makhallai poyon	поён	91	688
	Bedikho	Бедихо	45	316
	Aligalaboni bolo	Алигалабони боло	143	945
	Khakimi poyon	Хакими поён	101	687
	Komsomolabad	Комсомолабад	397	3'313
	Dakhai Gulmon	Дахаи Гулмон	15	106
	Obi borik bolo		41	313
	Zoroni maida	Зорони майда	35	310
	Zoroni kalon	Зорони калон	175	1'684
	Chinor	Чинор	49	577
	Pandovchi poyon	Пандовичи поён	52	246
	Shakhtuti poyon	Шахтути поён	35	261
	Roguni poyon	Рогуни поён	66	474
	Khakimi miyona	Хакими миена	94	722
	Shakjtuti miyona	Шахитути поен	66	656
	Khakimi bolo	Хакими боло	94	722
	Labi-djjar	Лаби джар	17	110
	Kumok	Кумок	63	419
	Pandovchi dekhi Khodji	Пандовичи Ходжи	36	294
	Novako	Новако	18	135
	Ainy (Kabujar)	Айни(Кабучар)	64	527
	Kh. Sherozi	Х.Шероз	26	156
	Margzori Sir	Маргзори сир	25	147
	Pandovchi Bulbuldara		24	161
	Khasandara	Хасандара	29	234
	Sari kosh	Сари кош	61	619
	Zarda	Зарда	8	54
	Kofara	Кофара	64	522
	Yakhch	Яхч	22	157
	Mujikharfi maida	Муяихарфи майда	75	710
	Mujikharfi kalon	Муяихарфи Калон	144	1'267
	Pandovchi sari dasht	Пандовичи сари дашт	69	616
	Kalvokho	Калвохо	7	44
	Yusti poyon	Юсти поён	32	230
	Pandovchi-agba	Пандовичи Агба	5	81
	Dushokha zamin	Душоха замин	60	529
	Sari Dju	Сати Джу	30	237
	Delvokhak	Деалохак	15	142
	Roguni bolo	Рогуни боло	22	132
	Miyonadara	Миенадара	59	482
	Dekhi shokh	Дехи шох	10	145
	Total Nurobod District (47 vill.)		**2'844**	**22'785**

Table 13-6: Affected villages, HH and persons, Rasht district

District	Village name	Название кишлаков	No. of HH	No. of persons
			Число домохозяйств	Число людей
Rasht	Shule	Шуле	143	1'105
	Dakhana	Дахана	47	435
	Dakhani gumush	Дахани гумуш	42	375
	Shulmak	Шулмак	235	1'330
	Sangimaliki	Сангималики	123	763
	Buni Sufiyon	Буни Суфиен	72	356
	Navobad	Навобад	1'299	6'433
	Loyeba	Лойеба	133	790
	Kalai Surkh	Калаи сурх	62	472
	Sangi-kar	Санги кар	72	475
	Pojei poyon	Почехи поён	168	1'248
	Podjei Bolo	Почехи боло	117	669
	Shohindara	Шохиндара	38	262
	Kizrok	Кизрок	36	260
	Kaznok	Казнока	25	195
	Kachamandi	Качиманди	13	104
	Karoluk	Каролук	60	323
	Yapoloki	Яполоки	71	492
	Yashm	Яшм	72	417
	Navdonak	Навдонак	164	1'434
	Deamirbek	Деамирбек	16	136
	Total Rasht District (21 vill.)		**3'008**	**18'074**
	Total Reservoir area (77 vill.)		**6'065**	**42'591**

The most affected of these three districts, in terms of number of villages as well as in terms of HH and persons, is Nurobod. As Figure 13-1 shows, the largest part of the future reservoir lies within that district.

13.5 Results of the Socio-economic Survey

13.5.1 Structure of the Affected Population

250 HH were interviewed, comprising a total of 2023 persons, resulting in an average of 8.1 persons per HH. This figure is rather high and might reflect the fact that in many cases adult children continue to live with their parents. This could be caused not in the least by the fact that in the project area, in view of the project under way and the need for resettlement, there are restrictions for building new houses. As a matter of fact, Stage 1 resettlement revealed an elevated number of cases where such extended families take the opportunity of being relocated for (finally) split into several HH, which then usually consist of one core family (i.e. parents with their children.

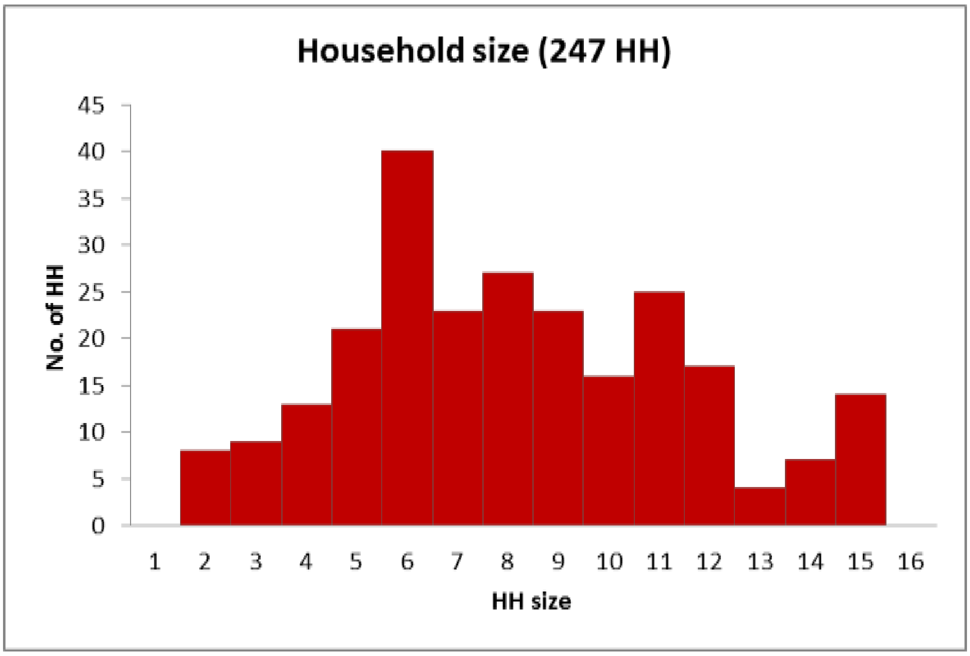


Figure 13-2: Distribution of HH size

Comparing these figures on HH size with a larger sample from all regions of the country (DHS 2012:24), two main differences become apparent, which however are linked to each other:

- the average HH size in the project area is 8.1, while in the DHS sample (4'456, only rural HH considered here) it is 6.9:
- the category of HH with 9 or more members (the DHS study does not subdivide this category any further) is 22.5% for rural areas in the country as a whole, while it is 42.9% in the study area (see following Figure).

Both these differences are presumably linked to the restrictions which apply in the study area for the construction of new houses, which led to the fact that adult children, when they got married and had a family of their own, still continued to live with their parents, leading to a large proportion of large HH and a high average number of HH members.

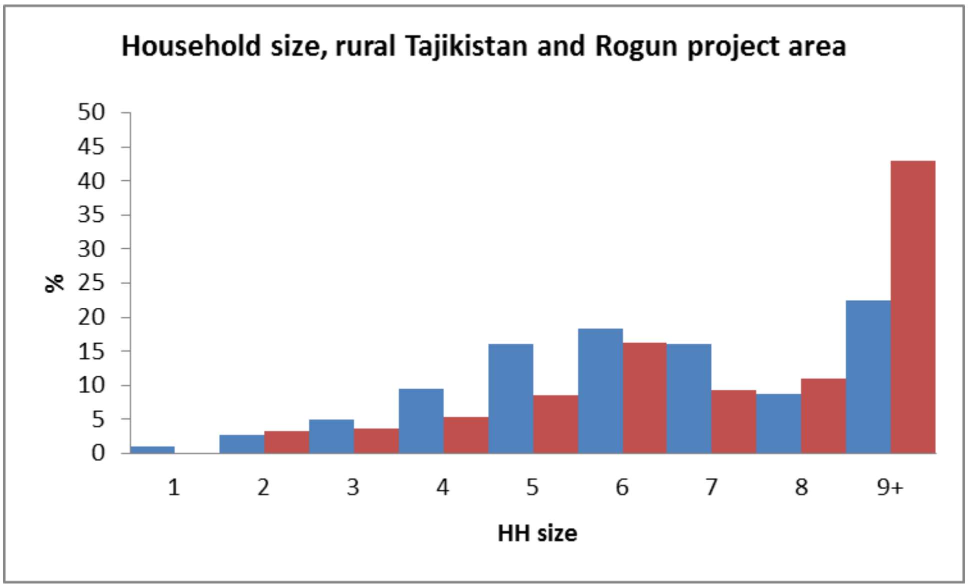


Figure 13-3: Comparison of HH size: Tajikistan and project area

blue columns: rural Tajikistan (DHS 2012)
red columns: study area (ESIA HH survey)

The following Figure shows the age distribution of the population.

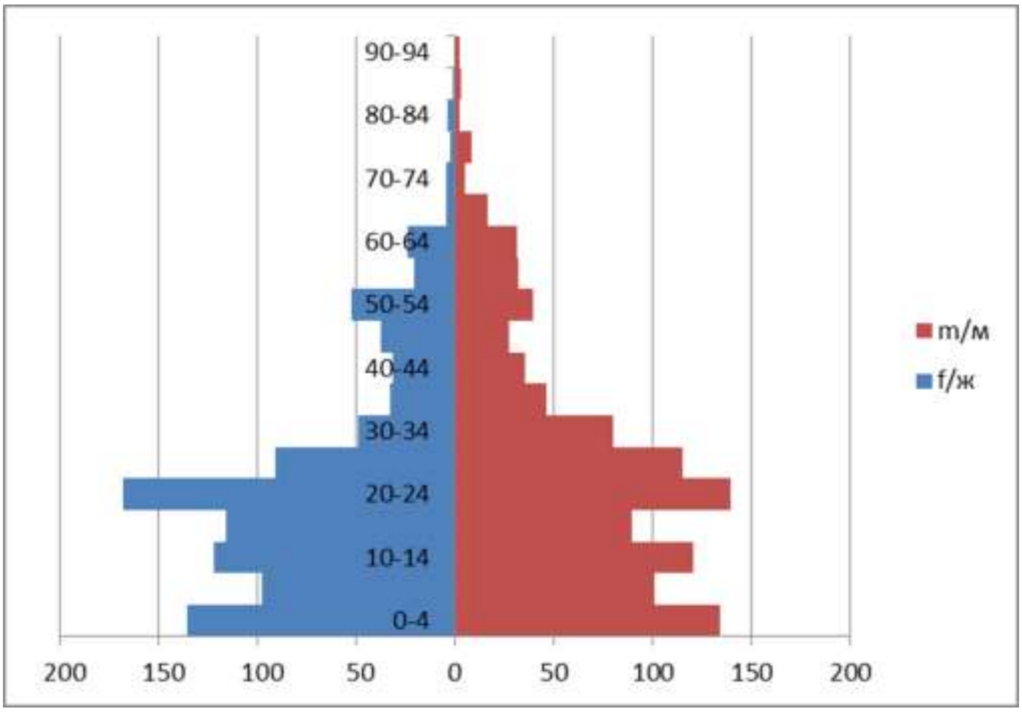


Figure 13-4: Age structure of the PAPs

As a comparison, the following Figure shows the age pyramid for a sample of the population of the whole country (DHS 2012: 37'779 persons from 6'432 HH, rural as well as urban).

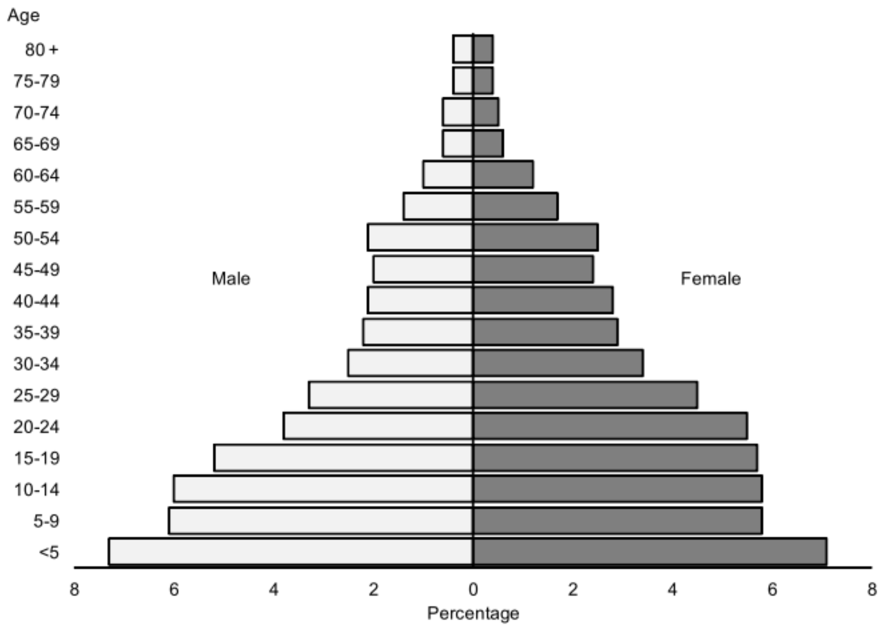


Figure 13-5: Popualtion pyramid, Tajikistan

Source: Tajikistan DHS 2012

Unlike the sample from the project area, the pyramid for the entire country shows the large proportion of the youngest cohorts which is characteristic for a population with a high reproduction rate; whether and if yes in which way the specific situation in the project area contributes to this difference cannot be said at this point in time.

13.5.2 Ethnicity, Language and Religion

The population of Tajikistan includes a number of different ethnic groups, mainly characterised by their main language (see Annex 13.2), the major part being Tajik (>60%), with Uzbeks, Russians, Kyrgyz, and a number of others.

In the project area, all HH interviewed identified themselves as Tajik.

Likewise, all the HH interviewed identified themselves as Muslim; countrywide, Muslims make up 98% of the population.

13.5.3 Socio-economic Status of the Affected Population

The affected population’s socio-economic status was noted during both the FGD and HH surveys. In general the project affected persons (PAPs) can be classified as poor people, who have to make sure that they have food security. Their education level is relatively low compared to the national level which is relatively high. Their survival is dependent on subsistence farming and income hinges on remittances sent from relatives working abroad or employment at Rogun HPP. Few, if any, are employed in the public sector, where salaries are low.

13.5.3.1 Household Subsistence

The majority of people in the project area practise subsistence farming and keep livestock, as this is also the case in other areas of rural Tajikistan. The rural population grows its own food and only if there is surplus will it be sold at markets. Agricultural products grown in the family gardens are mostly vegetables (onions, cabbage, tomatoes, and potatoes, etc.), fruit trees, especially mulberry, are also a common produce in the project area. Mulberry fruits and nuts are sold at markets if in excess or consumed at home. The only extensive fields noted were those of wheat, but none of the HHs relies solely on wheat as food security.

Agricultural production on the house plot and livestock are the most important sources for HH subsistence. This is illustrated in the following Tables. Note that in all the three following Tables, average means average per HH engaging in the respective activity.

Table 13-7: Agricultural production on HH plots

Product	Stage 1 (288 HH)			Stage 2 (246 HH)		
	No. of HH	kg/HH	% own consumption	No. of HH	kg/HH	% own consumption
Potatoes	254	884	86	207	1'533	84
Tomatoes	175	300	90	137	306	95
Vegetables	134	514	92	131	454	94
Onions	81	258	92	29	258	93
Wheat	36	1597	94	26	1'320	78
Any agriculture	**288**			**240**		

The Table shows that out of 246 HH, only 6 reported not to have any food production on their house plot. It also shows that most products are for self-consumption by the household.

Fruit trees are an important asset; in fact, ad the following Table shows, there is not a single HH which does not have any such trees.

Table 13-8: Fruit trees owned by HH

Type of tree	Stage 1		Stage 2	
	No of HH	Trees per HH	No. of HH	Trees per HH
Apple	255	13.2	212	23.2
Mulberry	277	18.1	223	22.8
Walnut	222	6.3	181	5.5
Pear	132	5.0	158	14.0
Other	163	26,6	147	39.3
Total fruit trees	**288**	**51.1**	**246**	**77.2**
Timber / fuelwood trees	124	35.7	148	67.4

Fruit as well are mainly used for HH consumption, however, on average about 30% of the harvest is being sold. This shows that the HH plot is not only a source of subsistence, but also provides a part of the HH income in monetary terms.

Livestock includes cows, goats, sheep and poultry, but most of it is for HH consumption and a minimum for sale at the markets. Livestock is also used to barter for household goods and food, should these be lacking. Also should cash be lacking for medical treatment or education of children, livestock is then sold as a last resort.

Table 13-9: Livestock

Species	Stage 1		Stage 2	
	No. of HH	Animals per HH	No. of HH	Animals per HH
Cows	242	3.9	194	4.4
Goats	168	9.5	154	9.4
Sheep	31	5.0	90	7.9
Chicken	176	10.6	167	18.0
Turkeys	9	4.8	21	13.2
Other	0	0	40	1.7
HH with any animals	288		208	

Cows, sheep and goats graze the extensive pastures surrounding the villages; this practice leads to the degradation of the vegetation described in Chapter 9.

13.5.3.2 Employment

The level of employment in the project area is relatively low. Most of the employed are men, while the larger part of women work as home-makers.

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Table 13-10: Employment in the project area

Occupation (%)	Stage 1 pop. (288 HH)			Stage 2 pop. (246 HH)		
	Total	Men	Women	Total	Men	Women
Farmer	1.0	1.6	0.4	4.4	6.8	1.7
Student	2.6	4.9	0.2	2.7	4.7	0.4
In service	3.2	5.5	0.9	5.0	8.0	1.7
Entrepreneur	2.4	4.6	0.2	3.4	6.1	0.4
Labor migration	**12.6**	**24.4**	**0.7**	**21.3**	**38.7**	**1.9**
Retired	11.0	10.9	11.0	8.6	8.1	9.2
Home-maker	37.6	2.4	73.3	38.5	1.9	79.3
Worker (Rogun HPP)	**14.4**	**27.0**	**1.7**	**4.7**	**8.6**	**0.4**
Unemployed	14.5	18.4	10.5	10.9	16.1	5.1
Other	0.7	0.4	1.1	0.5	1.0	0
Total	100	100	100	100	100	100

The Table above shows an interesting difference between Stage 1 and Stage 2 villages: in Stage 1 villages, the most important source of income is work on the Rogun HPP construction site, where 27% of the men are engaged, while 24.4% of the men from these villages engage in migrant labour. In the Stage 2 villages however, migrant labour, with almost 39% of the men, is the most important source of income; Rogun, with 8.6%, is still important, but much less than in Stage 1 villages. This is explained by the fact that Stage 1 villages are much closer to the construction site, offering the better perspective for getting jobs there. In both groups, the percentage of women working there is much smaller, since they mainly take on cleaning and cooking jobs at Rogun HPP.

While, as said above, most if not all HH engage in agricultural production, at the house plot for subsistence, and some in Dekhan farms for generating income, in both groups only a small percentage consider themselves to be farmers, i.e. derive their income mainly or exclusively from farming

Most of the income for the HH comes mainly from employment at Rogun HPP, other income is from migrant labourers in Russia, and very few salaried employees like teachers. Quite a number of men are retired and very few have ventured into small businesses. Because of the low or incomplete education, not many dare venture into own businesses without further training. This explains why quite a large proportion of income emanates from work taken abroad, though menial, from mainly Russia and other former Soviet Union countries.

Women, besides being home-makers, are also engaged in cultivating their house gardens, and they help in agriculture in the families which have farms. They are also engaged in selling the surplus products from the house gardens and the farm, in this way contributing to HH income.

13.5.3.3 HH Economy

Household income, in comparison between the two groups representing Stage 1 and Stage 2 resettlement area population, clearly reflects the difference in employment mentioned above, as the two following Figures show. These figures also show clearly that there are two main sources of HH income, namely, (i) salaries (whether from employment or in the form of remittances from migrant labour), and (ii) from selling agricultural products (whether form house gardens or farms). The two following graphs illustrate the situation in 2011, which was before the temporary reduction of work on site.

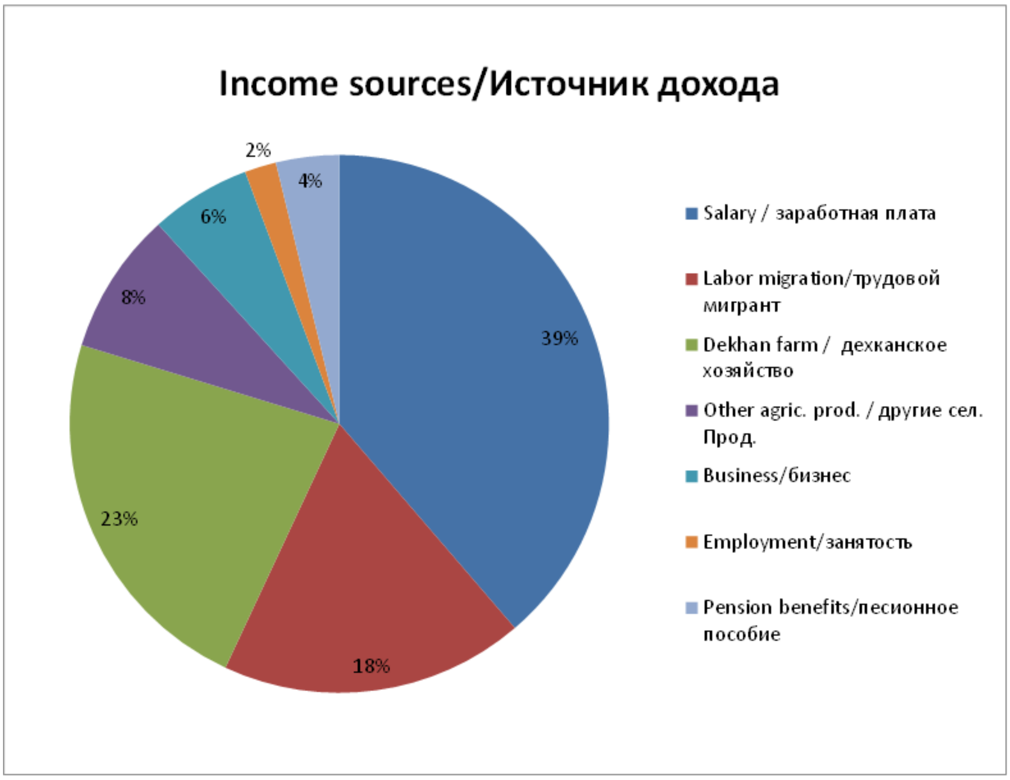


Figure 13-6: income sources, Stage 1 population

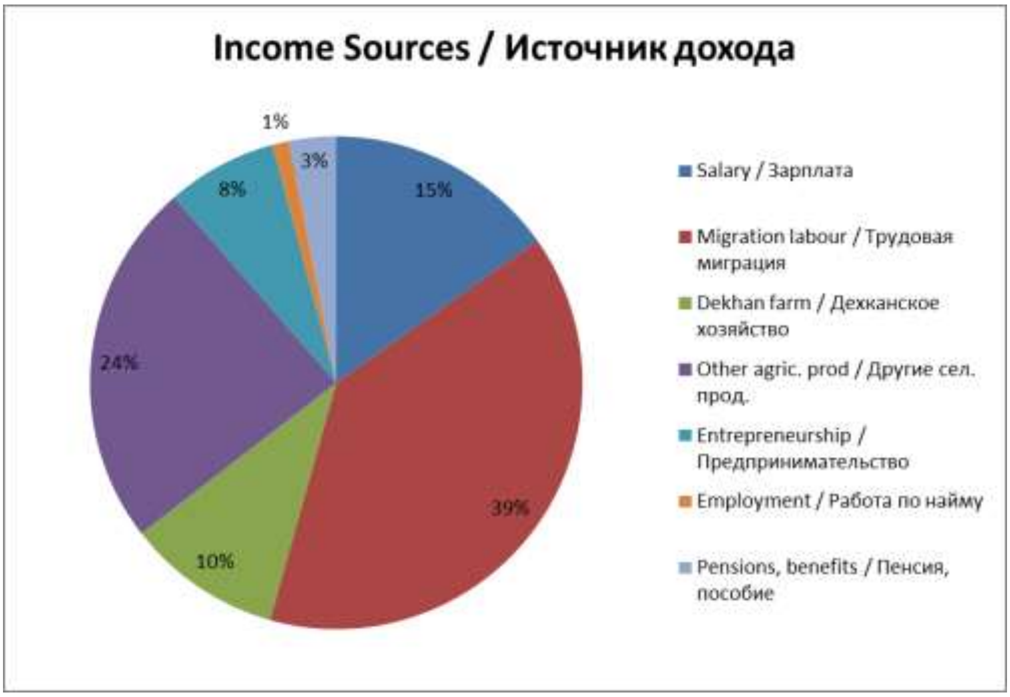


Figure 13-7: Income sources, Stage 2 population

The share of the income from work at Rogun HPP ("salary") is much higher for Stage 1, and the share from migrant labour is more important in Stage 2. In both groups, these two items account for an average of 55 to 60% of the overall HH income. Similarly, agriculture makes up slightly over 30%.

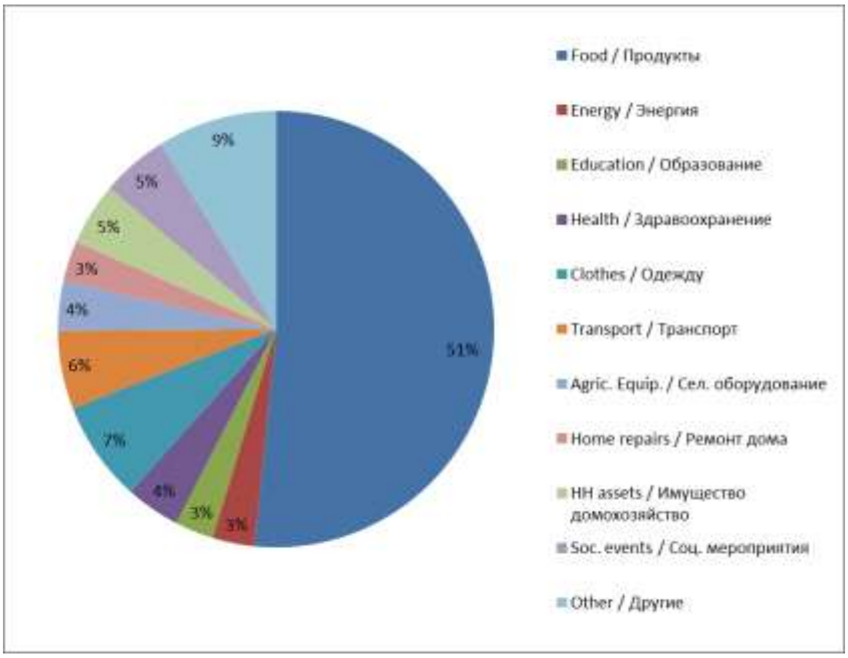


Figure 13-8: HH expenditures, Stage 1

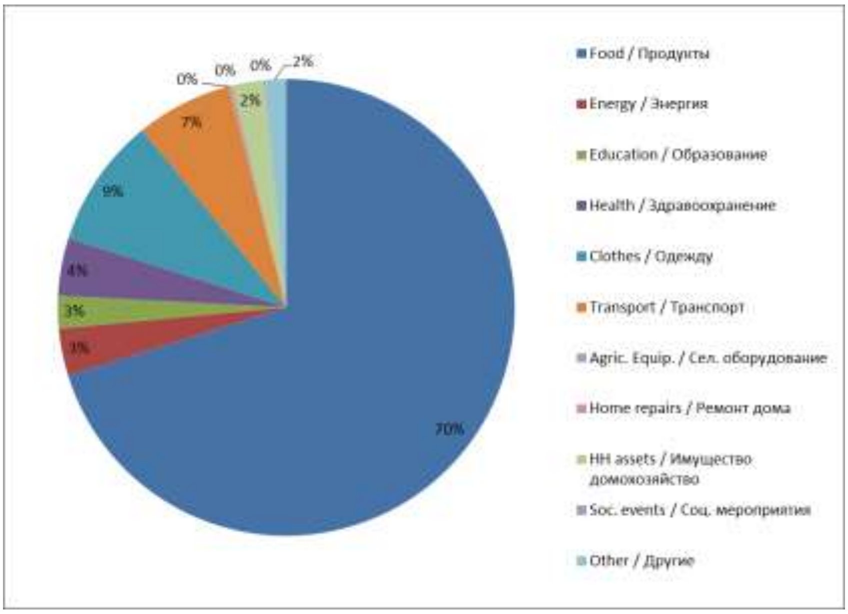


Figure 13-9: HH expendittures, Stage 2

Concerning expenditures, the two Figures above show that over half of the HH expenditures are for food, which is an indicator for a poor population. However, there is quite a considerable difference between the two groups, this item being much higher in Stage 2 HH. One possible explanation could be that persons working on the Rogun HPP construction site get food, there, in this way reducing the HH expenditures for food.

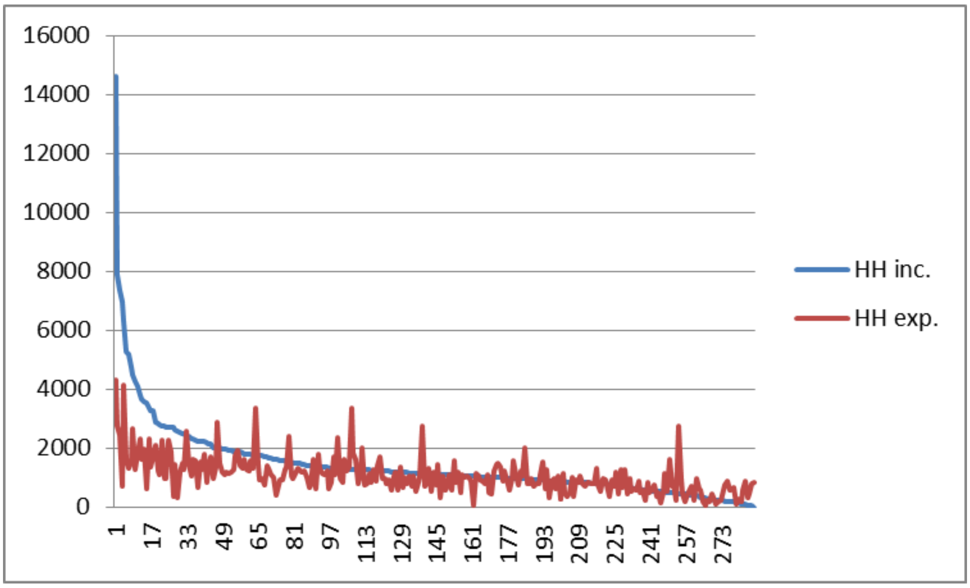


Figure 13-10: Income distribution and expenditures, Stage 1

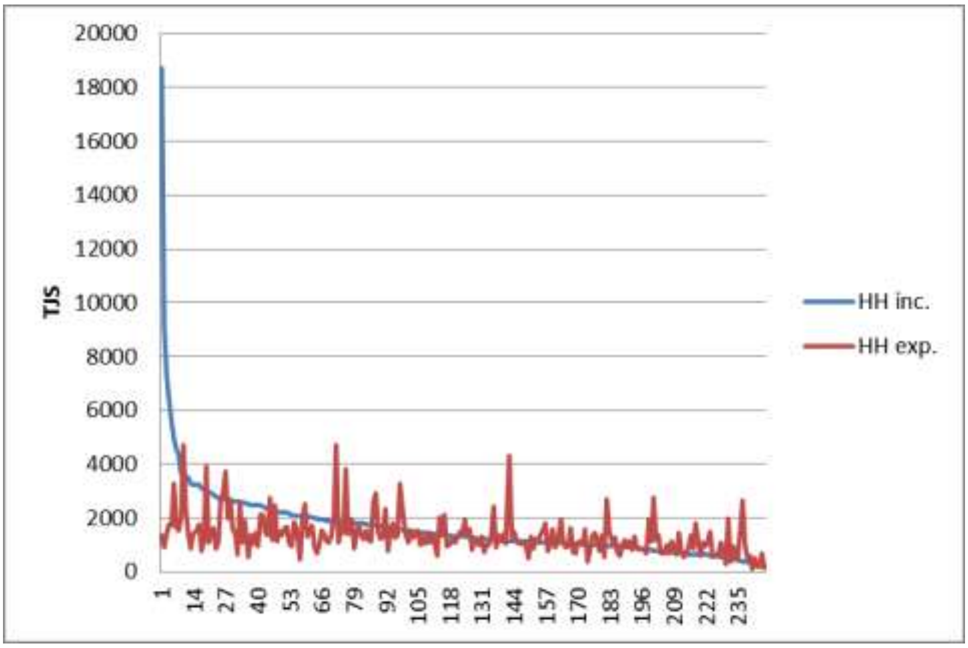


Figure 13-11: Income distribution and expenditures, Stage 2

Income distribution shows a similar picture for both groups, with very few comparably very high incomes, while the vast majority of incomes is low; average monthly income is 1'427 TJS for Stage 1'665 TJS for Stage 2, while the median value (which gives a better picture in this case since it is not influenced by a few very high values) is 1130 and 1300 TJS, respectively. The corresponding figures or expenditure are 1075 and 1000 TJS for Stage 1, and 1358 and 1220 TJS for Stage 2. For a number of HH, the Figures show a considerable discrepancy between income and expenditure, which is an indicator for the margin of error in the estimation of these values by the PAPs. Still, it confirms the picture of a poor population in its majority, with problems for matching income and expenditures.

13.5.4 Housing

Information on houses were obtained as part of the socio-economic survey. Main results are provided in the Table below.

Table 13-11: Housing conditions in the project area

Item		Stage 1	Stage 2
		(N=288)	(N=246)
House type	**Тип дома**		
Permanent (with foundation)	Постоянный (с фундаментом)	212	220
Temporary (without foundation)	Временный (без фундамента)	76	26
Roof	**Тип крыши**		
Slate	Шифер	143	179
Iron sheets	Железные листы	130	62
Straw	Соломенный	14	4
Roofing shingles	Кровля черепица	1	1
Walls	**Тип стен**		
Clay	Глина	257	218
Brick	Кирпич	5	14
Stone	Камень	20	3
Cement blocks	Цемблок	3	
Concrete slabs	Бетонная плита	2	1
Other	Другое	2	6
Floor	**Тип пола**		
Clay	Глина	159	100
Wood	Дерево	17	57
Cement	Цемент	109	88
Other	Другое	3	0

According to the Tajikistan Demographic and Health Survey 2012 (DHS 2013), in rural areas 29% of houses have an earth floor (none reported here), shingles are the most common roofing material (90%; <1% in our sample), and 55% of the houses have clay walls (89% in the project area). It can be said that from a point of view of materials used, housing standard in the project area is comparable to the one on the national level. However, many of the houses in the project area are in poor repair, presumably due to the restrictions imposed on the population regarding repair and improvement of houses in the zone of the future reservoir.

Concerning sanitation, while again, according to the DHS 2013, 94% of the rural households in the country used some type of improved toilets (pit latrine with slabs, 69.8%, and ventilation improved pit latrines, 23.8%, being the most frequent ones), all HH in the project area report using unimproved latrines.

Waste management in the project area is generally deficient, as shown by the following Table. Most HH dispose of their solid waste in their own compound.

Table 13-12: Waste elimination

Waste elimination		Stage 1 (N=288)	Stage 2 (N=246)
Pit in the yard	Яма во дворе	179	155
Communal pit	Коммунальная яма	47	46
Burn	Сжигаю	30	27
Bury	Закопать	32	15
Other	Другое	0	3

Different types of sources of drinking water are being used (see following Table).

Table 13-13: Sources of drinking water

Source of drinking water		Stage 1 (N=288)	Stage 2 (N=246)
Spring	Родник	139	85
Piped	Водопровод	102	119
Imported water	Привозная вода	42	32
Well	Колодец	2	2
Public pond	Общественный водоем	2	3
River / canal	Река/канал	2	5

Water is reported as usually being of good quality. However, some HH have to cover a substantial distance for getting drinking water.

Table 13-14: Distance to drinking water

Distance / Расстояние	Stage 1 (N=288)	Stage 2 (N=246)
in yard / Во дворе	85	148
near house / Рядом с домом	95	54
200 m	33	12
400 m	24	8
600 m	6	5
800 m	11	1
1 км	23	3
more than / более 1 км	11	15

13.5.5 Education Facilities, Public Services

In the project area, most villages have both primary and secondary schools but these vary in terms of grade levels and according to where they are located. At the village level, primary schools either go up to grade 4 or are lacking (e.g. Kishrog, Mirog, Talchakchashma), while secondary schools are mainly at the district centres. Some villages like Tagi Kamar have a school up to grade 11 and this also serves neighbouring villages, like Sech and Tagi Agba. However, due to the distance and road conditions during winter, some parents will opt not to let the girls go to school. The following Table shows the reported distances to the nearest school.

Table 13-15: Distance to school

	No. of respondents			%		
km	**Stage 1**	**Stage 2**	**Stage 1+2**	**Stage 1**	**Stage 2**	**Stage 1+2**
< 0.5	217	145	362	75.3	53.9	65.0
0.5-1	33	95	128	11.5	35.3	23.0
1-5	34	26	60	11.8	9.7	10.8
> 5	4	3	7	1.4	1.1	1.3
	288	269	557	100.0	100.0	100.0

Village infrastructure was one of the topics addressed in focus group discussions. The following Table provides information on social infrastructure (not restricted to schools) in a number of villages in Khakimi Jamoat.

Table 13-16: Village infrastructure reported in FGDs

Village	School			Medical facilities	Water		Mosque	Market
	primary	Sec. incompl.	sec.		Drinking	Irrigation		
Aligalabony poyon	-	-	-	-	+	+	-	-
Aligalabony bolo	-	+	-	+	+	+	+	-
Obi boriki poyon	+	-	-	-	+	+	-	-
Obi boriki bolo	+	-	-	-	+	+	-	-
Khakimi poyon	-	-	+	+	+	+	+	-
Khakimi moyona	-	-	-	-	+	+	+	-
Khakimi bolo	-	+	-	-	+	+	+	-
Kofara	-	-	-	-	+	+	+	-
Khasandara	-	+	-	+	+	+	+	-
Roguny poyon	+	-	-	+	-	-	-	-
Shohtuty poyon	-	-	-	-	+	+	+	-

It can be seen that none of these villages has a full set of these basic infrastructures and services. Four villages in this list have no school at all, and only one has a complete secondary school.

The following Table provides information on schooling achievements of the population in the project area (14 years and above). Since the proportions are rather similar, data for Stage 1 and Stage 2 population were combined for this analysis.

Table 13-17: Schooling (Stages 1+2, population over 14)

fem.	**жен**	**14-20**	**21-30**	**31-40**	**41-50**	**51-60**	**>61**	**Tot.**	**%**
no	нет	6	25	6	5	5	14	61	4.6
basic	начальная	112	32	15	6	12	29	206	15.7
sec. incompl.	средне не полное	143	122	64	35	31	13	408	31.1
secondary	среднее	99	200	115	79	59	29	581	44.2
special	Сред спец	1	2	0	3	6	0	12	0.9
higher incompl.	Высшее неполное	1	2	0	0	0	0	3	0.2
higher	Высшее	0	4	2	1	0	0	7	0.5
n.d.		24	10	0	1	0	1	36	2.7
Total		**386**	**397**	**202**	**130**	**113**	**86**	**1314**	**100.0**
male	**муж**	**14-20**	**21-30**	**31-40**	**41-50**	**51-60**	**>61**	**Tot.**	**%**
no	нет	1	5	2	0	1	10	19	1.4
basic	начальная	90	20	6	0	3	15	134	9.9
sec. incompl.	средне не полное	114	78	38	10	15	17	272	20.1
secondary	среднее	106	232	141	83	56	43	661	48.9
special	Сред спец	1	24	36	31	32	13	137	10.1
higher incompl.	Высшее неполное	10	25	6	1	4	1	47	3.5
higher	Высшее	0	17	17	2	18	10	64	4.7
n.d		13	3	0	1	0	0	17	1.3
Total		**335**	**404**	**246**	**128**	**129**	**109**	**1351**	**100.0**

The figures show that overall, there is a somewhat higher proportion of females without any schooling, and a lower proportion higher education. The rather high proportion of incomplete education (and slightly higher figure for no education) in the age class 21-30 years might be due to the fact that education of this cohort was affected by independence and civil war (respondents who were between 21 and 30 years old in 2011, the year of the census, presumably had most of their schooling between 1990 and 2000).

At the national level, adult literacy rate (15 years and above), stands at 99.7% (HDR, 2010) and in gender terms the population with at least secondary education stands at 93.2% for females and 85.8% for males. This is in rather deep contrast to the situation in the project area, as the following Table shows.

Table 13-18: Level of schooling

Stages 1 and 2	**m**	**f**	**all**
any school (%)	97.3	92.6	95.0
at least sec. (%)	67.3	45.9	56.7

It can be concluded that PAPs have access to both health and medical facilities (see Section 13.6 for details on health issues), but with impediments. Not all villages have health centres or schools but access to these will be through walking longer distances to the villages that have the facilities, or incurring costs in order to, for example, get to the nearest hospitals when acute medical care is required. The nature and quality of the roads does not help the situation nor does the distance to better quality public services, which are at the district centres. Most public services are concentrated at the district centres

13.5.6 Vulnerable Groups

Vulnerable groups were also identified during the initial fieldwork and are described as including the following:

- Disabled people, e.g. the handicapped, the seriously ill, the blind, maimed, etc. who need help if the village is to be relocated.
- Female-headed households and widowed women, would need to hire help to assist in building their new houses.
- The elderly who have no help in labour activities. This can also include pensioners.
- Youth: a significant portion of the affected population is under the age of 24 and will require special attention to issues related to education and job training.

The vulnerable tend to be ignored and do not, in most cases, speak out in gatherings if attended. For this reason they will need assistance depending on their needs and requests; and they will need representation, so that their interests are included.

Assistance to vulnerable groups and individuals will encompass the following:

- Assistance in moving, compensation and other negotiations. This is one reason why the Witness NGO has to be identified and will have a critical role to play (as e.g. making sure that vulnerable persons and HH are properly identified, and that they get the assistance they require) once implementation for the remaining PAPs gets under way.
- Assistance in construction of their houses, therefore a workforce other than family members will do the building construction. In some cases their social network in the village plays the role of assisting in constructing their houses.
- Assistance in receiving healthcare during moving or transition period.
- Assistance for livelihood restoration; while this is important for all PAPs, it might be of special relevance for vulnerable people.
- Monitoring and continuation of assistance after moving if required. Monitoring will have to be done, first of all, by RU, as well as by the monitoring entity which will have to be engaged.

13.5.7 Gender

Since women are to a great extent responsible for making the natural resource base productive (with their knowledge, skills and labour) and thereby contribute significantly to the well-being of their families, communities and national economies, planning for relocation should consider their preferences and should address their specific needs and constraints.

During focus group discussions, where women were well represented, no disagreements with their husbands on where to relocate were noted. However, men have had the final say. Widows and female-headed HHs have preferred relocating where the rest of the village chooses because of the social network in the village and assistance which may be accorded them.

13.5.8 Sites of Cultural Importance

Most villages have a cemetery, although in some instances, cemeteries are shared between neighbouring villages. In some cases, there are also other sites identified as holy sites by the villagers, which have a traditional meaning. Discussions held in summer of 2011 in a number of villages on this subject (See Chapter 14 and Vol. II, Annex 13.4.3) provide an impression of the importance of these sites. A well-defined procedure is in place for the relocation of graveyards (see Chapter 19).

13.6 Health

13.6.1 Health Infrastructure in the Project Area

Villages do have access to health centres, albeit some of these facilities are more than 1 km from the villages. The health centres cater mainly for primary health care. However, where complicated medical issues arise and better quality health care has to be given then the nearest district centres will be visited, e.g. Nurobod, Rogun or Dushanbe. These will have a hospital or bigger health facility, more medical staff and equipment, though not enough. This is mirrored at the national level where in 2009 there were only 20 doctors and 61 hospital beds for every 10,000 people (HDR 2010, page 1999). Most women give birth at home as each village has traditional birth attendants who are paid in kind. Most villagers in the project area go to Obi Garm in Nurobod should critical medical assistance be needed. Since most of the HHs are poor they will only incur costs when complicated medical issues arise and the sick have to be transported to district health facilities. Diseases such as tuberculosis, diarrhoea, typhoid are common, especially among children and seem to be on the rise during the summer season. Children up to the age of 3 get free vaccinations.

One important background information is the fact that health infrastructure and health services have deteriorated very considerably during the civil war following independence of the country. One considerable problem of the health sector outside of the capital is energy supply. This is especially severe in winter, when hospitals cannot be heated due to a lack of electricity; the original heating systems, which were largely based on coal, are mostly out of order, and coal is no longer available. Many schools in rural areas are facing the same problem. In recent years, considerable efforts were made for rehabilitating and improving the health system.

Some information on health infrastructure in the project area is provided here.

13.6.1.1 Rasht District

This district has the following health infrastructure:

- 1 district hospital in Garm (Rasht) with 226 beds.
- 19 local clinics, 4 of which in Garm, with a total of about 140 beds.
- 45 ambulatories ("medpunkts"); 33 of these were built in the 22 years since independence.
- 17 ambulances.
- A medical college, presently counting 657 students; this serves the entire region including Jirgital and Tavildara. The Medical University in Dushanbe has a quota reserved for students from this area.
- 1 psychiatric hospital and 1 cardiology centre, also for the entire area.
- 120 doctors, 334 nurses.

13.6.1.2 Nurobod District

This district has the following infrastructure:

- 1 central hospital with 100 beds. A new central hospital was built in Darband, the new district centre, in 2009, as a replacement for the one in the old district centre which will be lost at reservoir filling. Presently, both are working, the new one not yet to full capacity.
- 5 local clinics with a total of 100 beds.
- 1 regional polyclinic.
- 5 local polyclinics.
- 30 ambulatories ("medpunkts"); 10 of them were built only recently.
- One subsidiary of the Vakhdat medical college is located in Nurobod, presently counting 48 students.
- 42 doctors, 130 nurses.

Nurobod district will be the most affected by the project, and namely the only one where the district centre will be submerged. A new district centre, Darband, has already been built, including health services.

13.6.1.3 Rogun District

Here, the following health infrastructure is available:

- 1 central hospital and one district clinic, with a total of 175 beds.
- 2 district and 1 local polyclinics.
- 11 ambulatories ("medpunkts")
- 51 doctors, 142 nurses.
- In addition to that, there is one health centre and one clinic within the Rogun HPP construction site, which are mainly responsible for health services to the work force for the project.

13.6.1.4 Development of Health Infrastructure

As was said above, health infrastructure and services suffered greatly during the civil war, and efforts were and are being made to improve the situation. This is also the case in the project area, where in recent years a number of new structures were built and training of medical personnel has improved.

Obviously, in expanding the health services the fact that there is a hydropower project in this area is taken into account. This is exemplified by the two following observations:

- In every resettlement site, one of the first items to be built, after road network, electricity grid and water supply system, it the "medpunkt". This is done by RU in close cooperation with the Ministry of Health.
- A new hospital was built in Darband, the new district centre which replaces the old one, Nurobod, which will be lost due to reservoir impoundment.

13.6.2 Important Diseases

13.6.2.1 Main Health Problems of the Population

The most important cases for morbidity and mortality are the following:

- respiratory problems;
- cardiovascular problems;
- cancer,
- trauma (mostly from road accidents).

In this respect, the project area shows no specific differences to the country as a whole.

The following Table lists the main infectious and parasitic diseases.

Table 13-19: Main infectious and parasitic diseases in the country

Disease	Заболивание	2000	2008	2009	2010	2011	2012
Diarrheal diseases	Острые кишечные инфекции	72'912	67'757	64'017	67'349	64'908	53'830
Typhoid and paratyphoid fever	Брюшной тиф и паратифы A,B,C	3'434	1'272	2'381	729	427	225
Diphtheria	Дифтерия	3	1				
Whooping cough	Коколюш	24	7	6	13	51	5
Measles	Корь	39	7			4	11
Flue	Грипп	115'808	21'394	20'411	16'665	17'615	16'905
Acute respiratory infection	Острый инфекции верхних дыхательных путей	398'100	292'464	308'227	276'856	278'886	267'981
Tuberculosis, new cases	Туберкулёз	2'779	6'115	5'864	5'959	5'935	5'484
Viral hepatitis	Вирусный гепатит	9'863	7'773	10'961	9'886	11'079	11'601

Chicken pox	Ветряная оспа	668	1'361	1'050	1'400	1'403	1'081
Mumps	Паротит эпидемический	428	1'171	1'178	1'491	1'465	1'509
Malaria, new cases	Малярия, впервые диагностированнвя	19'064	317	162	106	75	32
Meningococcal diseases	Менингококковая инфекция	33	37	43	23	18	12
Itching (scabies)	Чесотка	6'845	1'941	162	1'930	1'576	1'288
Head lice (pediculosis)	Педиклез	2'552	386	846	458	364	320
Parasitic diseases	Паразитарный болезни	11'280	3'291	43'852	41'951	52'972	50'331

Source: TAJSTAT, 2013

13.6.2.2 Malaria

According to WHO (http://www.euro.who.int), malaria was endemic, although on a low level, in southern Tajikistan. In the late 1950ies, malaria was almost eradicated in the country. However, after independence, during the ensuing social unrest, the number of malaria cases increased again, to a peak of 30'000 cases in 1997. Since then, efforts were resumed to reduce the number of cases and finally eradicate the disease in the country. However, the recent increase in rice cultivation in the southern parts of the country have created new breeding grounds for the mosquitos which are vectors of this disease.

In recent years, a WHO guided Roll Back Malaria program and a common effort among Central Asian states (the Tashkent Agreement of 2005), led to a considerable reduction in malaria cases. In 2012, there were only 32 cases recorded in the country (see Table 13-19), and the transmission of *Plasmodium falciparum*, the dangerous form of malaria affecting the brain, was interrupted in 2009; the remaining cases are due to the much less dangerous *P. vivax*.

Malaria is usually dealt with in ESIAs for hydropower and other water resources development projects located in tropical areas, where it is endemic and often shows a high prevalence, and where the creation of stagnant water bodies can lead to an increase in the frequency of mosquitos, and thence in the number of malaria cases.

In the case of Rogun, this does not have to be considered as a risk. In fact, the project area is malaria free (see Figure 13-12), since it is located at an altitude, and therefore under climatic conditions, which does not offer suitable living conditions to the mosquitoes that act as vectors of the disease; the presence of the reservoir is not going to change this situation.

On the other hand, at least some of the resettlement sites, as e.g. Dangara, are located in areas where malaria occurs or did occur until recently. Still, given the very low number of cases and the ongoing efforts for eradicating the disease, the risk for resettlers is low. The malaria roll back program presently under way will continue, and there is no reason to suppose that the trend will be reversed. According to Mr. S. B. Rahmonov, Ministry of Health (oral comm. 2013-10-29), presently there are only about 10 cases per year, and the aim of eradicating malaria from the territory of Tajikistan is within reach.

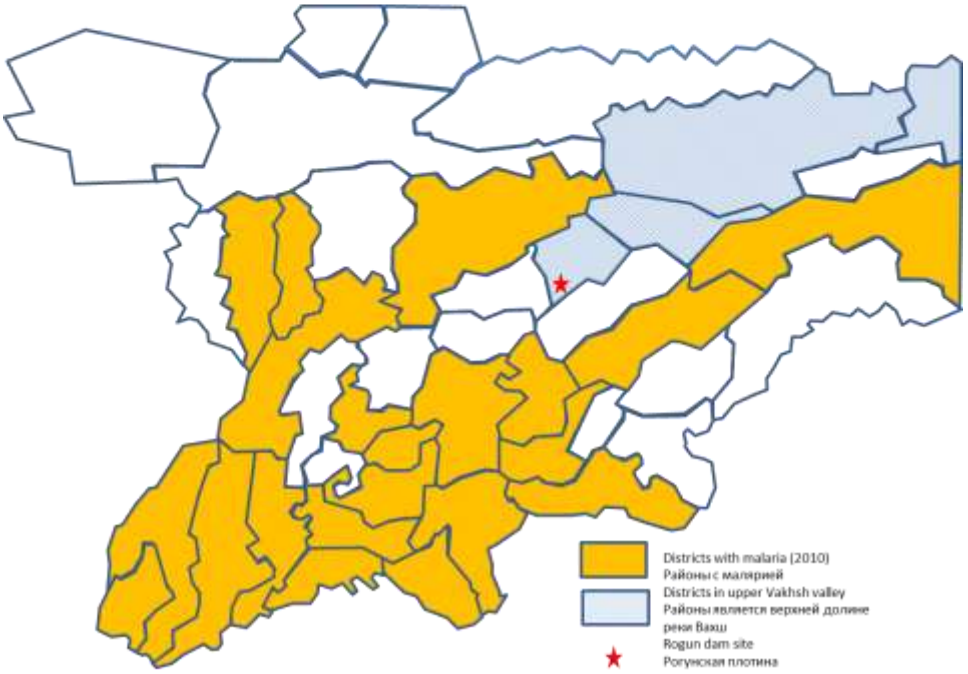


Figure 13-12: Malaria situation in south-western Tajikistan

Source: http://www.euro.who.int/en/health-topics/communicable-diseases/vector-borne-and-parasitic-diseases/malaria/country-work/tajikistan

13.7 Land Use

13.7.1 Land Use in General in the Districts of Rogun and Nurobod

The status of land use in the three affected districts as of May 2014 is shown in the following Table.

Table 13-20: Land use in Rogun, Nurobod and Rasht districts

Type	Rogun		Nurobod		Rasht	
	ha	%	ha	%	ha	%
Pasture	37'935	74.9	63'335	68	161'206	34.9
Fields	1'088	2.1	3'072	3	5'032	1.1
Hay land	20	0.0	828	1	373	0.1
Perennial crops	446	0.9	432	0	1'532	0.3
House plots	1'076	2.1	2'727	3	5'547	1.2
Presidential land	11	0.0	889	1	3'612	0.8
Forest / shrub	1'589	3.1	1'801	2	3'847	0.8
Other	8'514	16.8	19'713	21	280'111	60.7
Total	**50'679**	**100.0**	**92'797**	**100.0**	**461'260**	**100.0**

Source: State Land Committee of the Republic of Tajikistan, May 2014

[1] Other types include water, rock, glaciers etc.

As was pointed out in Chapter 9 (vegetation), most of the land is being used as pasture; these are pastures of low intensity and productivity, and this also includes land which was originally covered by forest. This is the reason why the largest part of Rogun and Nurobod districts are made up by pasture. Rasht district, which is much larger than the two others, shows a much higher proportion of land classified as "other", this due to the fact that it is located in generally higher altitudes, with a higher proportion of high mountain areas, including a number of small glaciers. Land used for agriculture, even including hay land, represents only a small fraction of the total land area.

13.7.2 Land use by Dekhan Farms

The main form of land ownership, besides the household ownership, is dekhan farm in Tajikistan.

Table 13-21: Structure of land use by dekhan farms

	Rogun		Nurobod	
	ha	%	ha	%
Number of farms	233		317	
Total land area	30'842	100	48'589	100
Irrigated land	332	1.1	2'413	4.9
Agricultural land	29'033	94.1	34'183	70.3
Including [2]				
Sown area	2'191	7.5	2'326	6.8
Perennial plantations (orchards)	145	0.5	332	0.97
Unused land			173	0.5
Hayfield			595	1.7
Pastures	26'697	92.0	30'757	90.0
2. Other land	1'809	5. 9	17'832	30.7

Source: State Committee on Land construction and geodesy of the RT

[2] In % to total area of agricultural lands

An analysis of statistical data shows that 84.4% of the total land area in Rogun is available for dekhan farms while 63.5% of land in Nurobod is accessible for dekhan farms. As statistics shows pastures are mainly available for dekhan farms. So, 92% of total agricultural land in Rogun and 90% of total agricultural land in Nurobod are pastures. The area of actually cultivated land (mainly for the production of cereals) is only 7.5% in Rogun and 6.8% in Nurobod. The irrigated area in Rogun constitutes only 1.1% and in Nurobod it is slightly higher at 4.9%. This reflects the fact that most of the land, although officially categorised as "agricultural" is of low productivity (shallow soils, slopes not favourable for agriculture, lack of water).

The production of crops and fruits is mainly concentrated in HH plots, and the leased lands are mostly used for grazing and are pastures of generally low productivity.

13.7.3 Impacts

13.7.3.1 Land

Land used by villages in Stage 2 will not all be submerged, but a large percentage of HHs will have to be relocated. Land that will not be affected falls into categories of forests, unused land and hay land. Most affected HHs will lose their arable lands and orchards, especially the dekhan farms and kitchen gardens, which hold their productive assets and sources of income. There are cases where land use will remain intact even after reservoir impoundment in the second stage. However, most of the productive agricultural land which also serves to secure food will be gone. The physical relocation of the villages lying below 1300 m asl will therefore be required in most cases.

According to meetings with the Hukumat and information from a report entitled "Nurobod District Development Program for 2009-2011" approximately 17'000 hectares of land in the reservoir area in Nurobod District will be lost. Of the land to be submerged, 1'345 hectares make up irrigated arable land already cultivated, 156 hectares are orchards, while 4'782 hectares make up the grasslands which are in effect pasture land in use. 371 hectares of household land rented on presidential land will also be submerged.

Overall, 36 farms, 62 km of roads, of which 3 km make up the National Road M41 and 59 km of local district roads, will be submerged.

The present land use and area of land in Nurobod district that will be submerged is shown in the following Table.

Table 13-22: Land that will be submerged in the three districts

	Rogun			**Nurobod**			**Rasht**			**Total**	
Type	**ha**	**%**	**% of res.**	**ha**	**%**	**% of res.**	**ha**	**%**	**% of res.**	**ha**	**%**
Pasture	40.85	5.7	0.24	4'782.44	41	28.43	962.89	21.8	5.72	5'786.18	34.39
Fields	0.00	0.0	0.00	1'835.19	16	10.91	410.26	9.3	2.44	2'245.45	13.35
Hay land	0.00	0.0	0.00	4.60	0	0.03	0.00	0.0	0.00	4.60	0.03
Perennial crops	0.00	0.0	0.00	199.89	2	1.19	143.78	3.3	0.85	343.67	2.04
House plots	4.70	0.7	0.03	370.65	3	2.20	191.53	4.3	1.14	566.88	3.37
Presidential land	1.50	0.2	0.01	203.91	2	1.21	45.58	1.0	0.27	250.99	1.49
Shrub	0.00	0.0	0.00	474.32	4	2.82	252.94	5.7	1.50	727.26	4.32
Other	673.38	93.5	4.00	3'813.00	33	22.67	2'411.84	54.6	14.34	6'898.22	41.00
Total	720.43	100.0	4.28	11'684.00	100.0	69.45	4'418.82	100.0	26.27	16'823.25	100.00
District	**50'679**	**1.4**		**92'797**	**12.6**		**461'260**	**1.0**			

Source: State Land Committee of the Republic of Tajikistan, May 2014

Forests are rare in the project area as most trees have been cut to get firewood. The remaining forests are located in higher elevations, far above the reservoir FSL. Resettlement will not put additional pressure on these remaining forests, since no villages will be built at these altitudes. Shrubs and bushes are found on the slopes of the reservoir but these are also decreasing as coverage since most are cleared to make way for cultivation.

There are no mining or industrial activities (with the exception of the Rogun HPP construction site) in the three districts.

Additional land will be required for coping with the expected influx of people into the area once the construction activities will be resumed (see Section 13.10.3). In this respect, two categories of people will have to be distinguished, namely:

- Workers on the construction site: presently, workers are housed in construction camps located within the construction site itself, and this will also be the case in the future. While the increase in their numbers will require the construction of additional quarters for them, there is sufficient space within the construction site available, and it will not be necessary to occupy additional land for this purpose.
- Other people moving into the area: these will be people who get (or come in the hope of getting) secondary jobs, i.e. jobs created indirectly by the activities related building the dam, like e.g. providing services for the work force, etc., or family members of people who work on site. A large part of these will move to Rogun town. This therefore will grow considerably, since space for living quarters as well as for the additional infrastructure required for the growing population will be required.

A development plan will have to be prepared for Rogun town, which will have to be based on a more detailed assessment of the expected development, and the possibilities to deal with it. This will mainly be a task for the local authorities, who will certainly require input and support from Rogun OSC for this purpose.

13.7.3.2 Livestock

Livestock production being part of the livelihood of most HHs will also be affected, although most of the hay land, located at higher elevations, will remain intact.

Depending on the site selected for relocation, pasture land is not available in the vicinity of some of the new villages, as e.g. in Tursunzade and Dangara, the two sites which are located at lower altitudes and in agricultural areas. These areas offer a far greater potential for agriculture (more fertile soils, irrigation schemes in place) than the villages of origin, but are less suitable for livestock husbandry, at least for the type of low input and low productivity husbandry practiced in the project area. Having their livestock in places located at greater distances from their houses might not be a practical solution for most HHs. Usually, people moving to one of these sites will reduce the number of livestock to be kept at the new site. However, they are aware of this situation before they decide where they chose to go. Options are available for choosing locations with sufficient amount of pasture land, which allow for keeping the traditional way of livestock husbandry, in case a HH considers this as a priority.

13.7.3.3 Conclusions and Recommendations

Productive land lost due to relocation is replaced in two ways:

- House plots: these are allocated to each HH, or, in the case of HHs consisting of multiple families wishing to relocate separately, to each family. This is a case that occurs very frequently; so. in the Stage 1 villages there are 289 HH with a total of 527 families, who all have already been allocated their house plot. This means that finally for the original HH much more land will be available as compared to what they had before, and this even in cases where a new plot (which uniformly have a surface of 800 m²) might be somewhat smaller than the original one.

- Agricultural land: resettlers who want to engage in agriculture are eligible for receiving agricultural land; this is standard procedure according to the land law and not related to resettlement, and it is also independent of the question whether they were engaged in agriculture before or not. They will then be allocated such land. Experience gained so far by RU has shown that only a small number of resettlers have actually applied for such land at the new sites; however, all that have applied were provided with land.

Replacement of land in the ways described is certainly an important part of livelihood restoration. However, taking into consideration the difference in conditions between the original places and the new sites (at least for sites outside of the original districts, i.e. Tursunzade, Dangara and Rudaki), efforts will be required for enabling the relocated persons to adapt to these new situations. This will be part of the livelihood restoration programs (partly under way, in part still to be developed or improved). Such programs, which are described to some extent in the RAP can be, among others:

- Training courses for people intending to engage in agriculture; such training is already offered by the Ministry of Agriculture to people who have completed their move to the new sites.
- More intensive forms of livestock husbandry (stable-fed cattle) should be considered as an alternative to evaluate and offer to PAPs.

Livelihood restoration will however not be restricted to land and agriculture. Especially in the case of HHs moving from a rural (Rogun reservoir area) to a peri-urban area (Tursunzade, Dangara, Rudaki), the situation of HH will change in many ways; there will be new opportunities (e.g. for getting jobs), which however will also require new skills. This means that different forms and types of training will have to be offered, and this might be of special importance for women, many of whom had limited schooling and no additional training, as well as for young people in general.

13.8 Infrastructure

13.8.1 Roads

The impoundment of the reservoir will submerge the main road M-41 leading from Dushanbe via Obi Garm to Garm and onwards to Kyrgyzstan (along the Vakhsh valley) and to Gorno-Badakhshan Oblast (crossing a pass leading to the Pyanj valley), the south-eastern part of the country.

This road needs to be replaced, since it is an international and an important national road. There is a project for this road, and construction started simultaneously with the construction of Rogun dam, in the 1980ies. As for the dam, work came to a halt at independence, and the structures already built suffered partly important damage in the meantime. Recently, the Planning and Design Institute, the entity in charge of road planning in the country, prepared a project for the completion of this road, which includes the necessary repair of structures already built.

In addition to the main road, a number of local roads, including small bridges crossing Vakhsh river, will be lost. While a considerable number of villages located below reservoir FSL will be relocated outside of the project area, some villages lying at higher elevations will remain, and access to then will have to be granted. For this purpose, two major new roads were included in the planning, one along the left bank of the lower part of the reservoir, from the dam to the main bridge which will cross the reservoir, the other on the right bank, upper part of the reservoir, between this bridge and Garm (see Figure 3-3 for the alignment of these roads).

While these access roads are necessary compensation measure, it is also clear that mainly for the villages on the left bank of Vakhsh, which till now were mostly accessible only via small suspended bridges crossing the river, access will be greatly improved with these roads.

13.8.2 Electricity Grid

The electricity grid in the reservoir area will also be affected by the project. A separate project for carrying out the required work to adapt the grid was prepared by Nurofar Institute, and includes the following:

- Substations:
  - 1 existing 35/7 kV station to be dismantled
  - 2 existing 110/10 kV stations to be upgraded
  - 4 new110/10 kV stations to be built
- 110 kV lines:
  - existing line: no changes; layout was made taking the future reservoir in account
  - 4 additional lines with a total length of 55.9 km to be built
- 35 kV lines:
  - dismantling of 24 km of existing lines
  - no new ones
- 10 kV lines:
  - dismantling of 137 km of existing lines
  - 117 km of new lines to be built
- 6 kV lines:
  - dismantling of 11 km
  - no new ones
- Other items:
  - dismantling of 180 km of 0.4 kV lines
  - dismantling of 180 transformers in settlements
  - installation of 5451 new HH connections.

This list is only the work to be done in the reservoir area, it does not include the work (already done or still to be done) in new resettlement villages. Structures to be removed mentioned here are those that need to be removed because they will be submerged. Structures to be built mentioned here are those to be built for connecting (or re-connecting) existing villages in the area that will not be relocated. All resettlement villages under development have already been connected to the electricity grid; detailed projects were and are made on a case to case basis.

13.8.3 Other Infrastructure

Villages have a certain infrastructure, although this is often rather deficient. It consists mainly of administrative buildings, schools, health post and mosques. As an example, the following Table lists the infrastructure present in the Stage 2 villages which were surveyed.

Table 13-23: Social infrastructure in affected villages Stage 2

Jamoat Name	HC	Sch.	Mos.	Mark.	Cem.	Comments
Humdon 5 villages	+	+	+	+	+	Primary schools in all villages except Kalvokho. Secondary till gr. 11 in Sarikosh. HC in Sarikosh only or go to Nurobod centre. Mosque at Sarikosh is big for all villages and Rasht District villages. Market accessible to Sarikosh village, or go to market at Nurobod centre.
Hakimi Хакими 11 villages	+	+	+	-	+	Primary sch in Obi boric and Roguni poyon, sec. schools till grade 9 in Aligalaboni, Khakimi bolo, Kasandra and till grade 11 in Khakimi poyon only. HC in Aligalabony, Khakimi poyon, Kasandra and Roguni poyon, or go to Obi Garm, Komsomolobod and Layron and Dushanbe for better medical care. No markets in Jamoat, just outlets, but use Sunday market in Chorsada. Mosques in all villages.
Yahak-yust 13 villages but 4 will be affected	+	+	+	-	-	Primary sch. only at Yusti poyon, sec. sch till grade 9 in Bedikho and Novako and one complete sec. sch. at Yahch, go to Komsomalabad for boarding sch. HC only at Yahch, go to Rogun, Nurobod, Darband and Obi Garm. Mosques present in all villages. No markets at all, go to Chorsada or Nurobod. Essential goods bought at Tagi Kamar closest to Bedikho village.
Muchikharf 4 villages	+	+	+	-	-	Primary sch. in Muchiharfi Maida and Zoroni Maida. Sec. Sch in Muchikharfi Kolon and Zoroni Kalon. HC in Zoroni Kalon, or go to Nurobod, Dushanbe or Hulozi 4km away. Mosques present in all villages. No market in any village, go to Sunday market at Chorsada.
Samsolik 5 villages	-	+	+	-	-	Primary sch in 3 villages, Pandovchi Bulbuldara, Dekhi Khodji & Dekhi Gulmon. Secondary sch till 9^{th} grade only at Pandovchi Sari Dasht. No health facilities exist; go to Darband, Samsolik and Komsomolobod villages, 4-25 km away. Mosques in all villages except Zarda. No markets exist; go to Darband, Komsomolobod or centre of Jamoat, about 12-25 km away to purchase HH products.

Source: Study Team, FGD October, 2011
HC = Health centre Sch. = School Mos. = Mosque Mark. = Market Cem. = Cemetery

Before relocation of any village, the RU prepares a detailed inventory of such structures, which will then be replaced in the new sites. In the resettlement carried out so far, infrastructure (e.g. schools, health centres) are greatly improved as compared to the original situation, and they are often dimensioned in a way as to serve also the host communities.

The same standard will have to be kept in the future resettlement (Stage 2)

13.9 Impacts of Impoundment on Settlements

13.9.1 Stage 2 Resettlement

As explained above, the villages which are or could be directly affected by construction activities (being located within the area used for construction of the dam and appurtenant structures) or by early impoundment (being located at or below a level of 1110 m asl), i.e. Stage 1 resettlement, are being relocated presently, and this process will be finalised before reservoir impoundment will start, which is expected to be the case three years after the construction starts.

This means that for the remaining villages located in the reservoir area, reservoir impoundment will be the only relevant impact. For the affected population, the following categories will have to be considered:

- Land located below an elevation of 1290 m asl: all this land will be submerged (reservoir FSL 1290 m asl) and will therefore no longer be available for its present use.
- Settlements (villages and single houses) located below an elevation of 1300 m asl: these will have to be relocated. For an FSL of 1290 m asl, a limit for relocation of (inhabited) buildings is assumed, in order to have a safety margin from the reservoir and in any case to provide for the eventuality of a 1 in 100 years flood; while land between FSL and the 100 years flood level can still be cultivated, it is not deemed safe for inhabited buildings.
- Villages and parts of villages around the reservoir, close to it but above a level of 1300 m asl: Basically, these need not to be relocated. However, it will still have to be decided, on a case by case bases, what will have to be done in these cases. Some of them may choose to be integrated into the relocation program, e.g. for the following reasons:
    - Loss of land: even if a house or village is not directly affected (i.e. not submerged), it could be that so much of its land would be lost that it is no longer considered as economically viable.
    - Loss of access: if a settlement loses its access and this cannot be reestablished in a satisfactory way, relocation might be an option.
    - Loss of social network: a number of villages stretch over a certain elevation range, the lower parts being submerged, the higher ones not. Here the option might be to relocate the entire village in order to keep social structures and networks intact.
    - Risk: if a village is located on an alluvial cone which might be affected by reservoir operation (risk of landslides induced by reservoir

impoundment and especially also due to reservoir drawdown), it might be required to relocate it.

These cases will all have to be analysed in detail in the resettlement planning for Stage 2, and the appropriate decisions will have to be taken. A time span of approximately 12 years, during which the reservoir level will gradually be increased, is available for this process. In any case, the PAPs will have to be consulted on a continuous basis and included in the decision making process.

13.9.2 Main Impacts

The main types of impacts which will occur during impoundment are described shortly in the following paragraphs:

All agricultural land and pasture land will be submerged, should it lie at 1290 m asl or below.

Traffic: Old roads, paths and footbridges will also be submerged, as will the communication lines.

Economic and social infrastructure: all economic and social infrastructures, i.e. water supply, schools, electricity distribution lines, telecommunication lines, local government administration buildings lying at or below 1'290 m asl will need to be relocated.

Host communities: it is important to note that host communities do not have to give up land which they cultivated so far and which will now be occupied by the new settlers. Land shortage is not an issue. The first relocated HHs to a new site might use some of the infrastructure of host communities, like e.g. schools; this is the case only during a short period and in a situation where only a few families are in this situation, and this does not put much pressure on existing infrastructure in neighbouring villages. On the other hand, host communities will also benefit from the infrastructure prepared for the new villages, as e.g. improved access roads, schools and health facilities.

Livelihood: can be affected in different ways, as e.g.:

- Loss of land: house plot or agricultural land; this is addressed above (Section 13.7), where compensation strategies are also explained.
- Loss of jobs: this will usually not happen in the case of Rogun, for the following main reasons: (i) persons who have a job on Rogun construction site will keep it even if they relocate to a different place, under a special arrangement which foresees a rhythm of two weeks work on site and two weeks at home; (ii) the few persons employed otherwise, e.g. as teachers in local schools, will continue to work in this function in the new sites; (iii) one major source of income for many households, migrant labour, is not affected by the change in place of living.
- Livestock: as explained in Section 13.7.3.2, not all resettlement sites offer good conditions for the traditional form of livestock husbandry. This will have to be mitigated for those who chose such sites.

Livelihood restoration programs, in the form of training for different activities, are in place (agricultural training, special training for women, e.g. in cooking and embroidery) and these will have to be expanded in order to ensure livelihood restoration; the Stage 1 RAP provides some more information on this important topic.

Public Health: Due to construction in both phases, an influx of workers is expected, casual, trained and those providing services. The new arrivals are likely to boost the economy of the nearby towns, and also encourage other activities like increased consumption of alcohol. With this there is a risk of an increase in communicable diseases like tuberculosis and other diseases unless strict health standards are kept. As of 2010 Tajikistan had an HIV prevalence of 0.3% among the 15-49 year olds, and this is the productive employable age. TB prevalence stands at 200 per 100,000 and this is a major problem as it is spread through air under sub-standard conditions, as could be the case where the labour force’s accommodation is not strictly checked. Close proximity to anyone who already has TB and coughs easily contaminates the surrounding air and anyone who breaths this in.

13.9.3 Villages Not Directly Affected by Impoundment

Not all the villages in the affected districts will have to be relocated due to Rogun HPP. There are many villages located above the future reservoir FSL of 1290 m asl, and at a sufficient distance from the construction site and the reservoir, and in general these villages will remain in place. This is shown for Nurobod district in the following Table.

Table 13-24: Villages in Nurobod: submerged and not submerged

Jamoat Nakimi (11'595)	Jamoat Muliharf (15'720)	Jamoat Komsomolobod (12'279)	Jamoat Yahakust (6'646)	Jamoat Samsolik (6'932)	Jamoat Khundon (9'784)	Jamoat Darband (1'204)
1.Aligalaboni poyon	1.Zoron	1.Sari pul	1.Bediho	1.Bulbuldara	1.Labi lyar	1.Shanraki Darband
2.Aligalboni bolo	2.Zoroni maida	2 Airport	2.Roguni poyon	2.Pyandovchi dekhi noli	2.Mazori Sir	2. Yonur
3. Chorsada	3.Muchiharf	3.Manalai poyon	3.Novoko	3.Pyandovchi tagi agba	3.Kavlokho	
4.Kumok	4.Muchiharfi maida	4.Chanor	4.Deni tag	4.Zarda	4.Khofizi Sherozi	
5.Obiboriki poyon	5. Chepak	5.Kuch-Ronsozon	5.Yahch	5.Denai gulomon	5.Sari kosh	
6. Obi boriki bolo	6.Ohangaron	6.Kuch-Ismoili S.	6.Yusto poyon	6.Sheho	6.Siyonob	
7.Nakimi poyon	7.Chromagzak	7.Kuch-Aloka	7.Roguni bolo	7.Denai tyag	7.Khufak	
8. Nakimi bolo	8.Navobodi maida	8.Kuch-Abdurasul	8.Sangdevor	8.Ulfatabod	8.Ushturgen	
9. Shahtuti poyon	9.Navobodi kalon	9.Kuch-Shoismati	9.Kumbak	9.Kabution	9.Kholibek	
10.Shahtuti bolo	10.Kalanak	10.Kuch-Khirmano	10.Moyonadara	10.Kalnazar	10.Shanri sabz	
11. Kofara	11.Danji baland	11 Kuch-Shaih abul	11.Sarily	11.Sherbegion	11.Tugchi	
12. Sari pulak	12.Khulozi	12 Deni shon	12.Aini	12.Farkak	12.Obilurd	
13.Nasandara	13.Chonaraki poyon	13 Devlohak	13. Iston		13.Tirgar	
14.Darai tytak	14.Chanoraki bolo	14 Aini	14.Yahak		14.Kholai Shanbe	
15.Lairon	15.Ravshani	15. Dushokhazamin	15. Yusti bolo		15.Kholai Murod	
16.Sarizakob	16.Pairav	16.Sebak			16.Turmich	
17 Siehgulak	17.Mennat	17.Degai			17.Kaftarguzar	
18.Tagikamar	18 Sabzikadam	18.Farkak			18.Yofuch	
19.Sadokat	19.Darai Sabzikada	19.Tutkhor			19.Pustinduzoi	
20.Lavchii poyon	20. Galaba	20 Kalanak			20.Khumdon	
21.Lavchii bolo	21.Shodmoni	21.Shashvolon				
22.Dudak	22.Danagiyon	22.Tugak				
23.Safedoron	23.Obigarmi	23.Saidon				
24.Kaskon	24.Voidara	24.Tegirmi				
	25.Degdonak	25.Sinlit				
		26.Langar				
		27.Pandovchi				

Source: RU
in red font: villages not directly affected by Rogun reservoir (i.e. not submerged); in black font: villages submerged and therefore to be relocated
in parentheses: number of inhabitants per Jamoat

The Table shows that out of the 125 villages in Nurobod district, 49 are located below or at the level of the future reservoir and will therefore have to be relocated in any case, while 76 are above this level, and therefore not directly affected by reservoir impoundment. In terms of inhabitants: out of the 64'160 inhabitants of Nurobod district, 22'753 are inhabitants of villages that need to be relocated.

This does not mean that the villages above FSL 1290 will not be affected in any way by the project. Indirect effects will be felt in any case. The following situations could arise:

- No impact: villages which are not influenced in their situation, neither positively nor negatively, no noticeable changes that could be attributed to the project.
- Affected by loss of land: even if a village is located above reservoir FSL, it could lose a considerable part of its land (used for agriculture or pasture). Note that in reality such villages have already been included in the "affected" villages, the list of which includes a number of settlements above FSL, but close to it (potentially exposed to a flood risks, and a risk of loss of land).
- Indirectly affected by change in accessibility. Loss of access; this will be the case for all villages on the left bank of Vakhsh river, lower part of the reservoir, and for many villages on the right bank. Mitigation here consists in building the replacement road for the existing main road and the new access roads (see Section 3.5.2.5). For many villages, this will improve the situation as compared to today. In addition to the road projects already identified, a number of local access roads may still be required.
- Indirectly affected - positively or negatively - by the economic development in the region due to Rogun project. Not all the villages will benefit to the same extent (certainly influenced by their proximity to or distance from the construction site), and in the same way not all will be affected by possible negative impacts, e.g. caused by the influx of workers from outside to the area.

In any case, resettlement planning (see Chapter 19) will have to take these conditions into account, and negative impacts of the project will have to be compensated in a suitable manner.

In the context of villages which do not have to be relocated, the following additional issues have to be considered:

- It cannot be completely excluded that there might be cases in which a village located above FSL 1290 might, in the perception of its inhabitants, due to the project find itself in a situation that would be considered as inacceptable or at least unfavourable, e.g. due to difficulty of access, longer ways to service centres, or isolation due to the fact that neighbouring villages were relocated. If in such a case the inhabitants of such a village would opt for being relocated themselves, this will have to be considered, and appropriate development assistance based on a careful assessment will have to be offered to them.
- Some villages located near FSL 1290 extend over a considerable altitudinal range, and the present plan is that such villages will be relocated entirely. In a case when only the lower parts of such a village would actually be submerged, while the higher ones would not be directly affected and could therefore stay in place. In such a case, the preference of the inhabitants of these village parts have to be considered. If they prefer to stay, it would have to be determined what

additional measures would have to be taken for them, e.g. in terms of upgrading infrastructure, or to what compensation they might still be entitled.

13.9.4 The Special Case of Obi Garm

13.9.4.1 Situation

Obi Garm is a spa resort located on the right bank of the tributary of the same name, which reaches Vakhsh river about 4 km u/s of the dam site.

As can be seen from the Figure below, the existing main road, which arrives from Dushanbe and winds through the village, will be interrupted just outside of the village by the reservoir, while this, at an FSL of 1290 m asl, comes very close to the settlement, without however directly affecting it. The new road, which is under construction (although work is not going on for the time being) will bypass the village, basically leaving the existing road as a dead-end street.

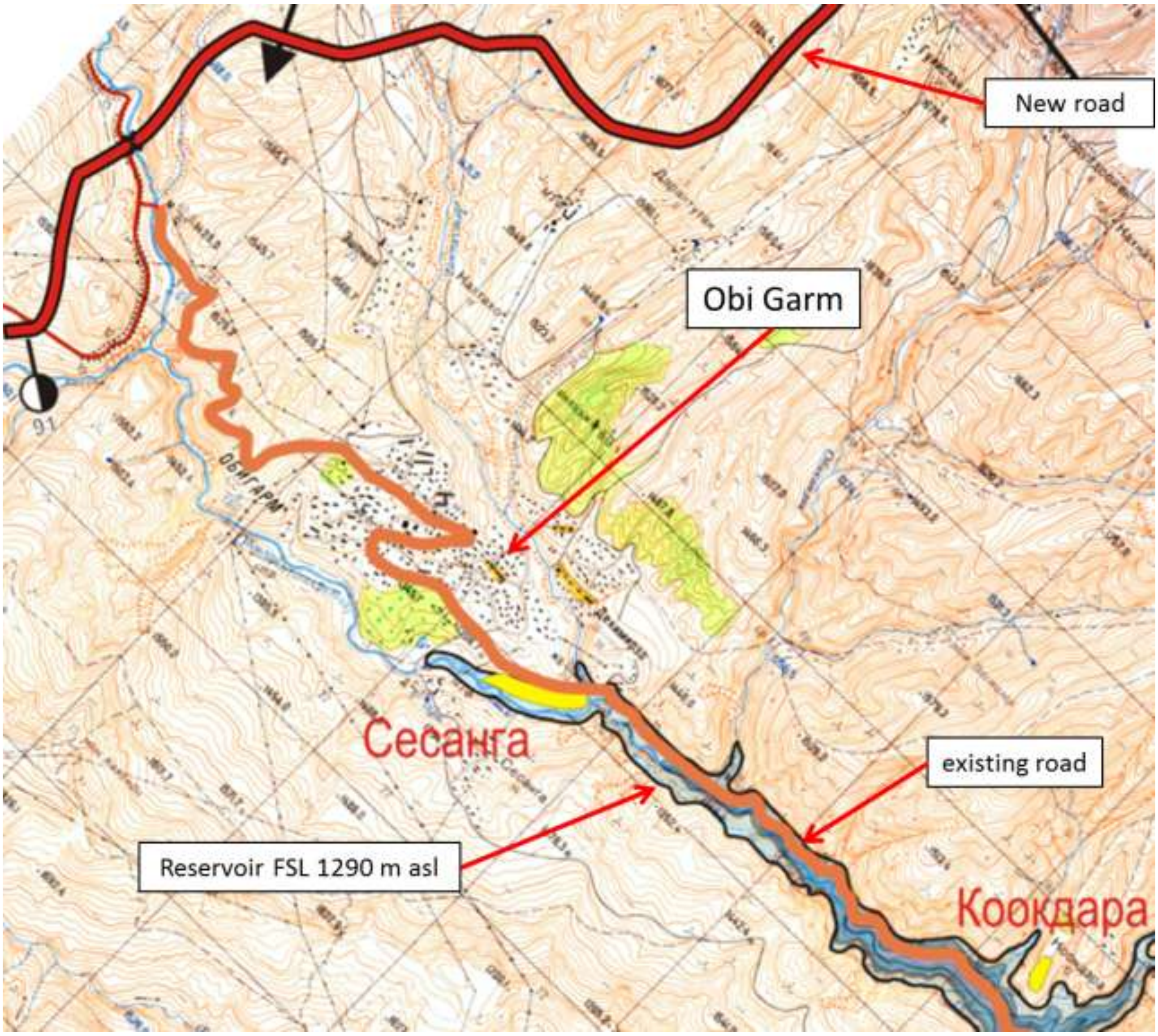


Figure 13-13: The situation of Obi Garm after impoundment

Source: Rogun reservoir area map 1:50'000 made available by RU

The existing main road will be interrupted as soon as impoundment starts, i.e. about 3 years after the start of construction, since parts of this road will already be submerged at stage 1 impoundment to 1100 m asl. Therefore, the main impact on Obi Garm, as soon as impoundment of Rogun HPP reservoir starts, will be the fact that traffic will no longer pass through the village. This will have the following main effects:

- No more transit traffic through the village can mean a reduction in clients, especially for shops and restaurants located on the main road.
- On the other hand, a very remarkable reduction in traffic will improve the situation in the village (less obstruction of the main road by traffic, especially heavy lorries, less noise and less air pollution; this will increase the quality of the site as a spa resort, and hotels, spas and sanatoriums are likely to benefit from this development.

General information: Obi Garm Jamoat is located 95 km from the city of Dushanbe and 15 km from Rogun city. The total population is 9'800 persons. The Jamoat consists of 11 villages. The centre of Obi Garm has the status of settlement and it consists of 6 quarters with a population of more than 1'000 persons (140 households) each. There is a resort facility in Obi Garm which has a status of national importance. Obi Garm has got an orphan asylum and an asylum for gifted children. There are 5 elementary schools and 11 primary schools and an infectious diseases hospital. The main income of the population, apart from work in the various resort facilities, is from work as labour migrants, agriculture and more than 30% of the men are working in the construction of Rogun HPP.

The dam impact on Obi Garm: According to the chairperson of the jamoat the impoundment of the reservoir associated with the construction of Rogun HPP will not have a negative impact on Obi Garm and there will be no damages. Obi Garm is situated at a sufficient height above the submerged zone of the reservoir. The republican main road Dushanbe-Kyrgyzstan passes the centre of Obi Garm, which connects all the districts of the Rasht valley with the capital of the Republic. The new road will bifurcate from the existing one at a distance of about 2.5 km from the centre of Obi Garm. According to the chairperson, that main road will bypass Obi Garm and will not have a negative impact on the economic situation of Obi Garm. Obi Garm will be connected with Dushanbe city as with Rogun and other districts (Nurobod, Rasht) via the new road. The chairperson of the jamoat mentioned that the main road which bypasses Obi Garm can have positive effects on Obi Garm’s development. Presently, every day a large number of heavy trucks passes the centre of Obi Garm, and this has a negative impact on the conditions of the roads, and in general to the safety of the population. The Jamoat Chairperson is of the opinion that if the main road does not go through the centre of Obi Garm, it may also positively influence the ecological status of Obi Garm as a resort.

The Chairperson of the jamoat noted that until 1999, seven villages of Sicharog jamoat geographically belonged to the Obi Garm Jamoat (Karigoch, Debiston, Kovukdara, Luguri Poyon, Luguri Bolo, Shokhi Aslon, Sebnok). The Sicharog village-centre of the Jamoat falls in the submerged zone, therefore the relation of the population with the centre of the Jamoat will be complicated. On the principle that current villages are situated close to Obi Garm (the furthest village, Debiston, is situated at a distance of 18 km), it is desirable, in terms of economics, to include them again into Obi Garm Jamoat.

13.9.4.2 Conclusions

The fact that Obi Garm will no longer suffer from heavy transit traffic, but will still be very well accessible, will certainly improve its quality as a holiday, spa and sanatorium resort. In this sense, Obi Garm could benefit from the project. One negative point will be the fact that the reservoir itself will not contribute to the attractiveness of the resort, in any case not if, as intended, Rogun reservoir will be used for regulating the entire Vakhsh cascade. This will lead to a situation where in spring the reservoir will be drawn down by up to 40 m, exposing a margin of bare rock instead of a "lake shore" situation, and this margin will only be gradually reducing during the summer, till finally in autumn the reservoir will reach its FSL again.

13.10 Regional Economic Impacts

13.10.1 Situation

Rogun HPP, or more precisely the various construction companies working on the construction site, is the only major employment opportunity in the project area; the only alternative is migrant labour, people going abroad to look for work, mostly to Russia. However, under the conditions of the present economic crisis it is increasingly difficult to find work. In this area, there is no alternative. Obviously, Rogun as an employer is of very high importance in Rogun District, and to less extent in Nurobod and Garm Districts, who are further away.

A high percentage of people (mainly men, but also a number of women, who work mainly in the kitchens, as cleaners etc.) are engaged in construction work for Rogun. In 2011, data collection for the RAP Stage 1 revealed that 27% of the male population of the Stage 1 villages were employed by Rogun, while 24% were migrant workers to Russia.

According to information received from Rogun Company, it is anticipated that during the most intensive period of construction activities for Rogun HPP there will be 13'000 workers on site.

It is important to note that an elevated number of workers stem from the villages which have to be resettled due to construction activities (the so-called Stage 1 villages). Special efforts were made to prevent people who are relocated from losing their jobs at Rogun site. In fact, resettled workers have a special agreement: they work for two weeks, and then they stay at home for two weeks; transport to and from their new place of living (mainly Rudaki or Tursunzade) is organised by the contractor. In this way the resettlement to be carried out urgently (Stage 1, risk zone of the construction area) can go on without people losing their jobs.

13.10.2 Impact of Slow Project Development

In the course of the assessment studies for Rogun HPP, it was decided to limit work on site to activities required for maintenance of already built structures. This was done since no firm decision on whether to go on with the construction of Rogun could be reached before the results of the assessment studies are available. On the other hand, it was also important to prevent further damage to and deterioration of the structures that already are in place.

While this decision was understandable from the point of view of project development, it had some serious consequences for the local work force:

- Before end of June 2012, a total number of 8'769 workers were employed by the various contractors on site.
- By end of January 2013, this number was reduced to 1'640, which means that in the period of half a year 7'129 workers had lost their jobs, and it was envisaged that further reductions in available budget would lead to an additional reduction in the number of jobs..

Workers were not actually relegated, but put on leave with the promise that they will be called in again as soon as the work starts again. Currently, there are no construction sites in the country which could offer jobs for such an elevated number of workers.

Rogun HPP Company itself currently employs 238 persons; so far due to the stop in work activities, no personnel of this company was laid off (as of end of March 2013).

13.10.3 Anticipated Effect of Rogun HPP on Employment and Population

Socio-economic effects not related to resettlement are basically twofold: one is the effect on employment, local as well as on the regional and national level, and the other is the effect on the local population.

13.10.3.1 Effects on Employment

This can be characterised as follows:

- As mentioned above, it is anticipated that during the peak activities on site there will be 13'000 workers.
- Presently, about 32% of the workers are recruited locally, while the other 68% stem from other parts of the country (35% from Khatlon Region, 8% from Khujand Region, 7% from Gorno-Badakhshan Autonomous Region, 18% from Dushanbe and Regions of Republic Subordination). It is anticipated that this distribution will be maintained. Although it might be questionable whether there are enough persons who can be hired locally, it is assumed here that this will be the case.
- A major construction site of this type creates a considerable number of "indirect" jobs, i.e. employment or occupations indirectly generated by the project, besides the work force on site. This includes jobs in the transport sector, in supplying industries and trade, construction work in the new resettlement villages, etc. Estimates for this indirect employment gained from a number of projects vary between 1 and 4 jobs created per job on site. Here it is assumed that there will be 1.5 such jobs on the regional and national level, and 1 induced job per 5 jobs on site at the local level. These latter are to a great deal spontaneous developments like catering or small restaurants for workers, and other services provided locally for the work force. While a development in that sense will certainly take place, it is not possible to make a very precise forecast about actual numbers.
- The construction period is assumed to be 16 years, and towards the end of this period, direct as well as indirect jobs will be gradually reduced. It is assumed that after the end of major construction works, i.e. after commissioning, some

work will still be going on for a few years (e.g. for site rehabilitation etc.), but that ultimately construction related jobs on site will go back to 0.

- Rogun HPP company presently has 240 employees, and this number will go up to 350 at the beginning of main construction activities, to be raised gradually afterwards. After commissioning, the company will employ about 800 persons. These will be permanent jobs.

Given these figures, and the constraints due to a (temporary) slowdown in project development mentioned in the Section before, overall development of direct and indirect employment generated by Rogun HPP can be expected to be approximately as shown in the following Figure.

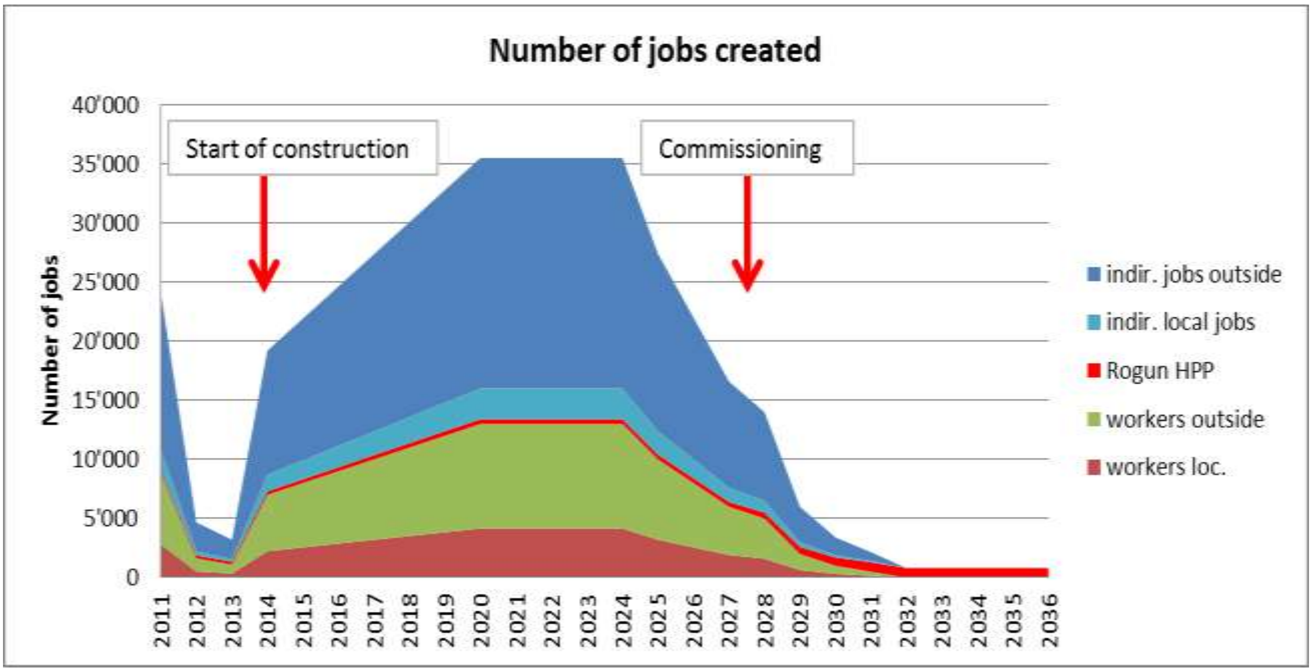


Figure 13-14: Direct and indirect jobs created by Rogun HPP

This Figure assumed that by the end of 2013 an agreement on Rogun HPP will be reached and that construction will start "for real" in 2014. Any delay in taking decisions would postpone the entire process accordingly.

It can be seen that the economic effect of the project, in terms of job creation, will be quite considerable. Even if the bulk of these jobs will be limited in duration, 15 or up to 17) years of generating employment in this order of magnitude will give a considerable boost to the economy of the project area, and will be by no means negligible even on a national level.

These figures do not include the economic effect which the improvement in electricity supply will have, which will be permanent.

13.10.3.2 Effect on Population of Rogun District

Expected effects of the construction activities and the project on the local population are illustrated in the following Figure.

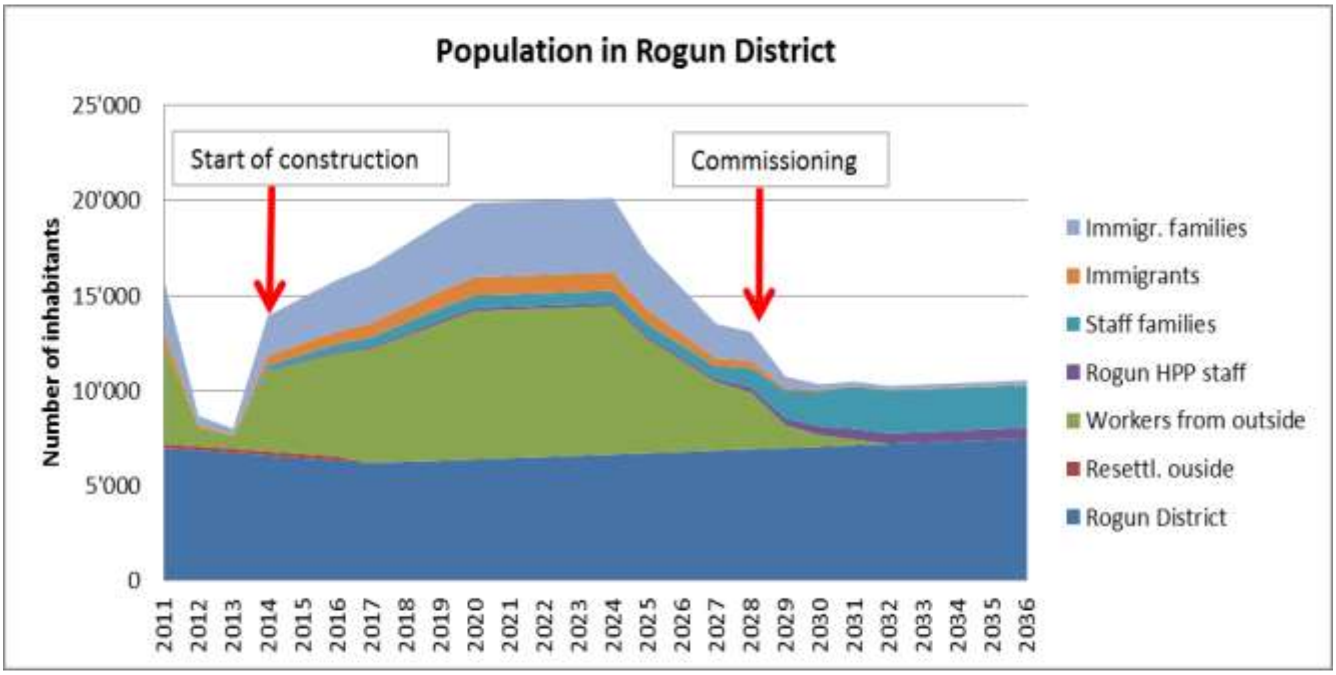


Figure 13-15: Project related population development in Rogun District

Of the three districts directly affected by the project, only Rogun District is taken into consideration here, and this for the following reasons:

- Rogun District is the project centre (i.e. containing dam and construction site).
- The other two districts (Nurobod and Rasht) are further away from the construction site. Even more importantly, already about 3 years after the start of construction, when the reservoir will be impounded to a level of 1100 m asl (Stage 1 impoundment), the existing road along the river will be interrupted, and access to these two districts will have to be via the new road (construction started, presently interrupted). This will increase the distance from Rogun construction site to these two districts. Their demographic development will be characterised mainly by resettlement, i.e. population will be reduced by a considerable amount.
- On the other hand, Rogun district, will experience an increase in population due to the project.

Population development in Rogun District is expected to take place as shown in the Figure above, with the following characteristics:

- The present population of the district is approximately 7'000 persons, who live mainly in the two local centres Rogun town and Obi Garm; neither of them will be affected by the reservoir, and both are located closely to the dam site. Access to these towns is already good, most of the main road from Dushanbe having been improved and upgraded in recent years. Improvement work on the access road from the main road to Rogun town is under way. It is assumed that this population is increasing with a rate of 1%/yr.

- Approximately 1700 persons from the district (8 villages) will have to be relocated, roughly 1100 of them in Stage 1. About 1200 persons will be relocated outside of the district (mainly to Rudaki and Tursunzade), which will lead to a reduction of the population of the district. The remaining about 400 will be relocated to new locations within the district (Novi Saidon and a new site near Obi Garm, Yoligarmova), these are not shown separately in the graph, since they will remain members of the local population.
- Workers from outside (approximately 68% of the entire work force) will find employment on the construction site. Most of them will be housed in the workers' quarters within the construction site and will not come with their families. Workers recruited locally are not shown separately in the graph.
- The staff of Rogun HPP will increase; these persons will come to live in Rogun, i.e. they will bring their families, on average 4 family members per job created. These people will remain on site after commissioning.
- The boost in economic activity in the region will trigger a certain amount of immigration to the project site, people who will come here looking for jobs (not necessarily directly on the construction site, also creation of induced jobs). These immigrants as well will come with their families. Most of them might again move out at the end of the construction period, but a certain number will settle there permanently.

This means that for the construction period there will also be a need to expand the entire infrastructure, mainly in Rogun town, but presumably also in Obi Garm (apartment buildings, schools, health services, shops, etc.). Some of this will then become obsolete at the end of the construction period. Overall, however, population in Rogun district will increase as a consequence of the project.

13.10.3.3 Social Management Measures During Construction

Handling the development of the population and the work force described above will be a challenge for both the local authorities and the management of Rogun HPP, since it presents a number of risks, which will have to be addressed with appropriate measures. The main risks and potential ways to deal with them are addressed here shortly:

- Local labour and workers from outside: given the very high number of workers required, it is quite clear that hiring them exclusively locally will not be possible; a considerable number will have to come from outside. However, it is important, for the economy of the region and also to minimise the risk of tensions between "locals" and "outsiders", that the company develops and clearly communicates its recruitment strategy. Some relevant points:
    - Given the same qualification, inhabitants of the area should be given priority for recruitment.
    - It must be ensured that resettled people do not lose their jobs; here, the company already has a mechanism in place which seems to work satisfactorily: workers who relocate from the project area to e.g. Rudaki or Tursunzade do not lose their jobs, but they continue to work on the basis of a "two weeks on - two weeks off" schedule.

- It must be ensured that local inhabitants do not only get jobs as unqualified labour, but are, in the measure of the possible, also considered for qualified jobs. Some specific training _- which could possibly also be offered as on-the-job training, might be required for achieving this aim. This would also increase the possibility for workers to find similar jobs after Rogun construction will be finalised.
- As shown in Section 13.5.3.2, the proportion of employment in Rogun is higher for Stage 1 (basically Rogun district) population than for the other two districts. Since Nurobod and Rasht district are also directly affected by the project, the opportunity for the population in these two districts for getting jobs on the construction site should be increased. This could be done, e.g., by opening local recruitment offices in Nurobod and Rasht, and by offering inhabitants of these districts the same intermittent work schedule as already in place for resettlers from Rogun district; this possibility should be offered independently of the fact whether a person was relocated due to the project or not, and inhabitants of villages not directly affected by the project should be given the same opportunity.
- On the other hand, recruitment of outside workers should not be done in Rogun, but preferably outside of the project area, like e.g. in a project office to be established for that purpose in Dushanbe. This would prevent people to come to the project area looking for a job (and then possibly stay there even if they are not successful, in search of other opportunities, see below).

* Camp followers: a large construction site invariably attracts people who come to the site, not necessarily for finding a job (or, as just mentioned, stay in the area although they have not found a job), but looking for some opportunity of getting an income indirectly related to the project. Such an influx can cause considerably problems in the project area. It is important that the local authorities as well as Rogun HPP are aware of this and cooperate for solving the issue; possible measures are recruitment outside of the area as mentioned above, strict regulations for any informal establishments (e.g. small temporary restaurants offering food to workers, which are often of low hygienic standard), etc.
* Conflict between work force and local population: Such conflicts can arise - or are almost inevitable - in the case of the presence of a very large work force, which might ultimately be larger than the resident local population. Relevant points:
    - One measure to counterbalance this is, as mentioned above, to hire local labour to the extent possible.
    - In addition, there will certainly be the requirement for Rogun Company to have suitably located, staffed and equipped community liaison office in the project area, presumably in Rogun town itself, where inhabitants of the area can get information on any issue related to the project, and where they can also voice their concerns, or deposit their complaints, if any.

    - One important point is the question of housing of the work force. Presently, this is done on the construction site, in workers' camps, and it is assumed that this will be done in the same way in the future. It is important that contractors will be obliged to provide adequate lodging quarters for their workers (see comments in Chapter 18).
    - Having a large - and predominantly male work force in one site also presents the risk inappropriate social behaviour and the spreading communicable diseases (see comments on this below).
    - Access control: presently, the construction site is fenced off, and access is strictly controlled; this is required, not in the least, for keeping unauthorised persons away from the site, and with this also away from accident risks. This measure will have to be maintained. It also has the side effect of preventing workers to haphazardly use, for any purpose whatsoever, land outside of the constriction area as such, which would not only increase the impact of the construction activities, but could also lead to a conflict with local residents.
- Health risks: bringing workers from outside also presents a number of health risks, like e.g. bringing diseases from outside to the project area, or, as mentioned, the risk for an increase of communicable diseases. Here, a number of measures are required, as e.g.:
    - Entrance health check for workers: this should be done for all workers before they actually start working. However, this should be accompanied by a non-discrimination policy: in case a disease would be detected, this should not be a reason for not hiring a person, but adequate treatment should be granted.
    - Instruction to workers, e.g. on hygiene, risks of communicable diseases and prevention measures (e.g. for tuberculosis), etc.
    - Adequate health services to be provided on site.

These measures are addressed in the ESMP (Vol. III of the ESIA report), see e.g.

- Owner’s Labour Force Management Plan (OLFMP) (Section 4.1)
- Contractor’s Labour Force Management Plan (CLFMP) (Section 5.1)
- Training and Capability of the Workforce (Section 5.2.1.1)
- Health (Section 5.2.2)
- Data sheets in Annex 2 of Vol. III, e.g. No. 2 (public health) an4 No. 4 (traffic management.

14 CULTURAL RESOURCES

14.1 Key Messages

Main points:

- The project area has been inhabited since a very long time, at least since the Neolithic period. Most archaeological sites in the area are related to the silk road, a branch of which passed through Vakhsh valley.
- Most of the known archaeological sites in the area that will be affected by the project were partly or entirely destroyed in the past, e.g. due to road construction.
- There is one site with ancient fortresses which are still intact, which has not been investigated so far, and which will be affected by reservoir impoundment. It is recommended to carry out an archaeological investigation of this site prior to impoundment.
- In addition to that, it is also recommended to carry out an ethnographic survey of the area before impoundment (and before relocation of the local population) in order to document local culture and oral traditions.

14.2 Theoretical Considerations

Dams and reservoirs can create conflicts with sites of archaeological, historical or cultural importance if such sites are within the directly affected area (i.e. within the construction site, where they may be destroyed by construction activities, or within the reservoir area, where they will be submerged at the filling of the reservoir). For this reason, it is important to know if such sites exist, so that, if required, adequate measures can be taken. Such measures have to be formulated depending on the type and the importance of the site, and can be, among others, the following:

- Excavation and documentation of archaeological sites, transfer of artefacts into a museum.
- Relocation of objects of cultural importance (like e.g. graveyards); such a measure, if required, will have to be planned and carried out together with the local population, and will have to observe the required cultural framework, like e.g. carrying out appropriate ceremonies.
- Reconstruction of buildings of cultural importance, as e.g. places of worship, in an adequate manner in a suitable site (e.g. in the resettlement villages).
- Ethnography: if site specific traditions, local orally transmitted knowledge etc. might be lost due to the displacement of the population, an ethnographic study should be carried out for documenting this knowledge.
- Formulation and implementation of a chance find procedure; this can be of importance mainly for the construction site, where during the construction process objects of importance might be found.

14.3 Results of Field Investigation

The Archaeology expert has carried out a six day field reconnaissance survey to the project area in order to check on known or suspected sites of archaeological or historical interest. Before the site visit, available sources (publications, archives) were consulted in order to identify sites of importance.

The following objects were identified and visited (see Figure 14-1):

1. Obi Garm fortress, originally measuring 35 x 25 m, 3 m high. It was partially destroyed by construction works. From the artefacts found on site it was concluded that it dated from 5th to 7th century.
2. Graveyards in Siacharog, 1st to 3rd century. The majority of the graves were destroyed, only three are left. Diameter of graves is 3 m, and they are covered with stone. In 1998, several of the graves were excavated by an archaeologist (Mr. I. Maslov). The conclusion of that exploration was that these graves do not have any scientific importance.
3. In Chorsada, there was a graveyard dating from 2nd to 1st century BC (Mandelstam 1954). Nothing of it remains.
4. Pumbachi I fortress, located at the entrance to Komsomolobod. Part of it was destroyed due to the construction of houses. According to information dating from the 1980ies, one part of it, measuring approximately 75 x 40 m, still existed. Pumbachi II fortress was located at the exit of the town. Both stem from the 7th and 8th century AD. Nothing of them remains today.
5. Three dwelling sites from the Neolithic period (younger stone age) were identified and explored in the 1980ies by Mr. I. Maslov (no published results). One was located about 50 m to the south of Pandovichi Poyon. Two similar sites had been discovered around 100 m south and 150 m east of Pandovichi Bolo. Later on these site were destroyed completely by house construction and agriculture.
6. In the eastern part of Pandovichi village there was a hill called Qalacha, measuring 70 by 40 m, dating from centuries 7 - 8 and probably erected as a lookout post. The larger part of it was destroyed during road construction. No exploration of this site has been made so far.
7. The Hamchur fortress dates from centuries 8 - 9. This fortress, a square of about 10 ha, is located in the south-eastern part of Yust village. It is well above reservoir FSL and not in danger from the project.
8. The Darband fortress is located in the western part of Gardanga village, in the south-west of Labijar, in the corridor of the road from Dushanbe to Rasht. The size is 13 ha. The site was explored by Yusufshoh Yakubov and I. Maslov in the 1980ies. It used to be the centre of the Rasht region (from 2nd till 8th century AD). The place was located on the trading road from Gissar to China, Badachshan and India, which was a part of the silk road. The city was divided into three parts: the residence of the king (shoh), the area occupied by the town population, and a suburb outside the town itself. This latter place was then occupied by new buildings of Novobod, after an archaeological excavation had been made. The site will not be affected by the reservoir.
9. Shokhon fortress dates from centuries 15-19. It is located 200 m north and east of Mazoni Sir, in the topmost part of the reservoir. It is a square of 34 by 27 m. It is

was, as most other fortresses in this area, surrounded by four outer walls. In 1983, Yakubov and Maslov carried out an exploration of the site by excavating an area of 4 y 4 m, which revealed the kitchen with a tanu (traditional oven for baking bread). The place dates from 7th and 8th century.

10. Navodonak is a remarkable place for its beauty. Navodonak consists of two words, nov and don, nov designating a specific structure for retaining water, don meaning spring. Navodonak consisted of three parts:
    a. Bachak fortress (Pisarak), an ellipse, 43 m long and 12 m wide, and originally of a height of 20 m. It stems from the 2nd to 1st century BC.
    b. Dukhtarak fortress, located near Pisarak fortress. It measures 87 by 80 m.
    c. Boturkhon fortress; it was used from 200 BC till 1200 AD, and its size was 50 by 40 m. It consisted of two parts, the shohnishin (residence of the king (shoh), and the shakriston, the dwellings of the population). This latter part was destroyed during Soviet times, when it was converted to an orchard.

    Like in the case of other fortresses in this area, the foundations are still (at least partly) there, but only traces if anything at all remains visible at the surface. These fortresses are either located just within the reservoir or else just outside in an area where they might be affected by shoreline erosion. For this reason it is recommended to make a detailed exploration of the site before reservoir impoundment. The site and its location in relation to the reservoir will have to be clearly identified.
11. Novobod fortress stems from the 7th or 8th century and was used till the 16th century. With a size of 75 by 40 m it was located at the entrance to Novobod. It was completely destroyed by house construction.
12. Yapoloki fortress was used from the 7th or 8th till the 18th or 19th century. It is located in the western part of Yapoloki village, its size is 148 by 116 m. It was surrounded by protecting walls on all four sides. However, in the 1990ies one person destroyed the remaining parts of the walls by bulldozer and built a house in the eastern part. This largely destroyed the historical monument. Since the place is located to the south of the village, it will not be affected by the reservoir.
13. Dakhana fortress, 16th to 17th century AD. It is located on the eastern side of the village and covers a square of 55 by 34 m. It was surrounded by protecting walls, but it was completely destroyed when the site was transformed into a field. Nothing is left of it.
14. Buni Sufiyon fortress, centuries 7 - 8, size 38 by 26 m. It will not be submerged and does not need to be investigated.

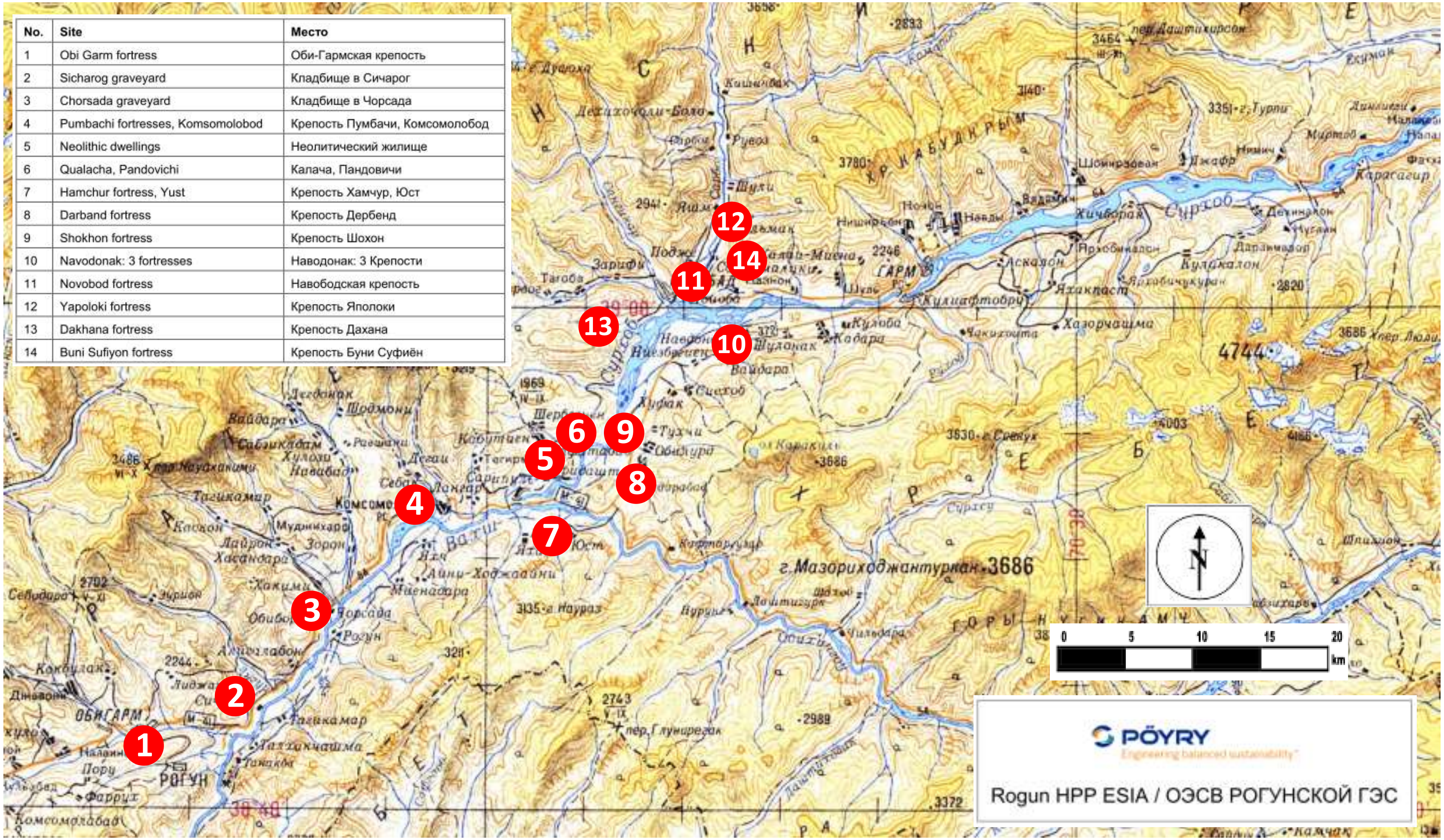
As can see from this list, a number of sites of historical interest were originally located within in Rogun reservoir area, but during the past years these sites were destroyed by changes in land use, and they cannot be studied any longer.

14.4 Historical Importance

The few findings of stone age sites confirms that the project area was inhabited already some 10’000 to 15’000 years before our era. Avesta (the holy book of Zoroastrianism), dating to 2’000 years BC, mentions a region called “Rankha” which, according to analyses of the writings and toponymy, is thought to correspond to the area where today

Rogun is located. Graves from different periods have been found in the project area, some from the Muslim period, others however considerably older. During several centuries the area had then a certain strategic importance, which is emphasised by the numerous fortresses which were built along the part of the silk road which led through the Vakhsh valley.

These few facts highlight the long time period during which the area has been inhabited. However, as the field work has shown, most of these historical sites have been destroyed, some of them rather recently, by human activities.



No.	Site	Место
1	Obi Garm fortress	Оби-Гармская крепость
2	Sicharog graveyard	Кладбище в Сичарог
3	Chorsada graveyard	Кладбище в Чорсада
4	Pumbachi fortresses, Komsomolobod	Крепость Пумбачи, Комсомолобод
5	Neolithic dwellings	Неолитический жилище
6	Qualacha, Pandovichi	Калача, Пандовичи
7	Hamchur fortress, Yust	Крепость Хамчур, Юст
8	Darband fortress	Крепость Дербенд
9	Shokhon fortress	Крепость Шохон
10	Navodonak: 3 fortresses	Наводонак: 3 Крепости
11	Novobod fortress	Навободская крепость
12	Yapoloki fortress	Крепость Яполоки
13	Dakhana fortress	Крепость Дахана
14	Buni Sufiyon fortress	Крепость Буни Суфиён

Figure 14-1: Sites of archaeological interest in the project area

14.5 Additional Investigation

An additional archaeological survey of the area was carried out by the Institute of Archaeology, Academy of Sciences of Tajikistan (Report received from RU in March 2013).

This survey focussed on Stage 1 impoundment area. No sites of archaeological importance were found there. The Report mentions that as today historical settlements were concentrated on higher terraces. 60 sites of potential archaeological importance on higher terraces along Vakhsh valley are mentioned, all above the reservoir level, but no list or map of these sites is provided. However, one site is mentioned that might be of special importance: the Dajmkhur tower, near Yusti village, on the left bank of Obihingou. The site coordinates are indicated as 38°50'33"N and 70°50'43"E; this location is clearly outside the reservoir and considerably higher than 1290 m asl.

14.6 Conclusions

The following conclusions have been reached during the field reconnaissance carried out:

14.6.1 Chance find procedure

The investigation so far, including analysis of previous work carried out in the area of the project, did not give any indication that any sites or objects of archaeological or historical importance would have to be expected at and around the dam site. Furthermore, it has to be considered that major construction activities have started over 20 years ago, and that most of the construction site has been interfered with in a quite considerable way already. The present construction site includes all quarries, borrow and dumping areas required for the construction of the dam and appurtenant structures, (see Section 3.6), and it is not foreseen to use additional areas during the construction period. For these reasons, it is not necessary to develop a chance find procedure for the construction site.

However, for any project related construction activities outside the dam and powerhouse construction site, e.g. for the local access roads to be built, or for new sites for relocation villages, such a chance find procedure according to OP 4.11 will still be necessary.

14.6.2 Exploration of sites within the reservoir area

Concerning the effects of the project on archaeological and historical sites, the following can be said:

- Out of the about 20 sites of historical interest in the project area, 12 were destroyed completely by different activities.
- Within the reservoir itself, there is no site of archaeological or historical interest which might require salvage action.
- However, Navodonak with the three fortresses of Dukhtarak, Pisarak and Boturkhon will probably be affected by the project. Therefore, it is recommended to carry out an archaeological investigation of this site. The funds required for such an investigation are estimated at TJS 500’000.00

(approximately USD 100’000). This cost, after checking of the exact location of the site and possibly making a more detailed estimate of the efforts required, will be included in the ESMP of the ESIA.

14.6.3 Local Culture

14.6.3.1 Sites

Graveyards are sites of socio-cultural importance for the local population. In cases where such graveyards would be affected by the project - and these will usually be cases where a graveyard will be submerged during reservoir filling - it has to be relocated. Tajikistan has a well-defined practice for such cases. Since this is an issue which is directly related to resettlement, it is treated in that context (see Section 19.7.1). The same is the case for sacred sites which may be present in some of the villages (see Section 19.7.2).

14.6.3.2 Oral Tradition

There is one additional point of historical and cultural interest, namely, the local culture of the present day population. Discussions with teachers and elders in Chorsada have shown that they conserve the history of their villages. Since this tradition and this knowledge is likely to disappear with the villages once the reservoir will be filled, it is important that this oral tradition should be recorded before this happens.

It is recommended that an ethnographic study will be done by the Institute of History, Archaeology and Ethnography, Academy of Sciences of the Republic of Tajikistan.

Costs for such a study are estimated at USD 150'000; this includes field work by a group of ethnographic experts, analysis of the data, and publication of the results.

PART C SYNOPSIS

In this Section, the impacts and mitigation measures identified in the previous Chapters will be analysed and finally defined, and the required plans or framework plans will be developed.

15 CLASSIFICATION OF IMPACTS

15.1 Scope

At present, one of the primary objectives of sustainable development is to achieve economic development in the framework of plans which are compatible with the environmental principles and prevent from destruction and depletion of renewable and non-renewable resources.

It is required to have macro and systematic views in this regard and to implement development infrastructures in conformity with environmental regulations to solve the environmental problems; the role of an ESIA report is to identify the conditions for compliance with these requirements. In fact, the main purpose of this study is to ensure that the environmental regulations and principles have been taken into consideration. At present, the assessment of the impacts is considered as a device for making optimum decisions on the planning and management aspects with environmental viewpoints.

15.2 Assessment Method

For preparation of EIA report, it is required to predict and identify the project impacts; then, the impacts are assessed applying one of the existing methods. Eventually, after analysing, the project will be finalized.

15.3 Impact Categories

Once identified, impacts have to be characterised depending on the magnitude, the direction, the duration and the overall importance of the impact.

In a general way, there are three main groups of impacts: positive, negative or uncertain. The scale used is explained in the following Table.

Table 15-1: Impact categories used

Definition of Impact
Strongly positive: highly beneficial effect, permanent or at least of long duration, affecting a wide area and/or an important parameter.
Positive: beneficial effect, of long duration or permanent.
Small positive: beneficial effect of lesser importance, either of short duration, limited in space, and/or affecting a parameter of little importance.
None: no or negligible impact, limited in time and space, and not requiring any measures, or environmental category not present.
Small negative: negative impact of limited duration, affecting a small area, and/or affecting environmental parameters of less importance. Note that in spite of the small effect mitigation measures may still be proposed or even required.
Negative: undesirable or harmful effect of limited concern, either temporary, limited in space or affecting parameters of medium importance.
Strongly negative, mitigation possible: strongly negative or detrimental effects (permanent, of high intensity, affecting important environmental parameters), for which mitigation measures can (and have to) be taken in order to reduce them to an acceptable level.
Strongly negative, mitigation not possible: strongly negative or detrimental effects (permanent, of high intensity, affecting important environmental parameters), for which mitigation or compensation is not possible. Such effects could be no-goes for a project.
Ambivalent: effect can be positive or negative, or a combination of positive and negative effects is possible.
Questionable: it is unclear (possibly due to project stage) whether the aspect will be of any relevance and/or an effect will result.

The categories used in this Table were then also used in the following Chapter, Table 16-1, where impacts are first described as they would become manifest without mitigation, and then what the resulting impact would be with mitigation measures implemented as proposed.

16 IMPACTS AND MITIGATION

16.1 Key Messages

In this Chapter, all the impacts identified in the previous sections of the report are summarised and evaluated briefly. Main conclusions are:

- There are three areas of important impacts, which need to be addressed in detail and where careful mitigation and management is required. These are:
    - impacts related to the construction site and construction activities, which will have to be managed carefully;
    - the local population whose livelihood will be affected by the project, and/or who will have to be resettled; and
    - potential effects of the project on downstream river discharge, which could negatively affect downstream riparians.
- Other impacts are less significant and easily mitigated, if mitigation is required at all.
- There is no impact of the category "strong negative, mitigation not possible"
- Impacts and risks identified in the analysis can be managed and mitigated so there are no unacceptable residual impacts.

For each impact the appropriate mitigation measures were then identified and described. A number of measures will have to be taken, especially during the construction period, for assuring a project implementation in compliance with environmental and social norms, and for preventing damage to the environment.

Following the identification of impacts caused by the project, mitigation measures were identified according to the following priorities:

- Avoidance: if possible, e.g. by modifications of the Project, measures will have to be sought which can avoid relevant impacts altogether; if such measures will actually be proposed, they will have to be checked with the TEAS Consultant in order to ensure that they are feasible, acceptable for the Project, and actually integrated in the planning.
- Minimisation: measures to reduce impacts to an acceptable level (e.g. noise reduction measures to ensure that legally defined noise levels are respected).
- Compensation: if avoidance and minimisation is not possible, then adequate compensation will have to be provided; this will be the case manly for the human population living in the area to be submerged (i.e. the population that will have to be resettled).

One additional dimension is the optimisation of the project with the aim of enhancing positive impacts.

Impacts before mitigation, mitigation measures, and remaining impact after mitigation (including, where applicable, the potential for increasing project benefits if appropriate measures would be taken) are described in Table 16-1 below.

16.2 Summary of Mitigation Measures and Monitoring Activities

In the Table on the following pages, as summary overview of the proposed mitigation measures and related monitoring activities is provided. For more details on these measures, especially for contractual purposes and implementation, see detailed description of these measures in the ESMP (ESIA Vol. III).

Table 16-1: Synopsis of Impacts and Mitigation Measures

Issue	Project component	Impact and significance before mitigation	Importance	Mitigation measures	Remaining impact after mitigation	Related Sub Monitoring and Management Plans (S-MMP)
Physical Environment						
Climate	Reservoir	A surface of water of 170 km^2 will increase evaporation, and it can have a moderating effect on temperature. Since the reservoir will not be large enough there will be no noticeable effect on the local climate. The effects (reduction of the number of frost days, reduction in summer temperatures, increase in humidity) will be limited to the immediate surroundings of the reservoir, and they will be too small to play any decisive role. There will be no GHG emission of any relevance from the reservoir (see Section 8.11.3).	**none**	Not required	**none**	No S-MMP

Issue	Project component	Impact and significance before mitigation	Importance	Mitigation measures	Remaining impact after mitigation	Related Sub Monitoring and Management Plans (S-MMP)
Air quality	Quarries, construction activities and transportation activities	Air pollution (dust, exhaust gases) mainly by nitrogen oxides (NOx) and Particulate Matter (PM10) • Emission related to construction activities • Emission related to transport of material. • Emission related to borrow areas. Impact restricted to construction site (including quarries and access roads) and construction activities (works, traffic, etc.).	**small negative / negative** → Minor impact, localised to construction site and access roads, and limited to the duration of construction.	Use adequate and well maintained construction and transportation equipment and the contractor has to develop a maintenance program to ensure this. Take good measures for dust suppression: • This includes among others good housekeeping. • Instruct workforce on appropriate measures to minimize air pollutants. • Optimization of storage on-site of materials that are known to be whirled up by wind. • Water sprinkling especially on unpaved roads. • Trucks which transport construction material for longer distances (quarry to construction site) should be covered. • Do not exceed speed limits. • Do not burn waste. Organize the sequences of construction activities in a way that the use of equipment powered by diesel fuel is optimized and duration is minimized (switch off the engine during parking periods).	**small negative** reduction of quantity of exhaust gas, dust; will be within legal limits	Environmental, Health and Safety Management and Monitoring of the contractor Equipment Maintenance Management Plan Traffic Management Plan Waste Management Plan Air Quality Management Plan → *For detailed information: see also Mitigation Measure Data Sheet No. 5, Air pollution (ESIA Main Report Vol. III, Annex A2.1)*

Issue	Project component	Impact and significance before mitigation	Importance	Mitigation measures	Remaining impact after mitigation	Related Sub Monitoring and Management Plans (S-MMP)
Noise	Quarries, construction activities and transportation activities	Impact caused by construction activities (works, traffic, machines, etc.), mainly on the workforce.	**small negative / negative** → Minor impact, localised to construction site and access roads, limited to the duration of construction.	Main aim: meeting Tajik and other applicable noise limits. Use adequate and well maintained construction and transportation equipment including state-of-the-art built in systems (muffler) to reduce the noise. The contractor has to develop a maintenance program to ensure to keep noise within legally permitted limits. Instruct the workforce to avoid unnecessary noise. Use adequate and state of the art techniques for blasting, which do not exceed the exposition time to the noise. Workers exposed to excessive noise have to be equipped with PPE (e.g. ear protectors) and the exposition time has to be limited. The quarry must be located in a sufficient distance to any populated area. Separate installation areas, for example mechanical workshops etc. from areas that are used by people for temporary housing and recreation; distance should be at least 10 m. Noise and vibration associated with the use of explosives needs to be monitored. Max 136 db Avoid any noise intensive activities such as metalworking, blasting (in quarries) etc. during night time. Avoid transporting of material (rock, concrete, etc.) during night, if they have to pass villages.	**small negative** → reduced noise level due to maintaining the noise standards set by international organisations such as WHO or Tajik legislation.	Environmental, Health and Safety Management and Monitoring of the contractor Traffic Management Plan Equipment Maintenance Management Plan Explosives Management Plan Health and Safety Management Plan → *For detailed information: see also Mitigation Measure Data Sheet No. 6, Noise and Vibration (ESIA Main Report Vol. III, Annex A2.1)*
Vibration	Construction activities and quarries	Main sources of impacts: traffic and use of explosives. Mainly on the workforce, possibly on villages in the risk zone if not yet relocated	**small negative**	Use best practice to reduce the dispersion of material and vibrations near any physical structures. Install a monitoring system at sensitive sites and monitor and record vibrations during blasting events. Use state of the art techniques. Restrict access during blasting events. Minimize night traffic through villages. On-demand monitoring of vibration, taking adequate measures if required.	**small negative** → reduced level of vibration due to maintaining the standards set by international organisations such as WHO	Environmental, Health and Safety Management and Monitoring of the contractor Explosives Management Plan Health and Safety Management Plan Traffic Management Plan → *For detailed information: see also Mitigation Measure Data Sheet No. 6, Noise and Vibration (ESIA Main Report Vol. III, Annex A2.1)*

Issue	**Project component**	**Impact and significance before mitigation**	**Importance**	**Mitigation measures**	**Remaining impact after mitigation**	**Related Sub Monitoring and Management Plans (S-MMP)**
Hydrology	Dam, reservoir, turbine operation; reservoir filling	Impact on the downstream area, if river discharge pattern is changed (seasonal and daily distribution of flows). Two main sources of impact: • filling of reservoir; • power plant operation. Main potential impacts: • on Tigrovaya Balka (and to a much lesser extent on other floodplain habitats along he Amu Darya) mainly by reducing summer peak flows: • negative impact on riparian countries (availability of water for irrigation) if summer flows are reduced. • positive impact on downstream area, and mainly on riparian countries, by reducing flood risk (reduction of flood peaks, cascade capable of handling PMF). • potential for making more water available for irrigation in the downstream area in the case of dry summers.	**negative** The direct effect of Rogun will be strongly influenced by Nurek, especially where the short term fluctuations during operation are concerned. However, if no adequate measures are taken, impacts on the entire downstream area are potentially serious during filling and operation. Potential for improving the situation /regulating flows for better flood management and for more water in d/s areas during dry summers)	This is, together with resettlement, i.e. with the direct project impact on the local population, the most relevant potential impact of the project. The most important mitigation measure consisted in finding a way to fill and operate Rogun HPP in a way which allows Tajikistan to remain within the conditions defined by the Nukus declaration and Protocol 566, i.e. by not using more water than allocated to the country, on a yearly basis, by ICWC. The hydraulic model for operation of the Vakhsh cascade, which was prepared by TEAS in close cooperation with the ESIA Consultant, shows that the cascade (i.e. mainly the combination of Rogun and Nurek HPPs, the other dams not having storage capacity of any relevance) can be operated in a way as not to change the runoff pattern, i.e. water availability, in the downstream area. GOT intends to operate the cascade in this way, which will not change the flow pattern (seasonal distribution of water) in Vakhsh river downstream of the cascade. In this way, Rogun HPP can be built and operated in compliance with present rues and practices for water allocation in the Amu Darya basin. It is recommended that the ICWC member states should modify existing agreements and practices to include operation of Rogun HPP The most important components of such modifications would be: • a firm commitment to operate the cascade according to the results of the hydraulic model, i.e. by respecting ICWC water allocation; • a commitment for not retaining any water in Rogun in especially dry years during the filling phase; and • a rule for making available additional water to the downstream areas in exceptionally dry years during the operation phase. For emphasising the credibility of such rules, it is important that an online monitoring system of Vakhsh Cascade operation is set up, and that the results of this be made available in real time in the internet, on a site accessible to all interested parties.	**none** as long as operated according to the identified operation rules. **positive** if potential for improvements is implemented.	Cascade Operation Plan (to be defined) Online hydrological monitoring, made publicly available. Modification of existing agreements and practices recommended.

Issue	Project component	Impact and significance before mitigation	Importance	Mitigation measures	Remaining impact after mitigation	Related Sub Monitoring and Management Plans (S-MMP)
Hydrogeology	Reservoir	The groundwater table in the alluvions along the reservoir will be influenced directly by the water level in reservoir, and especially by the yearly drawdown.	**negative** The reservoir could trigger local landslides by mobilising the sediment deposits along the FSL.	Needs to be monitored. Specific measures would have to be taken in the case that settlements would be at risk.	**small negative** reduced risk of accidents due reservoir triggered landslides.	Monitoring of landslide prone areas
Water quality	Construction activities	There is a risk of water contamination mainly during the construction period. Main sources: • Suspended solids from the construction site and related activities (excavations, quarrying, earthworks causing erosion, preparation of aggregates, disposal of material, etc.). Leads to higher silt load in the d/s area. • Water pollution with fuel oil, lubricants and other dangerous substances from leaking containers and from vehicles and machines. • Contamination of water with concrete increases pH to levels potentially harmful for aquatic life (fish, amongst others). • Contamination of water with Nitrite Ions (NO_2^-) as a result of blasting (quarries). Nitrite is highly toxic to the fish fauna even in low concentrations. Waste water: During the most intensive part of the construction phase, the construction camp will be populated by a large work force.	**negative** Risk limited to construction period. Localised, but potentially of serious consequences.	"Good housekeeping" on the construction site. All equipment, machinery, trucks and camp installations have to be located in a distance of more than 250 m to water used for human consumption and at least 150 m to any body of surface water. Water quality monitoring. Measures to be taken during construction, like e.g.: • No deposit, even for uncontaminated gravel from the quarry, near any body of surface water. Sedimentation and neutralisation ponds for reducing sediment load and effect on pH. Drainage water draining from quarry to be lead to sedimentation and neutralisation ponds before releasing it to the river. • Strict measures to prevent oil pollution of the river: Storage of fuel and lubricants away from the river, in tight containers placed on sealed surfaces. Storage areas designed to contain 110 % of the largest container/ vessel stored in the storage area, waterproof; equipment and material for clean-up avaialble. Good maintenance of vehicles and machines to prevent oil losses. No cleaning or maintenance of vehicles or machines in close proximity to the. To be done in specially prepared areas (workshops) equipped with oil skimmers. • Water from the batching plants, concrete mixer washing facilities and the crusher plants needs to be collected and treated (e.g. neutralisation ponds for effect on pH) before releasing to the environment. Waste water from the camp site must be collected in portable latrines or septic tanks and has to be treated before releasing into a river.	**small negative / none** → The water pollution control measures during construction and operation will considerably reduce the discharge of water deteriorating substances and thus improving quality of the surface waters	Environmental, Health and Safety Management and Monitoring of the contractor Equipment Maintenance Management Plan Wastewater Management Plan Waste Management Plan Pollutant Spill Contingency Plan *→ For detailed information: see also Mitigation Measure Data Sheet No. 8, Waste Water Management (ESIA Main Report Vol. III, Annex A2.1)*

Issue	Project component	Impact and significance before mitigation	Importance	Mitigation measures	Remaining impact after mitigation	Related Sub Monitoring and Management Plans (S-MMP)
Water quality	Reservoir	Change from river to lake ecosystem.	**small negative** No large amount of biomass will be submerged, therefore no water quality deterioration, absence of large settlements and industries in the catchment area.	Given the situation of the project area no specific major mitigation measures are required in this respect. Proper waste and waste water management in the communities around the reservoir would be desirable; however, this is not in the direct responsibility of Rogun HPP.	**small negative**	Water Quality Management Plan during operation Waste Water Management Plan during operation Waste Management Plan during operation
Geology	Dam and reservoir	No valuable mineral deposits within the area to be submerged → no project impacts	**none**	Not required	**none**	No S-MMP
Seismicity	Dam and reservoir	Dam and reservoir are located in a seismic active area. There is a risk of reservoir triggered seismicity, which could result in an increased frequency of small earthquakes.	**small negative** Reservoir triggered seismicity cannot be of a higher magnitude than a potential spontaneous earthquake would be.	The dam is designed so as to withstand the probable maximum earthquake (see technical studies). The reservoir will be filled over a period of 16 years to mitigate this risk. The installation of a micro-seismic monitoring network is proposed.	**small negative**	Seismic Monitoring of Rogun HPP (*ESIA Main Report Vol. III, chapter 7.2)*
Soils	Reservoir	Soils will be lost in the area covered by the reservoir (up to 170 km^2). Erosion due to the drawdown of the reservoir. Landslides could put some settlements on risk.	**small negative** → Localised effect, limited to the reservoir area; no important concern.	For the loss of soils within the submerged area is no mitigation possible. Watershed-management plan with special concern on the side banks of the future reservoir (e.g. monitoring of sensitive areas).	**small negative**	Watershed Management Plan Re-cultivation Management Plan Erosion Monitoring Plan during operation

Issue	Project component	Impact and significance before mitigation	Importance	Mitigation measures	Remaining impact after mitigation	Related Sub Monitoring and Management Plans (S-MMP)
Soils (Topography, geomorphology)	Construction area, quarries, burrows and dumping areas	Main risks: Soil erosion and landslides. • Creation of open and erosion prone surfaces during construction phase. → In the absence of vegetation cover the soil will become more susceptible to erosion. • Sediment deposits along the FSL of the reservoir may be mobilised, leading to local landslides. • Small negative effect (visibility, change in morphology). While a natural process, erosion can locally be accelerated by the project.	**negative** Localised effect, can have negative effects.	Special risks for Rogun HPP construction site since the site already exists since 30 years. Following measures need to be implemented: Reuse as much as possible of the excavated material. Excavate material inside of the future reservoir and deposit unused, uncontaminated material in the future reservoir. Keep additional sites as small as possible. Good engineering practices will help controlling soil erosion both at construction sites and in peripheral areas, particularly in borrow and dumping areas and along access roads. Following measures have been mentioned: • Install sediment traps. • Drainage channels where necessary. • Prevent steep slopes, define optimum height of work evaluating the instability of the rock, soil etc. • Stabilise, compact and strengthen steep slopes. • Adequate selection of road tracks, taking into account the landscape, technical environmental and social aspects. • Construct drainage ditches at roads if there are passing through mountainous area If the slope is more that 16 % they have to be paved. • Install culverts with enough capacity for strong rains, drainage pipes and channels have to be of an adequate size and should be equipped with screens at entrance and exit points to reduce the risk of clogging. • Re-vegetation of surfaces after (temporary) use. • Focus on erosion control measures along roads. Monitoring of erosion prone sites during operation, measures as may be required.	**small negative** → The erosion prevention control measures during construction and operation will considerably reduce the soil erosion and therefore also the suspended solids in the river and thus improving quality of the habitats and water quality. → visibility of remaining scars in landscape and of possible landslides, mud and debris flows will be reduced.	Environmental, Health and Safety Management and Monitoring of the contractor Erosion Management Plan Site Rehabilitation Plan. → *For detailed information: see also Mitigation Measure Data Sheet No. 9, Erosion prevention (ESIA Main Report Vol. III, Annex A2.1)*

Issue	Project component	Impact and significance before mitigation	Importance	Mitigation measures	Remaining impact after mitigation	Related Sub Monitoring and Management Plans (S-MMP)
Soils	Construction activities	Contamination of soil	**negative**	The maintenance of machinery and lorries has to be done in workshops, liquids including cleaning water should be collected in tanks. Storage of fuel and lubricants has to be in tight containers placed on sealed surfaces underneath a roof. The storage has to be equiped with all safety measures to prevent oil spilling including fire fighting equipment. The area needs to be marked. Sufficient quantities of oil absorbent have to be stocked and have to be easily accessible in case of an oil spill. The contaminated absorbent has to be disposed of properly. Hazardous waste has to be stored in designated closed tanks or areas. Solid waste generated during construction and at campsites will be properly treated and safely disposed of only in demarcated waste disposal sites. All activities which could contaminate the soil have to be carried out on a sealed surface. If accidental spillage occurs, the contaminated soil has to be excavated and disposed of properly.	**small negative** → reduced risk of soil contamination; unexpected spills and leakages will be treated properly and fast, the contamination of soil will be locally and due to clean-up mechanisms not spread into the surrounding or drained into the water and/or groundwater	Environmental, health and safety management and monitoring of the contractor Equipment Maintenance Management Plan Wastewater Management Plan Waste Management Plan Hazardous Material Management Plan Pollutant Spill Contingency Plan → *For detailed information: see also Mitigation Measure Data Sheet No. 10 Hazardous Material Management, No. 11 Equipment Maintenance Management and No. 12 Pollutant Spill Contingency Plan (ESIA Main Report Vol. III, Annex A2.1)*
Biological Environment						
Vegetation and flora	Construction area, reservoir	The reservoir will submerge an area of up to 170 km². Vegetation on this land will be lost. Loss of two floodplains (natural habitats).	**small negative** Impact of minor importance, since no critical natural habitats, no especially rare vegetation types and no rare or endangered species will be lost.	Measures during construction: • Damage to the natural vegetation to be minimized. • The useful wood to be made available to the local population. • Re-vegetate as far as possible the reservoir banks with native shrubs and trees in an appropriate manner. Offset for submerged floodplains: measures for improvements in Tigrovaya Balka.	**small negative** **positive,** if measures for Tigrovaya Balka implemented	Watershed Management Plan Re-cultivation Management Plan Site Restoration Plan Pre-impoundment survey
Vegetation and flora	Transmission line and new access roads	Occupation of land and loss of vegetation due to the construction of new roads which are necessary to grant access, e.g. to villages remaining around the reservoir. TLs not part of present ESIA, will require their own assessment.	**small negative** only small impact expected. However, road construction in this area can trigger erosion, which can locally become quite massive.	Use existing facilities and roads where possible for access roads and Transmission and Distribution Lines (T&DL). Measures for stabilising the berms and slopes in order to minimise erosion. Do not use any herbicides for vegetation clearing (manual clearing rather than mechanical or herbicides). Re-vegetation of disturbed areas with native species.	**none / small negative**	Erosion Management Plan Site Restoration Plan

Issue	Project component	Impact and significance before mitigation	Importance	Mitigation measures	Remaining impact after mitigation	Related Sub Monitoring and Management Plans (S-MMP)
Vegetation and flora	Work force (construction phase and operation)	Destruction of vegetation / flora by work force The vegetation cover within the construction area is already degraded due to the past construction activities, the clearance of the dam site and appurtenant structures like camp sites, access roads, etc. → additional impact is estimated to be negligible / very small	**small negative**	Any illegal logging of the work force must be forbidden. In general: Strengthen the awareness of the workforce for the environment (protected areas, plants and wildlife) to avoid logging, hunting etc. at project site and in the surroundings. Construction site to be fenced off for preventing use of areas outside.	**none / small negative**	Needs to be part of the employees contract and of the HR Policy
Vegetation and flora	Future resettlement areas (Surroundings of the reservoir)	As an indirect impact / result of the resettlement land will be used, which (partly) has not been occupied until now. These areas are rather small compared to the inundation area.	**none / small negative** Resettlement carried out so far was done in areas largely used for agriculture until now, no valuable habitats were affected	Mitigation measures depend on the way how many people will be resettled in the future (i.e. relocated outside of the project area) and how many will stay in the region. → Question of available capacity of the remaining land for the number of resettled people and their livestock (needs to be addressed in the course of preparation of the Stage 2 RAP)	**none / small negative**	Specific plans for resettlement areas.
Vegetation and flora	Reservoir (first filling)	In general: Submerged biomass can produce anaerobic conditions and might cause problems (water quality, GHG) when discharged downstream, containing toxic substances (mainly H_2S). Furthermore submerged biomass leads to water quality deterioration in the deeper layers of the reservoir; effect on people, who depend on drinking water quality.	**none** Small amount of biomass to be submerged, oxygen depletion due to submerged biomass will not be a problem.	Pre-impoundment clearing not required, however, trees should be cut. Use of timber and other useful wood (e.g. fuelwood) as valuable resource growing in the reservoir area.	**small positive** → wood / timber as valuable resource for local people	No special plan required, implementation along with resettlement.

Issue	Project component	Impact and significance before mitigation	Importance	Mitigation measures	Remaining impact after mitigation	Related Sub Monitoring and Management Plans (S-MMP)
Terrestrial Fauna	Construction area, roads and all temporary structures	Fauna mainly depends on their habitats, which are neither rare nor valuable in the project area. In addition, the habitats are already strongly influenced by human use and the situation is not new (construction activities are on-going since the 1980ies). The impact on fauna caused by the project is small and of minor importance.	**small negative**	The impact on fauna within the reservoir cannot be mitigated. Since fauna is strongly related to their habitats, damage to the natural habitat should be minimized where possible. It should be forbidden to destroy additional areas due to dumping of construction material. Reconstruction of habitat through reforestation with native species. Offset measure required as compensation for submerged floodplains: Tigrovaya Balka.	**none /** **positive** if measures for Tigrovaya Balka are implemented.	Watershed Management Plan and Re-cultivation (will improve habitats for terrestrial fauna. Plan for measures in Tigrovaya Balka.
Terrestrial Fauna	Work force (construction phase and operation)	Disturbance (e.g. noise) caused by the presence of a high number of people. Risk of illegal hunting.	**small negative**	Hunting by members of the work force must be forbidden. In general: Strengthen the awareness (training) of the workforce for the environment (protected areas, plants and wildlife) to avoid logging, hunting etc. at project site and in the surroundings.	**small negative**	Noise Management Plan. Hunting ban needs to be part of the employees contract and of the HR Policy.
Terrestrial Fauna	Reservoir	Up to 170 km^2 of habitat will be submerged.	**small negative / none** → Impact of minor importance, since no valuable habitats and no rare or endangered species will be lost. The most valuable habitat type affected are two river floodplains which will be submerged.	The affected floodplains are a natural habitat, but not a rare one in Tajikistan. As an offset for this impact, it is proposed to contribute to the management measures for Tigrovaya Balka.	**small negative / none** **positive** if plan for Tigrovaya Banka implemented.	Watershed Management Plan and Re-cultivation Management Plan will improve habitats for terrestrial fauna.
Fish	Dam	Interruption of the river by a dam, which will be an obstacle to fish migration.	**small negative** → All migration already blocked by Nurek. Therefore, not considered as serious impact.	Not required	**small negative**	No S-MMP

Issue	Project component	Impact and significance before mitigation	Importance	Mitigation measures	Remaining impact after mitigation	Related Sub Monitoring and Management Plans (S-MMP)
Aquatic Fauna	Reservoir	Part of the river will change from river to lake conditions → change from a lotic ecosystem more to a lentic ecosystem.	**small negative** → Impact of minor importance. Fish fauna is poor, migrations (if there were any) already interrupted by Nurek dam.	No direct mitigation measures required. However, it is recommended to study the potential of the future reservoir for fish stocking and/or aquaculture. → Carry out a study for developing the fisheries potential in the reservoir; consider possibility of floating cage aquaculture. Note that the potential will be determined largely by the mode of operation of the reservoir. A large seasonal drawdown will reduce such a potential considerably.	**small negative / none** **positive** if potential for fisheries can be developed.	Fish Monitoring Management of Natural Populations, Fisheries Development Plan (needs to be developed)
Aquatic Fauna	Reservoir filling phase (Stage 1)	Will have a negligible impact on the downstream area since the reservoir will be full to this level in a short time, retaining a small amount of water.	**none**	The defined minimum discharge will have to be released.	**none**	Operation Plan
Aquatic Fauna	Reservoir filling Phase (Stage 2)	Will have an effect on the d/s area by retaining a large quantity of water.	**small negative**	Reservoir filling to be made according to the proposed rules. Release of the defined minimum discharge.	**none**	Operation Plan
Aquatic Fauna	Construction activities	Risk of water contamination	**negative**	See mitigation measures for water quality	**small negative / none** The water pollution control measures during construction and operation will considerably reduce the discharge of water deteriorating substances and thus improving quality of the surface waters	Environmental, health and safety management and monitoring of the contractor Equipment Maintenance Management Plan Wastewater Management Plan Waste Management Plan Pollutant Spill Contingency Plan → *For detailed information: see also Mitigation Measure Data Sheet No. 8, Waste Water Management (ESIA Main Report Vol. III, Annex A2.1)*

Issue	Project component	Impact and significance before mitigation	Importance	Mitigation measures	Remaining impact after mitigation	Related Sub Monitoring and Management Plans (S-MMP)
Landscape	All visible parts of the project	The visible structures will change aspect of landscape.	**small negative / negative** during operation, the impacts are reduced to the remaining visible structures (dam, reservoir, switchyard, new roads, etc.), considering that all mitigation measures were taken into account.	No mitigation possible for the drawdown area. Mitigation measures • Landscaping and re-vegetation of temporarily used areas so that this areas can return into a natural ecosystem. • Start with the re-vegetation of areas as soon as possible. • Unused material for example from the quarries should be deposited in a way compatible with the landscape and should be re-vegetated. • Ensure the conservation of the landscape where possible. • If possible, dump unused, uncontaminated material in the future reservoir. Keep additional sites as small as possible.	**small negative / none / positive**	Watershed Management Plan Re-cultivation Management Plan Waste Management Plan Site Rehabilitation Plan
Protected Areas	Operation	There is no protected area in the area affected by dam and reservoir. One protected area (Tigrovaya Balka), located d/s of the Vakhsh cascade. It is an important floodplain habitat with a very special and rare vegetation type and associated fauna. It depends on seasonal fluctuations in river discharge.	**none** Tigrovaya Balka was already affected by Nurek HPP. The hydraulic model shows that under the proposed operation scheme for Rogun HPP there will be no change in river flows downstream of Nurek, and therefore no additional impact on Tigrovaya Balka caused by Rogun HPP.	Operation of the cascade according to proposed regime. Additional measures specific for improving the situation in Tigrovaya Balka could be: • Participation of Rogun HPP in the on-going efforts for improving habitat conditions; this would be a valuable offset for the impact of Rogun HPP on vegetation, fauna and natural habitats. • Release of occasional "artificial floods"; this would have to be done in close coordination with all concerned stakeholders, mainly also to prevent damage to inhabited and cultivated areas. This is proposed to be taken as offset measure for the loss of two floodplains (see above).	**positive**, if offset implemented	Plan for measures in Tigrovaya Balka
Human Environment						
Human population	Reservoir (stage 1)	Physical displacement has to take place. 7 villages will have to be resettled.	**strongly negative**	The affected population has to be resettled. Resettlement plan focuses mainly on physical relocation and livelihood restoration. Resettlement has started (so-called Stage 1 resettlement, villages affected by the construction activities). A Resettlement Unit is in place.	**none / small positive** resettled people will be at least not worse off than they were before; conditions should improve.	Resettlement Action Plan Monitoring of the resettled people

Issue	Project component	Impact and significance before mitigation	Importance	Mitigation measures	Remaining impact after mitigation	Related Sub Monitoring and Management Plans (S-MMP)
Human population	Reservoir (stage 2)	The reservoir area of 170 km² is rather densely populated. Physical displacement has to take place. A total of 77 villages with approximately 42'000 inhabitants will have to be resettled.	**strongly negative** This is considered as a very substantial negative impact of the project.	A resettlement action plan will have to be prepared for the remaining villages (Stage 2). Resettlement plan focuses mainly on physical relocation and livelihood restoration. Resettlement planning will have to be done and implemented in stages, in accordance with the implementation of the technical project, mainly given the long construction time of up to 15 or more years.	**none / small positive** resettled people will be at least not worse off than they were before; conditions should improve.	Resettlement Action Plan (Stage 2) Monitoring of the resettled people
Local Economy	Work force and construction activities, and operation	The project area offers little prospect for economic activities; subsistence agriculture is important for the livelihood of the local population; unemployment rate is very high. Presently, there are two main means of income generation in the project area: • emigration to Russia in search of work; • Employment in Rogun HPP (construction work).	**positive**	Even if the job opportunities are largely limited to the construction period, this is very important given the duration of these activities of about 15 years → Wherever possible, local inhabitants should get preference in job allocation. Problems caused by recent stand-still of construction activities (relegation of a large number of workers due to the agreement of WB with GOT to limit work to the absolutely required maintenance work) needs to be taken into consideration.	**positive** Potential positive impact on the local community (generation of jobs), although limited to construction period.	Socio-Economic Development Plan Contractor's Human Resources Management Plan

Issue	Project component	Impact and significance before mitigation	Importance	Mitigation measures	Remaining impact after mitigation	Related Sub Monitoring and Management Plans (S-MMP)
Health	Construction sites / camps, construction activities	Potential negative effect on health (communicable diseases brought from outside by workers)	**small negative / negative**	All workers should attend a work shop on communicable diseases (TBC, etc.). How to get infected, how to recognise symptoms, what should be done and on prevention measures. Every worker has to have the necessary vaccination (Hepatitis A and B, Tetanus, etc.). Overall good housekeeping contributes to maintain hygienic and safe conditions on the construction site. Local population should be allowed to benefit from health infrastructure in construction camp. Install Project Information Centre and prepare a Community Relation Plan and inform the population about the Project. Control activities affecting waters and landscape used for recreation. Develop training and lectures about environmental conservation for the local population (waste education, agricultural education). Development of activities to enable the strengthening of new sources of revenue for the local population. Improve infrastructure in the area directly affected by the project (maintenance of access roads). Speed limits and a safety driving training should be implemented.	**positive** minimisation of transmission of diseases, health protection for the local population and for the work force	Community Relation Management Plan Health and Safety Management Plan Traffic Management Plan → *For detailed information: see also Mitigation Measure Data Sheet No. 2, Public Health (ESIA Main Report Vol. III, Annex A2.1)*
Land use	Reservoir	Land, used for agriculture and pastures, will be submerged. Impact on forest: rather small only on steep slopes.	**small negative / negative**	A re-cultivation program will be developed. The re-cultivation will be carried out with native species. Remaining forest above FSL should be given better protection (neither tree cutting, nor burning of vegetation above final FSL).	**none / small negative**	Watershed Management Plan Re-cultivation Management Plan Resettlement Action Plan

Issue	Project component	Impact and significance before mitigation	Importance	Mitigation measures	Remaining impact after mitigation	Related Sub Monitoring and Management Plans (S-MMP)
Fishing	Reservoir	Fish fauna is low (species, quantity). Fish do not have any economic importance for the local population. Therefore only small impacts / chances are expected in terms of establishing commercial fisheries in Rogun reservoir and/or possibly impacts on existing fisheries.	**none / small negative**	Measure of prevention: Avoid water contamination (see water quality measures)	**none** **positive** if fisheries can be developed	Fish Monitoring Program Fish Management and Fisheries Development Plan. → *For detailed information: see also Mitigation Measure Data Sheet No. 8, Waste Water Management (ESIA Main Report Vol. III, Annex A2.1)*
Cultural Resources (archaeology, culture)	Reservoir	Submersion of up to 170 km² of land, relocation of local population. The area is archaeologically rather important, since it was inhabited at least since the Neolithic period. A number of archaeological sites were related to the silk road passing through this valley.	**small negative / negative** 14 sites of archaeological interest were identified in the project area; most of them were partly or totally destroyed in the past. One site within the reservoir area remains intact and has not been investigated yet.	Two measures of different nature proposed: 1. Excavation of one site, so far not investigated but affected by reservoir impoundment. Archaeological investigation prior to impoundment. 2. Carrying out of a socio-cultural survey of the affected population prior to relocation, in order to document the local (oral) traditions. Chance find procedure to be developed for project related activities outside the construction site (e.g. construction of new roads).	**none** archaeological site excavated and documented **positive** local culture documented	Special plans to be developed: Cultural Heritage Management Plan Chance find procedure
Emergency preparedness	Lower Vakhsh valley, downstream of Nurek to confluence with Pyanj; Amu Darya valley as far d/s as the Aral Sea.	Flood due to exceptionally high inflows; Risk of flood caused by a dam break	**strong negative**	Main measures: engineering; dam designed according to highest safety standards (TEAS). Develop an Emergency Preparedness Plan.	none risk level reduced to acceptable level (TEAS risk assessment).	Emergency Preparedness Plan Technical measures (as defined by TEAS)

Issue	Project component	Impact and significance before mitigation	Importance	Mitigation measures	Remaining impact after mitigation	Related Sub Monitoring and Management Plans (S-MMP)
General construction related issues						
Waste, hazardous waste and storage of hazardous materials	Construction Phase, Operation Phase	Contamination of soil, water, health risk; due to: • Domestic waste (mainly during construction). • Solid waste (mainly during construction and demolition of old structures of Rogun HPP). • Liquid waste (from maintenance of all lorries and construction machinery). • Hazardous waste (can occur during construction time for the maintenance of the Machinery).	**negative**	Develop a waste management system. Install garbage cans for temporary waste disposal of domestic waste. Those have to be collected and disposed according to the regulation of solid waste management and approved by the local authorities. No waste shall be disposed of or buried on the site. Illegal dumping, either at the construction camp, along the roads or in the surrounding areas, or into the river shall not be allowed. Solid waste generated during construction and at campsites will be properly treated and safely disposed of only in demarcated waste disposal sites. In general waste should be reduced, re-used, recycled and the disposal should be controlled. Hazardous waste (oil, chemicals, etc.) has to be stored in a designated closed tank and/or area. Until will be delivered to companies specialised on the proper disposal or recycling of those hazardous wastes. Containers have to be available at the workshops for the disposal of used filters, gaskets and other spare parts. A full cleanup of the site has to be carried out before main construction starts. A full cleanup of the site has to be carried out after construction. All wastes accumulated during construction and all demolishment wastes from temporary structures have to be disposed properly. A continuous monitoring of the proper waste handling by the contractor and by the Owner is indispensable to ensure that problems are identified and addressed early Instruct workforce on appropriate measures to minimize waste. Spill / emergency preparedness plans in case of major accidents (fuel tanks, etc.).	**small negative / none** Appropriate waste handling measures result in minimisation of contamination of the environment and in improved health protection	Waste Management Plan Hazardous Material Management Plan Consturction Site Emergency Preparedness Plan → *For detailed information: see also Mitigation Measure Data Sheet No. 7 Waste Management and No.10 Hazardous Material Management (ESIA Main Report Vol. III, Annex A2.1)*

Issue	**Project component**	**Impact and significance before mitigation**	**Importance**	**Mitigation measures**	**Remaining impact after mitigation**	**Related Sub Monitoring and Management Plans (S-MMP)**
Use, transport and storage of explosives	Construction Phase	Accidental explosions with potential negative effect on work force.	**negative**	Take into account the procedures established by the responsible authorities of Tajikistan and/or any international standards accepted by the country. Do not use explosives in areas not authorized for this purpose. Explosive material should be stored in a state of the art storage (solid structure, fire resisted material, ventilation for heat control, electrically grounded, clean and dry, exclusively for explosives) it has to be labelled with the necessary warnings, and needs to be closed and lockable. The storage needs to have an area open surrounding of 10 m and no other combustible material is allowed to be stored in a distance less than 20 meter. Detonators should be stored in a different storage or at least in a different compartment of the storage. Blasting agents should be stored separately from explosives, safety fuses and detonating cords. Only authorised persons should be allowed to store, handle, use and transport explosive material. The authorisation has to be maintained if required by the Tajik legislation and the certificate should be kept on site. For transport of explosives use designated closed containers with insulation. Use separate containers for the detonators. Do not allow people, workers and animals in a distance of less than 500 m of a blasting point. Implement suitable warning system (banners, mobiles, sirens etc.) Activate an auditable alarm 15 minutes before blasting.	**positive** improvement of safety for work force	Explosives Management Plan → *For detailed information: see also Mitigation Measure Data Sheet No. 3, Explosives Management (ESIA Main Report Vol. III, Annex A2.1)*

Issue	Project component	Impact and significance before mitigation	Importance	Mitigation measures	Remaining impact after mitigation	Related Sub Monitoring and Management Plans (S-MMP)
Occupational Health and Safety	Mainly Construction Phase and Operation Phase	Work accidents, occupational diseases (skin irritation, noise, etc.)	**negative**	Develop occupational health and safety procedures like to wear protective equipment, proper handling of hazardous substances, etc. All workers have to use the relevant protective equipment (helmet, gloves, goggles, work boots, masks, ear plugs, etc.). All restricted plant facilities have to be labelled with caution signs, especially those with potential risk for workers. All construction areas shall be marked and fenced to avoid accident from unauthorised people. Fence off all areas like excavation pits, quarries etc. to prevent accidents. First aid kits need to be available at the construction site for fast action if an accident occurs. Accessible consultation sheets for review in case of contingency or emergency situations. These should have phone numbers for police, fire fighters, Red Cross, personal supervisor or project leader. Prepare a scheme of the evacuation routes and where the fire extinguishers are located within the plant and place them at conspicuous places. Maintenance of machinery (preventive and corrective; during construction and operation). Provide sufficient potable water. Assign during construction a special area for the food intake. Separate installation areas, for example mechanical workshops etc. from areas that are used by people for temporary housing and recreation; distance should be at least 10 m. Install portable toilets for the disposal of manure generated by the builders in a distance of at least 15 m to the river. They should be regularly maintained and disinfected. The number of latrines is correlated with the number of employees and there should be one toilet for every ten (10) workers. Workshops and camp site must have acceptable conditions of light, ventilation and safety for workers. Label T&D Line poles indicating danger, high voltage.	**positive** reduction of accidents, health protection, appropriate reaction in case an accident happens	Health and Safety Management Plan Construction Site Emergency Preparedness Plan → *For detailed information: see also Mitigation Measure Data Sheet No. 1, Occupational Health and Safety (ESIA Main Report Vol. III, Annex A2.1)*

Issue	Project component	Impact and significance before mitigation	Importance	Mitigation measures	Remaining impact after mitigation	Related Sub Monitoring and Management Plans (S-MMP)
Occupational Health and Safety	Working at height on structures	Work accidents	**negative**	Numerous measures required (see ESMP), as e.g.: • PPE • training of work force on accident prevention and first aid • specific safety measures depending on risk of work place (e.g. welding, crushing plants, work in heights, work near water).	**positive / small negative** reduction of risk of accidents, appropriate reaction in case an accident happens	Health and Safety Management Plan
Traffic and roads	On site (construction site), off site (transportation routes)	Additional traffic passing through villages. Medium impact on air, work force and population.	**negative**	Adequate signing, warnings and controls have to be implemented like speed limits, roads in use or under construction. Enforce maximum load restriction. All vehicles have to be well maintained. Implement a maintenance program for access roads carried out before winter (cleaning gutters, improvement of the road if necessary, etc.). Develop procedures for parking and on-site traffic movement. Use if feasible project buses to transport workers to the site.	**small negative** reduce risk of accidents and injuries to persons, reduce air emissions (exhaust gas, dust), reduce lubricant and oil losses.	Traffic Management Plan Equipment Maintenance Plan → *For detailed information: see also Mitigation Measure Data Sheet No. 4, Traffic Management Plan (ESIA Main Report Vol. III, Annex A2.1)*

17 ENVIRONMENTAL AND SOCIAL MANAGEMENT PLAN

Based on the identification of impacts and required mitigation measures as shown in the preceding chapters, a preliminary Environmental and Social Management Plan (ESMP) was developed. This is provided in a separate document, Vol. III of this ESIA. This Chapter provides a summary of the ESMP

17.1 Objectives of Environmental and Social Management Plan

The ESMP (ESIA Vol. III) will help Rogun HPP to address the adverse environmental impacts of the project, enhance project benefits, and introduce standards of good environmental practice. The primary objectives of the plan are to:

a) Define the responsibilities of project proponents, contractors and other role players, and effectively communicate environmental issues among them.

b) Facilitate the implementation of the mitigation measures identified in Chapter 16 by providing the instructions on how to handle the issues, and providing an implementation schedule.

c) Define a monitoring mechanism and identify monitoring parameters to ensure that all mitigation measures are completely and effectively implemented.

d) Identify, as far as possible at this stage, the resources required to implement the ESMP and outline corresponding financing arrangements.

e) Define the mechanisms and procedures for the participation of affected communities and other key stakeholders during the implementation period; this would include a proactive communication plan and mechanisms to address grievances and complaints.

17.2 Construction Site Management and Rehabilitation

As mentioned, Rogun HPP is a special case with respect to the fact that construction activities started a long time (over 20 years) ago, and were resumed after a prolonged interruption about 6 years ago. This means that a very large construction site is already in place. Even if at present, under the agreement of the Republic of Tajikistan with the World Bank, construction activities are restricted to absolutely required maintenance measures aiming at preventing additional damage to structures already built, it is still a large construction site. According to the TOR for the ESIA, a construction site audit had to be carried out (see the following Chapter). In Vol. III, comments are made and recommendations provided on requirements for construction site management aiming at achieving general good housekeeping and acceptable environment, health and safety (EH&S) conditions on site. In addition, recommendations are made for construction site rehabilitation. These aspects, which are usually not, or at least not in that detail, the subject of an ESIA, are dealt with in Chapters 5 and 6 of Vol. III.

17.3 Responsibilities

The ESMP makes a distinction between responsibilities of the Project Owner (Rogun OSC, Republic of Tajikistan), the Contractor and any other national or local government organisations which are involved in the process. In many or most cases this responsibility is clearly attributable. So e.g. the Contractor will be directly responsible for all environment, health and safety (EH&S) measures related directly with construction sites and activities; this includes items as diverse as solid waste management, availability of PPE (personal protection equipment) for workers, health care services for the work force, etc.

However, in some cases responsibility is not a priori clear. So e.g. it is primarily the Project Owner who is responsible for implementing mitigation measures which are not related to construction, as e.g. archaeological investigations or planting of trees for slope stabilisation outside the construction site perimeter. Obviously, he can mandate a contractor with this work. This also applies to other basic responsibilities of the Project Owner.

If the Project Owner engages an Owners Engineer (OE), this latter will have the responsibility to supervise the contractors; normally this supervision of the Owners Engineer covers the construction period and construction related issues, e.g. EH&S measures related directly to construction sites and activities. These responsibilities will have to be defined in the contract of the Owner's Engineer.

In any case, the Project Owner has the following overall main responsibilities concerning environmental management (in the wider sense of the term):

- To make sure that the required measures are properly implemented, whether by him directly or by a third party.
- To formulate clear conditions (in the tender documents) for all obligations of the contractor(s); it must be very clear that such conditions, e.g. concerning EH&S measures, also apply to subcontractors, and that the contractor has a responsibility for their performance.
- To monitor implementation of these measures (by its own work force and by subcontractors) and to take adequate steps in case of non-compliance.

Contactor responsibilities will include

- the timely preparation and implementation of environmental and social measures as stipulated in contractual documents;
- to ensure appropriate quality assurance, control and enforcement measures (internal monitoring) related to environmental and social;
- to ensure that local grievance and complaints mechanisms are in place to handle disputes in a timely manner.

National and local government agencies' responsibilities will include

- to ensure compliance with legal requirements under their jurisdiction;
- to support and facilitate the implementation of key elements of the ESMP and RAP, for example the review of architectural design; etc.

The Figure on the following page gives a list of the main environmental management plans which will have be developed, and shows how responsibility will be shared between PIU/OE on the one hand and the main Contractor on the other hand.

17.4 Operating Rules

The project owner will have to define detailed operating rules for Rogun HPP, meaning that existing operating rules will have to be adapted to include Rogun HPP.

These rules are essential also for impact mitigation, since they will define the way to operate the entire cascade with the overall aim of doing this according to the intended operation regime, whose main purpose is to maintain the present flow pattern of Vakhsh river downstream of the cascade. The basic conditions for these rules were developed for and are described in the TEAS Reservoir Operation Studies, and they are also described and discussed in Section 21.3.4.

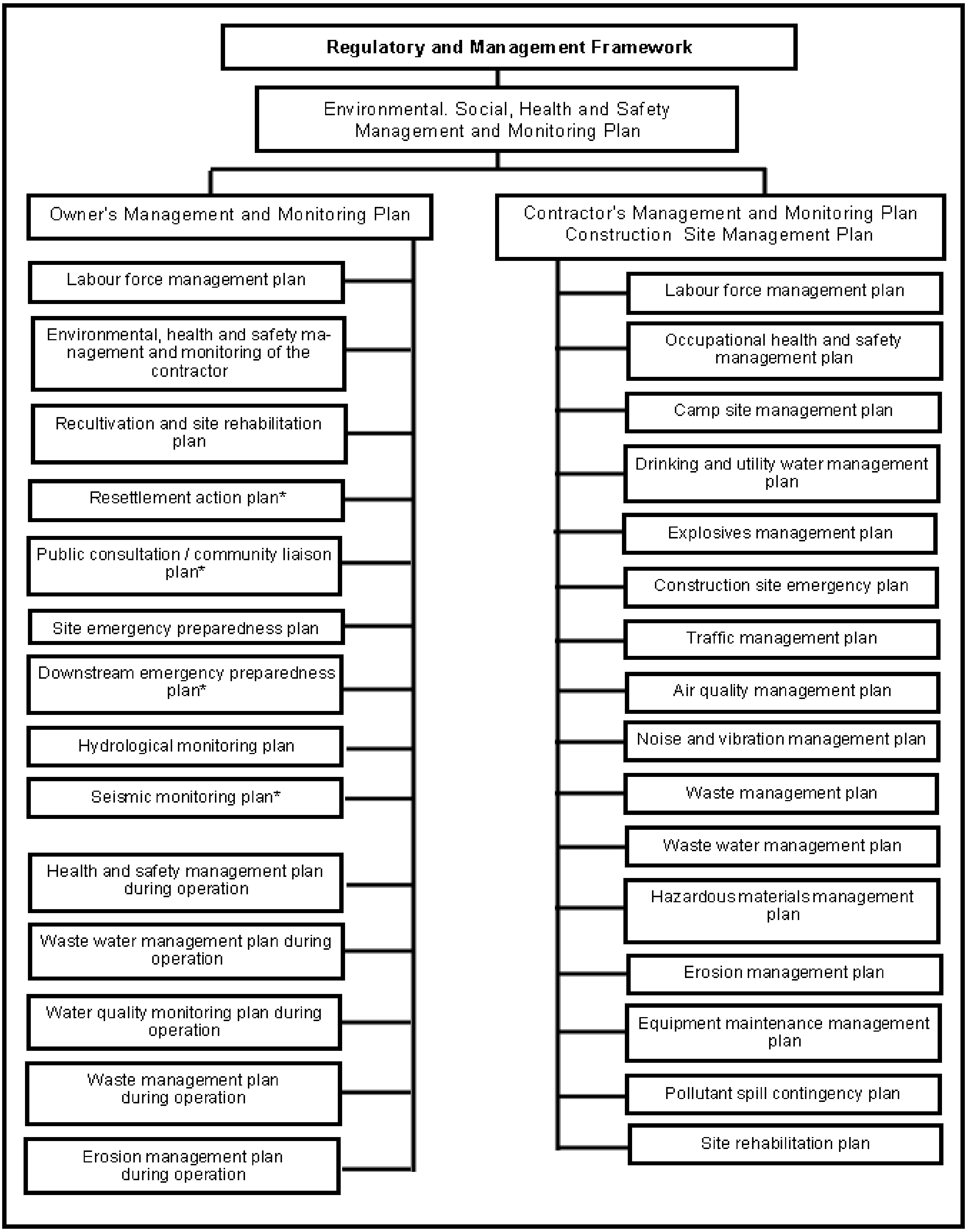


Figure 17-1: ESMP and Sub-ESMPs

* Responsibility that can be allocated to, or shared with, a third party (not necessarily the or one of the construction contractors)

17.5 ESMP and RAP

The main social impacts and measures, i.e. everything related to impacts on the local population requiring compensation, or in other words all activities related to resettlement, are dealt with on a different level. A Resettlement Unit (called "Directorate of the Flooding Zone of Rogun HPP) is in place and has started working in its present from in 2011.

Within the present ESIA, the following main steps have been carried out in relation with issues concerning the local population and resettlement:

- Description of the socio-economic situation of the local population (Chapter 13 of the present report)
- Outline of a resettlement plan for Stage 2 of Rogun HPP development (Chapter 19 of the present report).
- Resettlement Policy Framework (RPF): separate document.
- Resettlement Action Plan (RAP) for Stage 1 resettlement: separate document
- Resettlement Audit: separate document.

For the implementation of the project, these documents will have the same importance, and will be equally binding, as the ESMP; for this reason, aspects related to resettlement (in the wider sense of the term, and not limited to physical relocation) are not repeated in the ESMP.

18 CONSTRUCTION SITE AUDIT

18.1 Key Messages

Construction of Rogun HPP started in the 1980s, was then interrupted following the independence of Tajikistan from the Soviet Union, and was resumed recently. It is a very large construction site, for which an environmental, health and safety audit had to be done. The situation is described here, and measures for eliminating or reducing environmental, health and safety risks are proposed. Major aspects where measures are required are waste management and health.

18.2 Approach

In general terms, the construction industry is one of the world’s major industries. Despite mechanization, construction remains a major employer of labour – it often employs between 9 and 12 per cent of a country’s working population, and sometimes as much as 20 per cent.

There is, however, a price to pay for this continuous growth and activity. Although it is difficult to obtain accurate statistics in an industry in which many accidents go undetected and unreported, in many countries known fatal accidents, and those involving loss of working time, frequently exceed those in any other manufacturing industry.

Contributing to the high rate of accidents are those characteristics of the industry which distinguish it from the rest of the manufacturing sector. These are:

- the high proportion of small firms and of self-employed workers;
- the variety and comparatively short life of construction sites;
- the high turnover of workers;
- the large numbers of seasonal and migrant workers, many of whom are unfamiliar with construction processes;
- exposure to the weather;
- the many different trades and occupations.

In order to analyse the current situation of waste management, health and safety management in line with the national and the international applicable legal framework and standards in Rogun HPP construction site, a 3 days site visit was conducted in Rogun HPP construction site.

Additionally, during the site visit, implementation of necessary applicable measurements with regard to protect quality of ambient air in both confined/closed and open spaces and quality of drinking and utility water were scrutinized in the construction site of Rogun HPP. Furthermore, current application of sanitary measurements was investigated in the entire construction site.

The path which was followed for this study can be summarized as below:

- Related current documents (e.g. reports, maps) that have been prepared for Rogun HPP Project were studied.

- National and international legal framework and standards have been reviewed.
- Rogun HPP construction site visit was visited.
- Rogun HPP construction site personnel were interviewed about the related issues.
- A meeting was held in Sanitary Institution with three personnel of the institution to gain additional information.

18.3 Situation at Rogun HPP Construction Site

The audit described here was carried out in May/June 2011, and when the description provided here refers to "present situation", it reflects the situation of 2011. In the meantime, work was going on (and was later on limited strictly to maintenance work required for preventing deterioration of structures already built; see Section 13.10.2). The audit was not repeated since then; however, during later visits to the construction site the impression was gained that efforts were already being made for addressing some of the issues raised during the audit, especially concerning waste management on site.

In a meeting on June 5th, 2014, management of OSC Rogun HPP provided information indicating that many of the issues described in this chapter have been addressed, which confirms the impression the consultant got on subsequent visits to the site, as mentioned above.

Still, the recommendations for construction site management made here (and provided with much more detail in Vol. III, ESMP) are still valid.

18.3.1 Domestic Solid Waste and Hazardous Waste Management

Currently the construction activities in Rogun HPP construction site is restricted to rehabilitation of existing structures therefore the volume and the variety of hazardous waste is limited. It should be mentioned that even with the large number of workers which is present in the construction site and without a formal waste management system just a little amount of unattended domestic waste is visible within the construction site.

Based on the statement of one of the site engineer in Rogun HPP construction site, 2,800 workers are present in the construction site on a daily basis. 1,800 workers out of the 2,800 workers have been staying in construction workers camps on daily basis. Therefore the volume of domestic waste generation would be $1060\ \mathrm{kg/day}$ $[(0.45 kg/day * 1800) + (0.25\ kg/day * 1000) = 1060 kg/day]$. It should be noted that an assumption was made regarding the daily domestic waste generation per capita in order to calculate the total daily waste generation of the Rogun HPP construction site. Furthermore the assumption was made base on the visual inspection of the site visit and general knowledge of the county average income level (low income).

As mentioned before, the hazardous waste stream has not been identified in Rogun HPP construction site yet. Therefore the generated volume and variety of the hazardous wastes are unknown by the site engineer. However in reference to the site investigation, the hazardous waste variety of construction sites can be classified as follows:

- Paint, varnish, wood treatment and preservatives and associated containers;
- Cleaning chemicals and associated containers;
- Oils and lubricants and associated containers;

- Asbestos;
- Contaminated soils;
- Insulation materials;
- Coal tar and bitumen and associated containers;
- Flat accumulators and worn out oil, air filters from construction heavy vehicles; and
- Flat batteries and printer cartridges from office activities.

Currently the above mentioned types of hazardous waste are generated in Rogun HPP construction site. Once construction of Rogun HPP starts the variety and the volume of hazardous waste will increase. Therefore an effective and efficient waste management system shall be prepared and applied to the site.

In regard with the solid waste management three main points were taken into account during the site visit namely (i) management of related documentation including HSE trainings, (ii) evidence of designated technical personnel to handle the related issues, and (iii) site applications of domestic and hazardous waste management systems.

The key findings related to documentation, training and management concerning the waste management system of Rogun HPP construction site can be provided as follows:

- During the site visit it became clear that the site has no formal solid waste management system, which should have been prepared in compliance with the respective national and international regulations and/or standards.
- HSE training activities regarding environmental management issues are not evident.
- HSE site management team has been not constituted.
- A method/system has not been developed to track the legal obligations related to the HSE issues by administration of Rogun HPP construction site.

The key findings related to the current applications in line with the solid waste management in Rogun HPP construction site can be provided as follows;

- General housekeeping is badly managed.
- The domestic solid waste containers are not evident.
- In some parts of the construction site little amount of organic domestic wastes are left on the ground
- Metal scraps are all over the construction site, abandoned directly on the soil without any intermediate protection layer between the soil and the metal scraps, although the site has a metal smelter facility.
- Small numbers of worn out tyres are abandoned directly on the soil in some places in the construction site.
- Dustbin lorries are not present.
- There is no particular area designated as solid waste collection area.

The key findings related to the current implementations of hazardous waste management in Rogun HPP construction site are given as follows:

- Medical waste is poorly managed. Based on the statement of one of the doctors from the medical headquarter centre, the average daily medical waste generation is 10 kg/day in the medical headquarter centre. The other medical centre's waste generation is unknown. The medical waste of all medical centres is being burned in an open area by the personnel of the centres. The ambulance is used for transporting medical waste to the remote burning area.
- Empty containers containing residues of lubricants are abandoned on the ground.
- The surroundings of drilling sites are contaminated by residue lubricants/oils. Soils contamination is evident in some part of the construction site of Rogun HPP.
- The water containing residue of concrete is discharging directly to the nature without any pre-treatment activities. Therefore the surrounding soil of designated areas for washing the concrete mixers and some areas in concrete batching areas are covered by concrete residue.
- A hazardous waste intermediate storage area is not present.

18.3.2 Industrial and Domestic Wastewater Management

The construction site of Rogun consists of two types of wastewater namely domestic wastewater and industrial wastewater. Both types of wastewater should be subject to treatment processes before discharging it to the environment. The industrial wastewater is generated in two forms in the construction site.

1. Industrial wastewater which is originating from concrete batching works. The content of the industrial wastewater may include cement, sand, aggregates, chemical admixtures, fuel and lubricants.
2. Industrial wastewater which is generated by aggregate washing activities. The content of the wastewater is mainly suspended solids. Furthermore depending on the rock type the wastewater may have a high pH.

Key findings related to management of the generated industrial wastewater in Rogun HPP construction site can be provided as follows:

- The site engineer indicated that eight concrete batching plants are operating in Rogun HPP construction site and each has a 60 m^3/hour gross and a 40 m^3/hour effective capacity. The inspection was held in two of the concrete batching plants. It was realized that the wastewater generated by both of the plants are directly released to the environment without applying any pre-treatment. Furthermore major amounts of the wastewater goes directly into the river Vakhsh after part of it is absorbed by the soil. Additionally, it was noticed that the situation related to the wastewater in the remaining six concrete batching plants is not different from the one in the visited plants.
- In the designated concrete mixers washing areas the impact related to the industrial wastewater is more severe than at the batching plants, since the amount of released wastewater is higher. It was stated that the average capacity of one concrete mixer is 6 m^3 and nearly 25 mixers are present at the

construction site. During the inspection in washing areas it was noticed that in order to clean the concrete residue inside the mixers, these are completely filled with water. After the washing operation, the polluted water is directly discharged into the environment. Moreover the outside of the mixers are washed and this situation leads to a water pollution via oil and fuel as well.

- The site has 6 crusher facilities. One of the crusher facilities has a 1 million m^3/yr aggregate production capacity and had been designed as a closed crusher facility. The wastewater generated in the closed crusher facility is collected in a sedimentation pond and the treated water is re-used in the same process again. However the sludge in the sedimentation tank is directly dumped into the environment. The capacity of the remaining five open area crusher facilities is varying between 12-15 m^3/month aggregate.

The key findings regarding domestic wastewater management in Rogun HPP construction site can be provided as follows:

- The construction site has a Domestic Wastewater Treatment Plant with a full capacity of 700 m^3/day. It was constructed in 1986. In the years between 1986 and 1992 the plant was operating with full capacity; due to suspension of the Rogun HPP construction in 1992, the plant was taken out of operation. It was clearly acknowledged that the plant since then has not been functioning efficiently.
- The plant will be submerged once the Stage1 dam construction is completed.
- The second Domestic Wastewater Plant is under construction. The domestic wastewater treatment plant was projected as two phases. First phase of the wastewater treatment plant has a 4,200 m^3/day treatment capacity and it is under construction. Second phase of the plant has a 5,800 m^3/day treatment capacity and the construction of the second phase of the plant has not been started yet.
- The construction site is enormously big. In different locations different varieties of works are being carried out by the workers far away from the main construction camp and the sanitary facilities. However in those locations there are no toilets available. Given the rather large work force, this poses a serious threat to site hygiene.
- Furthermore there is a remote workers camp in the construction site. It was visited during the site visit. It was stated that approximately 100 workers are accommodated in the camp. The camp has no link to the sewage system. Two toilets are serving the workers' needs. It was indicated that no septic tank was located underneath the toilets. Moreover the wastewater which is generated in baths and by other cleaning activities are directly discharged into the environment without applying any treatment to the wastewater.

18.3.3 Drinking and Utility Water Quality Management

During the site visit in Rogun HPP the household water quality management system was scrutinised in line with the national and international applicable regulations and standards.

As already mentioned previously 2,800 workers are present in Rogun HPP construction site and 1,800 workers out of this 2,800 are accommodated in the workers camps of the construction site. The clean water is needed mainly for following household needs:

- Drinking water
- Showering
- Washing dirty cutleries, tableware
- Laundry
- Cleaning/washing surfaces
- Flushing toilets etc.

The water is also used for other purposes, such as irrigation and dust suppression. The water quality for these usages does not have to be as high as for the household water quality.

It was stated that household water sources for the construction sites are mainly spring water and artesian well water. The site has 5 artesian wells, each of them has a 63 l/second water capacity. The administration buildings and the main worker camp and part of the construction site have a water distribution pipeline. The length of the water distribution pipeline is 18 km. In that case permanent water supply is present at those areas. Additionally the main construction site has water storage tanks. However the condition of the tanks is not known, especially whether they are still hygienically sufficient to store drinking water. It was stated that the quality of drinking water has been tested by a related laboratory in accordance with the national regulation. On the other hand an observation was made during the site visit that the quality of the tap water is not sufficient. The colour of the water is brownish and has a strange odour. Furthermore it was discovered that the water quality control is not evident in the workers camps which are located in different parts of the construction site. However it was said that the drinking water is being supplied by special trucks to the workers who are working in remote areas within the construction site.

There is no water purification plant within the construction site. The water is pumped from the sources to the water distribution pipeline without any purification applications.

18.3.4 Ambient Air Quality Management

Quality of ambient air in both confined and open spaces was considered during the site visit in the construction site of Rogun HPP in line with the national and international related regulation and standards.

The key findings regarding open space air quality management in Rogun HPP construction site can be provided as follows:

- Due to the dry and hot season conditions dust emission is generated by heavy construction machinery traffic and wind in access roads of the construction site.
- The pavement of the access road within the construction site are mainly compacted earth lining, this situation is increasing the volume of dust emission.
- Crusher facilities within the construction site are one of the sources of the dust emission. Conveyors which are part of this facility are not closed and a ventilation system is not evident in the closed crusher facility.

- Unloading and loading of materials are also an emission source.
- The mouths of the cement silos in concrete batching plants are not closed properly and no filters are fixed, which increases the dust emission.
- Trucks which are shifting the borrow material in construction site are not covered and therefore they are another source of the dust emission.
- Dust emission also originates from borrow areas, borrow material storage areas, and excavated material storage areas.
- Road sprinkling is carried out in the construction site in order to suppress the dust emission.

The key findings regarding confined spaces air quality management in Rogun HPP construction site can be provided as follows:

- Construction activities generate dust emission in confined spaces.
- A relatively high intensity of heavy construction equipment traffic generates exhaust gas in confided spaces.
- Fume is originated by welding activities in confined spaces.
- The ventilation system is not sufficient in confined spaces.

18.3.5 Health and Safety Management

An overall Health and Safety site investigation was conducted in Rogun HPP construction in line with the national and international regulations and standards, the key findings on related issues can be summarized as follow:

- The site does not have a formal Health and Safety Management System
- The documents related to the Health and Safety management such as safety policy, procedures and introductions are not evident.
- The site does not have a designated Health and Safety officer/manager.
- Health and safety trainings are not evident in Rogun HPP construction site.
- The safety signs and informative signs throughout the site are missing.
- The traffic signs are not adequate and efficient.
- Evidences of the landslides, erosion phenomena, unstable slopes, risks of rock fall are threatening wellbeing of the workers and the environment.
- The poor condition of electrical installation creates a severe source of hazard for the workers' safety.
- The measures which have been taken for fire protection are not adequate and efficient.
- Site traffic management is not sufficient and adequate in both access roads and the tunnels for access road.
- There is no sign to indicate maximum speed level throughout the construction site.

- Bad condition of access roads is one of the obstacles for safe traffic flow in the construction site.
- Adequate signalling or other control arrangements or devices are not installed to prevent dangerous movements of vehicles and earth-moving or materials-handling equipment.
- Measures which have been taken for fall protection are not adequate and sufficient (e.g. poor condition of scaffolds). Falls of persons from a height, and similarly of materials and objects, represent the most serious safety risk in the construction site.
- Sufficient guard-rails and toe boards or other forms of edge protection are not provided to prevent a worker or materials falling from heights.
- The dust emission, hazardous fumes, and exhaust gas in tunnels for access roads are evident and the ventilation system in the tunnels is not sufficient and adequate. This situation presents a big health risks in the construction site.
- The lighting is not sufficient in tunnels for access roads.
- The noise level is high in the closed crusher facility.
- Safety and rescue equipment are not provided.
- First aid kits are not present in appropriate locations.
- Adequate Personal Protective Equipment (PPE) has not been provided to the workers.
- Unauthorized entry is evident in the construction site. Kids of the workers have been detected during the site visit.
- The sanitary condition of the workers' camps is extremely poor.
- The toilet facility is insufficient and inadequate in the worker camps.
- The shower facility is insufficient and inadequate in the worker camps.
- The ventilation system inside the bedrooms or communal areas of the workers is insufficient and inadequate.

18.3.6 Medical Centres

The high number of labour, the size of the construction site and the high risk level of the industry require a well-organized medical care. In this respect during the site visit in Rogun HPP constriction site a particular importance was given to the medical centers. The key findings of the investigation on medical centers is summarized below:

- The site has totally 7 medical centers including one medical headquarter center. The medical centers are located in different parts of the construction site.
- The records regarding the patients are kept in this center, including the other 6 medical centers records, since February 2010.
- The records regarding work related injuries and mortalities are kept separately.
- According to the records approximately 10 work related accidents are occurring on a monthly basis.

- According to the records since February 2010, 3 work related mortalities occurred.
- It was stated that a premedical test has been conducted to the workers. If a communicable disease is detected, the worker is monitored during the work period. The records about the patients are confidential.
- It was indicated that no epidemic phenomenon has occurred in the construction site.
- It was stated that no mass food poisoning event has occurred in the construction site.
- A monthly health report is prepared by each of the medical centers and sent to the medical headquarter center.
- A monthly report is also prepared by the main medical center and sent to Rogun Hospital and Dushanbe Hospital.
- Specialists are being called to the centers from Rogun or Dushanbe Hospitals whenever needed.
- The main medical center made an agreement with the Rogun and Dushanbe Hospital in order to send the patients to these hospitals in case the patients cannot be treated on site.
- Medical headquarter center has an ambulance and a first aid station.
- The medical centers personnel salary and the medicine expenses are paid by Rogun Construction Company.
- The centers have been managed in accordance with the national health policy.
- On average 100 patients visit the main center on a daily basis.
- The medical headquarter center has 2 doctors and 1 nurse on duty on a daily basis.
- The monthly average number of patient admission for the other centers is respectively 600, 600, 200, 315, 400, and 115.
- The other centers have 1 doctor and 1 nurse each.
- Two of the medical centers give first aid service at the tunnel entrance of the main access road in the construction site.
- According to the statement of the medical headquarter doctor, a health examination is applied to the cooks, the centers’ doctors and the nurses in 4 months intervals by Sanitary Institution of State located in Dushanbe.

18.3.6.1 Asbestos

Breathing in asbestos dust can kill by causing irreversible lung damage and cancer. There is no known cure for asbestos-related diseases. The more asbestos dust breathed in, the greater the risk to health. There are control limits for the various types of asbestos.

In many countries those who work with asbestos to any extent, and in particular in removing and disposing of asbestos, require to be licensed or to hold a permit. In working with asbestos insulation board, workers will probably need to wear suitable protective clothing. Only working methods that keep asbestos dust levels as low as possible should be used (e.g. use hand tools and avoid breaking boards).

Figure 18-1: Breaker hall with largely damaged asbestos boards

Remaining asbestos containing material (see picture above) will have to be removed and stored accordingly.

18.4 Conclusions

It should be noted that Rogun HPP construction has not been fully commissioned yet. Even so, a large number of workers are present on the construction site. The main contractor is Rogun Construction Company. Furthermore, 22 small construction companies are also present in Rogun HPP construction site. Prevailing conditions of the construction site are not promising with regard to health and safety management. There are many types of hazards threatening the workers' life and health. However, it was noticed that the management of medical centers is being carried out very well except where medical waste handling is concerned.

In this respect, the Health and Safety Management Plan (HSMP) that will have to be prepared by the main contractor shall be carefully followed by Rogun Construction Company and the other construction companies. An outline of and elements for such a plan are provided in Chapter 5.2 of Vol. III (ESMP). Sub-plans shall be prepared by the Rogun Construction Company in cooperation with the others. The procedures and the introductions to prevent work related accidents, injuries and mortalities including related training programs shall be formulated in compliance with primarily national and international standards. The language of the sub-plans and the related documents shall be simplified for the workers.

Health and Safety management including the site implementation team shall be formed in participation with all the construction companies. Moreover a Health and Safety committee shall be formed and committee meetings shall be performed on a monthly basis.

The budget shall include expenses of health and safety measurers’ implementation such as proper PPE, safety and rescue equipment procurement. Moreover, budget is needed to improve the conditions of the worker camps. Furthermore a full equipped ambulance is needed for patient transfers from site to Medical Headquarter Center and also from there to the hospitals. A comprehensive Medical Waste Management Plan shall be prepared and implemented.

It is essential for someone to care for the children while their mothers are at work, prepare their meals and feed them regularly. It may be possible for mothers themselves to take turns to look after the children. Mothers, especially nursing mothers, should be able to visit their children during recognized breaks from work.

A clean and well-ventilated room, preferably with access to an enclosed space, is the main facility needed. A few items of simple furniture are necessary for the children to sit or lie down, and some toys help. There should be provision for feeding the children with nutritious meals at regular times and, for this, there should also be access to cooking facilities or a canteen.

In order to carry out all work on site in an optimal way, and especially for reducing the risk of accidents, specific training will be required; detailed plans will have to be developed for this purpose by the project owner and/or by the contractors. Some areas for which training will be required are e.g.:

- Awareness, accident prevention: all workers must be instructed in the use of the PPE and in safety measures to be taken for accident prevention. This training must be specific for the work a person carries out.
- First aid: all workers must get a basic training in first aid, and in each work group there must be a number of persons with some more advanced training in this respect. This measure has to go along with instructions on procedures to be taken in the case of accidents, and first aid material must be made available throughout the site.
- Specialists will need training specifically for their jobs; this applies e.g. to welders, workers in crushing plants, drivers and other categories.

These requirements for training are mentioned throughout the different Sections of the ESMP (Vol. III).

On a different level, training may also be required for skills development; this is of special importance for improving the potential of inhabitants of the project area for getting jobs on the construction site (see Section 13.10.3).

19 RESETTLEMENT PLANNING

19.1 Key Messages

Resettlement caused by the project was identified as one of the two main project impacts. Main points are:

- The project will require the resettlement of 77 villages from the project area, with a total population of about 42'000 people.
- Mitigation here consists in carrying out the resettlement according to international standards (OP 4.12), which means fair and adequate compensation of all losses caused by the project, following a procedure which includes the affected population in the process, and which allows them to get their share of the project benefits.
- An organisation is in place for carrying out this resettlement, which has the capacity and the capability to do this.
- Resettlement is under way for Stage 1, which comprises the villages located within the construction site (7 villages with about 2000 inhabitants).
- Resettlement of villages in the area of the future reservoir is presently on hold; it will be carried out in stages during the construction of the dam, which will last for about 15-16 years.
- There is a ban on construction of new houses and on major repair on existing ones in the reservoir area. However, given the long time required for project development and implementation, it is not acceptable to impose such a restriction on the affected population. Here, a suitable solution will have to be found.
- The chapter defines the principles and procedures to be applied for this resettlement process. A Resettlement Policy Framework was developed, with takes into account national resettlement policies as well as OP 4.12, and this forms the basis for resettlement implementation for Rogun HPP.

19.2 Introduction

19.2.1 Scope

The TEAS recommended alternative of Rogun HPP, FSL 1290, will require the resettlement of a total of 77 villages, with a total population of about 42'000 persons, from three districts. This process has already started, and it will continue in parallel with the construction of the dam and the filling of the reservoir, i.e. it will be distributed over a period of about 16 years. Since 2009, a Resettlement Unit (RU) is in place, which is in charge of the resettlement.

Resettlement for Rogun HPP is being done in two stages according to project development, as follows:

- Stage 1: this covers the area which is affected by the first phase of reservoir filling, when the reservoir will reach a level or 1110 m asl. It comprises one village which lies at or below this level, as well as 6 villages which are located within the area affected by dam construction activities. This Stage 1 is the objective of a RAP, which is a stand-alone document. While reference is being made to this RAP, the details are not repeated here. The physical relocation of Stage 1 will have to be finalised within 3 years after the start of river diversion, since at that point in time the reservoir will be filled to the level of 1110 m asl, and this level will then be maintained for about 4 years.

- Stage 2: this covers the period between year 3 and the completion of dam construction and reservoir filling up to the final FSL of 1290 m asl (13 years). During this time, the reservoir will be gradually filled in line with the increase in dam height (see Figure 1 in Annex).

19.2.2 Specific Conditions of Rogun Resettlement

The conditions for resettlement for Rogun HPP are rather unusual due to the history of the Project. Resettlement started in the 1980ies, when construction work for Rogun started. In 1991, after independence, all work, including resettlement, came to a halt. The civil war then caused considerable and largely uncontrolled movements of populations, and during this period some people who had been resettled returned to their original places. Resettlement started again in 2009 with the efforts for finally implementing Rogun HPP. Our efforts have revealed that it is almost impossible to receive reliable data on these past processes, and data received are often contradictory.

In the beginning of 2011, a new organisation was put in place. The official name of this organisation, translated from Tajik, is “Directorate of the Flooding Area of Rogun HPP”; in this ESIA report, and in the RAP, it will usually be referred to as the Resettlement Unit (RU).

In 2011, in accordance with agreement with the World Bank, Stage 2 resettlement was put on hold for the period until RAP Stage 1, RPF and Resettlement Audit are prepared, disclosed and published.

19.2.3 Summary of Stage 1 Resettlement

Given the fact that people live in the so-called risk zone (i.e. within the construction area or in the zone which will be submerged and an early stage of project development), and because many of the inhabitants of these villages at that time were in the process of building their houses in the new locations, the agreements between the World Bank and the Government of Tajikistan was that Stage 1 resettlement could continue in accordance with the applicable legal and institutional framework as well as with international good practices.

Stage 1 consists of the following 7 villages: Chorsada (below elevation 1110 m asl), Kishrog and Mirog (these two often being counted as one), Talkhakchashma, Tagi Kamar, Tagi Agba, and Sech. As of April 2014, out of 527 families living in these villages, 80 had moved to the new sites, while 247 are in the process of building their houses. All the 527 families already have their house plot allocated.

19.3 Summary of Stage 2 Resettlement

A great number of villages and their assets in the three districts of Rogun, Nurobod and Rasht lie at or below 1290 m asl which will be the FSL of the reservoir once it is completed. In these three districts 70 villages will have to be relocated; these are listed, with number of HHs and persons, by district in Table 13-4 to Table 13-6, and in Vol. II, Annex 13, Table 18, by village elevation. These villages will need to be relocated to new sites and lost land and destroyed crops and trees will have to be compensated. This is also the case for direct impacts of lost buildings and properties, as well as communal social and economic infrastructure.

The impacts described in Chapter 13 clearly show the need for relocating these villages. Villagers have since the Soviet times been prepared to relocate and are now fatigued. The FGDs held in June 2011 in affected villages showed that people know that they will have to relocate and are already in a difficult situation, as they are not supposed to repair or maintain their old houses given the fact that the government put a ban on maintenance and repair of the houses in these villages.

Villages which will not necessarily have to be physically relocated might still suffer economic displacement (i.e. loss of sources of livelihood) and disruption of social networks (see Section 13.9.3).

In spite of the situation with the project in development, the human population of the area is not a static entity. Population movements take place, and even under the prevailing conditions some activities involving construction or amendment of houses go on and are inevitable. This emphasises the necessity of a timely, ongoing and adaptive planning of the resettlement.

19.4 Lessons Learned From Resettlement Already Done

Resettlement already done dates back to the Soviet era and data on this has proved difficult to obtain. However, the earlier resettlement done at this time shows that quite a number of settlers returned to their original villages during the civil war due to various factors like insufficient services and unfavourable climate conditions, among others.

19.4.1 Land Issue

In the project area, most households have multiple families within one house plot. Under Stage1 resettlement, each family has received their own house plots; however, these may be slightly smaller or larger than the original house plots. All resettled people are entitled to receive land for agriculture if they want. In that case, in line with national legislation, they have to apply for this land. So far, all families who have made this application were given land according to their request. As an example, in Dangara six HHs have got together and applied for land to farm together; this was granted and they now run a 30 hectare farm and pay TJS 30 per hectare as tax. Obtaining the extensive land applied for is dependent on whether those applying for it have proved that they can work the land (seen through increased agriculture productions). Normally, the Jamoat and Ministry of Labour and Social Security representative at district level deal with the land applications.

When it comes to pasture, the resettlement sites identified (and under development) so far can be separated into two groups, namely:

- those close to the project site, like Novi Saidon and Yoligarmova, being developed for Stage 1 resettlement, and Darband, which will be the new district center of Nurobod district (where resettlement efforts are presently on halt, since this is a Stage 2 resettlement site); and

- those located in lowland areas, like e.g. Dangara and Tursunzade (where presently HH from Stage 1 are being relocated to, but which will also accommodate a considerable number of Stage 2 HH once this process will be resumed.

In the first category, located in the mountains of the larger project area, there is ample pasture land available, since the conditions are basically the same as those in the present villages; however, as today, not much land suitable for agriculture is available there. On the other hand, the lowland villages are located in agricultural areas, with irrigation schemes in place; these sites are suitable for agriculture, but pasture land is scarce in these areas. People are aware of this situation before they decide where to go.

It is important to note that the host villages are not giving up land which they used so far, but that additional land will be made available for the resettlers.

19.4.2 Livelihood Restoration

An important aspect of resettlement is to restore or improve livelihoods of the resettled. The resettled should be able to re-establish household incomes and livelihoods following the loss of land and impacts to agricultural production. To mitigate these impacts and assure PAPs, the project will develop and implement livelihood restoration based on what the affected persons choose. These activities can be developed and implemented via the present actors Ministry of Labour and Social Security, the Jamoats and identified NGOs, etc.

According to the survey conducted in two villages in 2011, resettlers’ livelihoods had not improved much as such, only a few HHs showed signs of improved conditions. Since 2011, additional efforts have been undertake to address livelihood issues. However, there is still a need for designing additional livelihood restoration strategies for the affected persons.

RAP will identify other livelihood strategies that will be based on what PAPs choices are. To date indications point towards training in agriculture to improve technique and crop production; women also want to improve livestock breeding and also start their own tailoring/sewing businesses, while men indicate their preference for starting businesses and some want to continue their work at Rogun HPP.

Some livelihood activities are ongoing at the new sites, e.g. in Dangara a chicken farm is successful where resettlers get chickens from the farm, breed them and can sell eggs and excess meat, but also use the same as food for their family. The activity ensures both food security and earning an income. In Nurobod, cotton cultivation has absorbed a number of resettlers who have obtained land, in Dangara a free-economic zone is also to be created that will engage resettlers to improve their livelihood. The RU is presently preparing activities which will cover their livelihood restoration programme, e.g. involving donors in funding investments (micro-credits).

19.4.3 Inclusion of Host Communities

Host communities are the communities that already live in the vicinity of the newly established villages for the resettlers. These host communities have so far been consulted and monthly meetings at the Jamoats are held to hear their views. Host communities’ participation in the identification of the likely impacts on their communities and offering mitigation measures for these is vital. Host communities should also have a share in the resettlement benefits, and these have so far included improved social infrastructure, e.g. schools, health centres, markets, mosques, etc. In addition, it is pertinent that the livelihood activities that will be identified by PAPs should also include host communities, especially training to be received by the relocated villagers in agricultural land use improvement techniques and practices. Improved access roads, increased connection to electricity, improved water are all benefits that host communities have received. To date no pressure has been felt at the social facilities, as not all the PAPs have moved yet; RU is making efforts to ensure that such facilities and amenities are in place before en mass relocation is carried out.

The inclusion of host communities has also ensured that conflicts have so far not arisen. The monthly or semester meetings at the Jamoats have contributed to a continual communication and exchange of information between the host communities, the resettlers and the RU.

19.4.4 Assistance for Moving to New Sites

Transportation of settlers is done according to law, Resolution 47. Settlers themselves decide when they want to relocate once their houses are constructed. Interviews with some resettlers who had already moved revealed that a normal saloon car was at the family's disposal to help them transport to the new site. When field work for the RAP Stage 1 was carried out, in the period of April to November 2011, a number of cases were reported where apparently transport capacity had not been sufficient for transporting all movable HH assets.

This situation led to a number of recommendations by the Consultant, including that transportation means for resettlers has to be sufficient for carrying all their assests to the new site. Where the PAPs' effects that they wish to have transported get left behind, transportation compensation should be given. The amount of cash for transporting the left-over effects should be agreed between the two parties (PAPs and government organ responsible for transportation of settlers and their effects). The PAPs should not have to pay for extra transport as is the case now, all transport costs for moving should be borne by the project.

Since the beginning of 2012, this problem has been solved. RU makes sure that sufficient transport capacity is made available in any case for all movable assets to be relocated to the new site. This is important also given the fact that HH are allowed to take any material from the old house, which still can be used, to the new site, to be used there.

19.4.5 Impact on Vulnerable Groups

The National Resettlement Policy needs to include a clause on vulnerable groups and gender. In the present practice, special assistance is provided to vulnerable HH, e.g. for the construction of the new house, for moving or for any problems these HH may face at the new site. However, there is no proactive identification of vulnerable HHs, these have to apply for special assistance. A policy of actively identifying such HHs and offering them assistance is required.

Women headed households, the elderly and sick and households with insufficient labour to survive may require additional assistance and consideration with regard to logistics of the relocation. These HHs may also be disadvantaged more significantly due to disruption of their current living conditions and way of life.

From fieldwork there are indications that female-headed HHs have an income from sales of excess agricultural products, farm labour and handicrafts. Women may therefore be more dependent on income from agriculture and any disruption of this income due to land loss or the time required to re-establish family gardens could lead to an impact on the overall standard of living of female-headed households.

Programmes specifically targeted at women and female-headed households to help re-establish disrupted incomes from agriculture will be developed. These could include farming methods to increase the productivity of available land, as well as skills training, livestock husbandry and training schemes to promote alternate income sources, plus access to micro-credit. Literacy and numeracy are also likely to be sought after as most resettlers were found not to have completed their education.

To date courses are offered in sewing and embroidery at the Jamoat, and these are free of charge. Other courses will be identified to augment choice available for women. For men additional courses are called for to complement construction building and computer literacy. NGOs already operating at the new sites districts can be used to assist resettlers and host communities in training in the new livelihood activities, should their expertise be required.

The RU has factored in vulnerable group where of the 100% resettlers, 21% are vulnerable people who include widow, maimed, lame and female-headed HHs. However, as according to law, the pensioners are also considered as vulnerable and the amount they receive in pension depends on the group they belong to (sick, lame, maimed, etc.). No special attention is, however, given to their obtaining extra land, as application for additional land is considered the same for both men and women (equal terms) and gender is normally dealt with by the Jamoats. RU needs to have staff dealing specifically with gender and sitting in the Social and Environment Department. The gender person would then liaise with the Jamoats to ensure that gender is taken seriously.

19.4.6 Ban on Home Construction and Repair

When a RAP is prepared, a cutoff date is declared, which is usually defined as the point in time when the official project announcement was made and/or the HH survey of affected HH is carried out. The aim is to prevent affected populations from engaging in activities whose only aim would be to increase compensation (e.g. by doing some improvements to houses or other immovable structures, planting fruit trees etc.).

In the case of Rogun, a ban on the construction of new houses and on major repair or improvement of existing ones was declared when construction of Rogun HPP - and resettlement for it - started back in the 1980. This ban is still in force, and it seems to be largely respected by the inhabitants.

However, with the difficult history of the project, as was mentioned repeatedly in this report, this led to a situation where people have lived with this ban for over 30 years. One consequence is that very often, married couples with their children continued to live in the parents' house, instead of building their own houses, and that as a rule the condition of housing has deteriorated considerably over this time span.

RU takes the following measures for reacting to this situation:

- When the "house passport" is prepared, it is noted whether in the HH in question there are more than one family, and whether these have the intention to create their own HH.
- If yes, the families intending to create their own HH in the new site are given a house plot (at no cost) in the new resettlement site; however, there is no provision for building a new house (a HH living in one house is entitled to compensation for one house).

The ban on construction is problematic since it has been in vigour for such a long period. A cutoff date needs to be declared in a moment in time when relocation will be done soon (i.e. for a time span of 2-3 years at most). If for any reason implementation of the resettlement will take longer, it will need to be modified. It is not acceptable to keep people from building new houses or improving existing ones for a time span of 5, 10 or even more years. Here, an adequate solution will have to be found and communicated to the PAPs, especially to those whose relocation will happen only towards the end of the construction time. Compensation will also have to be made for any improvements etc. done during this period.

19.5 Summary of Resettlement Instruments

Resettlement in the future will be guided by two operational documents, the Resettlement Policy Framework and the Resettlement Action Plan Stage 1. These instruments have been developed taking into consideration findings and recommendations of the Resettlement Audit.

19.5.1 Resettlement Policy Framework

The Resettlement Policy Framework is to be understood as the guidance for preparing subsequent site specific resettlement Action Plans. It is provided as a separate document. The framework is based on the World Bank’s Operational Policy 4.12 (OP 4.12) on Involuntary Resettlement, the National Resettlement Policy, the Land Code, Civil Code and the Constitution of Tajikistan.

The purpose of the policy framework is to clarify resettlement principles, organizational arrangements. The resettlement policy framework covers the following elements, consistent with the provisions described in OP 4.12:

a) a brief description of the project and components for which land acquisition and resettlement are required
b) principles and objectives governing resettlement preparation and implementation;
c) a description of the process for preparing and approving resettlement plans;
d) estimated population displacement and likely categories of displaced persons, to the extent feasible;
e) eligibility criteria for defining various categories of displaced persons;
f) a legal framework reviewing the fit between borrower laws and regulations and Bank policy requirements and measures proposed to bridge any gaps between them;
g) methods of valuing affected assets;

h) organizational procedures for delivery of entitlements

i) 1(i) a description of the implementation process, linking resettlement implementation to civil works;

j) a description of grievance redress mechanisms;

k) a description of the arrangements for funding resettlement, including the preparation and review of cost estimates, the flow of funds, and contingency arrangements;

l) a description of mechanisms for consultations with, and participation of, displaced persons in planning, implementation, and monitoring; and

m) arrangements for monitoring by the implementing agency and, if

n) required, by independent monitor.

19.5.2 Resettlement Action Plan for Stage 1

Stage 1 covers the villages which are located within the so-called risk zone, i.e. within the construction site for Rogun dam and power house, and which therefore have to be resettled urgently (6 villages) as well as one (Chorsada) which is located below an elevation of 1110 m asl, and which therefore will be submerged as soon as the reservoir starts filling for reaching the so-called Stage 1 reservoir; this is scheduled to happen three years after start of dam construction, i.e. after the moment of river diversion.

While in an agreement between WB and GOT all resettlement work for Stage 2 was halted until the RAP and RPF will be disclosed, it was nevertheless agreed that Stage 1 resettlement could go on, namely for three reasons:

- Difficult situation and considerable risks for settlements located within the construction site.
- Limited time left available for relocation once the construction work will start.
- A considerable number of HHs are in the process of building their new houses at the relocation sites, and to move to these new sites. They would find themselves in a very difficult situation if this process were to be interrupted for a not well defined period of time.

The Stage 1 RAP is presented in a separate document.

Once the RAP is completed, it will cover all PAPs of the 7 villages, whether they have been relocated already or not. It is informed by the Audit.

19.6 Summary of Resettlement Policy Framework for Stage 2

19.6.1 Main Conditions

The RAP for Stage 2 will follow the same procedure and principles as for Stage 1. It will have to be flexible so that it can be adjusted to any new conditions which might arise during the implementation period of the Project. The time span for project implementation also has to be taken into consideration; this will be rather long in any case, lasting for a period of approximately 16 years.

This last point is very important. The main aim of timing the resettlement will have to be in any case that compensation, of whatever type, will in any case have been made before any assets (mainly land and houses) are taken over by the project, i.e. before impoundment. Since this will be made in stages, increasing in more or less regular steps over the duration of the construction, resettlement will have to be in line with the development of the technical project. E.g., it will not necessarily be required to relocate somebody if, from the project development schedule, it is clear that his house and land will still be available for a period of 10 years. On the other hand, timing of relocation of individual HHs will have to depend also on other considerations rather than only water level in the reservoir, and not in the least on the preferences of the persons in question. It will probably not make much sense (and not be acceptable from a social point of view, e.g., to relocate isolated houses which happen to be located at a 100 m higher elevation, several years after the main part of the village they belong to will have been relocated. It also has to be clear that the affected population is by no means a static entity, but that it is rather dynamic, with changes and development taking place all the time, like e.g. the formation of new HHs when children of PAPs get married and start their own HH:

Another point is the sheer size of the task. Approximately 42'000 persons from over 6'000 HH will have to be relocated. It is obvious, that this cannot be managed in a very short while.

This means that a constant and thorough follow-up and planning will be required, and that no comprehensive, detailed and final plan can be developed at the present stage.

19.6.2 Detailed Planning

The detailed plans for the second phase will include, among others:

- Detailed HH survey and FGD as carried out in Stage 1 in order to ascertain the loss of assets and land, crops and trees.
- Working out the compensation packages for all affected HHs.
- Defining the different categories of PAPs and their entitlement.
- Carrying out Public Consultations.
- Defining livelihood strategies and planning for these.
- Identifying new resettlement sites if not yet chosen.
- Plan for implementation.
- Budget for the whole exercise.

In summary,

- A complete survey of all affected HH has to be carried out. This means elaborating on the questionnaires to be used and interviewing every individual household; in order to maintain a comparable standard for all PAPs, it is recommended to apply the same procedures (including questionnaires) as were used for Stage 1; obviously, as pointed out above, constant checks will have to be made and adaptations as may be required, in order to keep in line with any new development which might arise.

- Also a detailed survey of the farm land has to be carried out, i.e. counting each individual HH’s valuable trees, physically measuring their land used for agriculture and valuing this.
- Creating a comprehensive databank indicating name and gender of affected persons and what and how much they will lose. The databank should be made with the possibility of adding new information when collected. Wherever possible data that covers ownership, income and other aspects should be disaggregated.
- Eventually a cut-off date should be set by the GOT (RU) so no new immigrants move into the project area, because once the survey is completed no new registries will be taken. It is crucial that people are informed as early as possible if they have land that will be affected in the project area. The cut-off date is a sensitive and difficult problem. While it is clear that efforts directed only at aiming to increase the amount of compensation to be received should not be encouraged, and where possible should be excluded from compensation, it is also clear that it is not possible, and not acceptable from a socio-economic point of view, to prohibit any development activity in an entire region for a period of several (and up to 15 or more) years. For this reason, it is also recommended to develop the RAP in stages according to project development, and to define the cut-off dates accordingly.
- The drafting of the livelihood strategies and income restoration is crucial. The RU staff together with the Jamoat technical staff and seconded staff from various ministries should assist in drafting of the plans.
- An NGO will be appointed as Witness NGO, in order to have a continuous follow-up on the process.

As mentioned above, the RU in place seems to be well capable of handling the present and future resettlement for Rogun HPP. This does not exclude the possible need of an adaptation of this entity in the future, to enable it to handle this task also under changing conditions in the future.

Resettlement is always a process, and this is especially true for a project of the size and duration of Rogun HPP. For this reason, resettlement will have to be planned and implemented as an ongoing development activity. Trying to prepare a detailed and final RAP for Stage 2 at this point in time would not answer to the requirements.

19.7 Specific Compensation Issues

In this Section, two specific compensation issues encountered during the preparation of the RAP Stage 1 and the field work for the Stage 2 RAP outline are presented and discussed shortly.

19.7.1 Relocation of Graveyards

Most villages have their own cemeteries. If the village is being relocated, these graveyards need to be relocated as well. Relocation of graveyards (planning and supervision) is one task among others of the Environmental and Social Department of the RU.

There is a regulation stemming from the Soviet Union which was formerly followed in such cases. This regulation is still applied, mainly for determining the costs of the procedure. Basically, the procedure as it is applied today is as follows:

- If the graveyard of a village needs to be relocated, a meeting with inhabitants of the village is held, where the decision is taken on how to proceed and to where to relocate it.
- The decisions of this meeting are noted in a protocol, which is signed by all participants.
- This protocol then goes as a request for relocating the graveyard to the Islamic Centre of the Republic of Tajikistan for approval.
- Once the permit from the Centre has been received, a private company then is contracted for carrying out the work; this company will also see to it that the required ceremonies in the old and new sites are carried out, usually with participation of the mullah of the village.

One cost estimate showed relocation costs for graveyards as TJS 1’000’000 for 1’000 graves; this would correspond to costs of about TJS 1’000 (approximately USD 210.00) per grave.

19.7.2 Sacred Sites

In a meeting held on 2011-08-15 with RU, sacred sites were mentioned; these seem to be sites used traditionally, without any special infrastructure, and without having a formal status, usually a place where somebody died or where something else of importance happened. See also Section 13.5.8 for further information on this subject.

It will have to be checked with all the villages to be relocated whether they have any such site, what their importance is, and whether and, if yes, what type of compensation might be required.

19.7.3 Villages Not to Be Relocated

Villages which are located above the FSL of the future reservoir will only be relocated if they would otherwise find themselves in a very difficult situation; the main parameters here are lack of land (village as such not affected, but most of its agricultural land to be submerged) or access (village would be very isolated, with very difficult access).

If a village is not relocated, this does not mean that the situation will remain exactly the same as it is now. In fact, there are two main measures for which there is already a plan, namely:

- Access: since the existing main road as well as a number of local roads and some (mostly very small) bridges providing access to a number of villages will be submerged, new access is required. This is planned in the form of the new access roads (see Figure 3-5). Especially for villages on the left bank of the reservoir, this will greatly improve the access. Presently, for these roads (with the exception of the replacement for the main road) there is no detailed project as yet (see Report entitled "Infrastructure Replacement and Resettlement Costs for Dam Alternatives").

- Electricity supply: local substations and distribution nets will be lost due to impoundment, and this would also affect electricity supply to villages not to be relocated. A detailed project with determination of costs already exists for the entire local transmission and distribution net to be dismantled and built.

In addition to these two items, for which there is already a plan and/or a firm commitment, there is the intention to improve the situation in these villages during the construction time of Rogun HPP, according to needs of the population, e.g. by improving or building schools, health infrastructure, water supply systems etc. However, for this there are no specific detailed plans or projects as yet.

These aspects will have to be evaluated and planned in detail during phase 2 of the resettlement. This will be done in stages in parallel with the development of the project.

19.8 Institutional Aspects and Procedures

19.8.1 The Resettlement Unit

Resettlement was resumed in 2009, and in 2011, the Resettlement Unit in its present organisational structure was put in place (see Stage 1 RAP for additional details). This unit is not part of Rogun OSC, and it is also not a department of any Ministry; it is directly under the President of Tajikistan, reporting directly to the government of the Republic.

19.8.2 Consultation Process

Consultation with the affected population is an important aspect of resettlement. It aims primarily at to objectives:

1. to provide information to the affected population on the project, its consequences for them, the options they have, and the way the resettlement program will be developed and implemented; and
2. to get a feedback from the affected persons on their concerns and suggestions, and also to let them know how this input will b eintegrated into the process.

Consultation needs to start early (in a typical project in the feasibility phase, i.e. long before any work is being done on the ground), and has to continue throughout the entire process. It includes activities on different levels, like consultative meetings in the communities, continuous contact with village authorities and organisations, group discussions (focus groups for addressing the needs of specific parts of the affected societies), and individual interviews and discussion. See Sections 23.3 and following for more details).

19.8.3 Entitlement

An entitlement matrix of a general type was prepared as part of the RPF, and it was also applied in the Stage 1 RAP. This matrix will also serve as a basis for identifying entitlement in the future Stage 2 resettlement.

19.8.4 Grievance Process

Compensation for lost assets etc. need to be negotiated and agreed upon with the PAPs, on the basis of an inventory of the losses incurred. In any case, if somebody is not in agreement with the defined compensation, or if there is any other complaint, people need to have the possibility to deposit a complaint and to have it dealt with. This grievance process must be well defined, and, very importantly, people must be well informed on their rights and on the possibilities they have in this respect. Any grievance mechanism comprises several (usually three) tiers, the first one being a complaint on the local level (village authority, of village resettlement committee), the last one being the court, whose decision will be final.

The process is described in the RPF and in the Stage 1 RAP. In the case of Rogun HPP, this mechanism is already established, and PAPs are informed in detail on the possibilities they have, and the places where they can, deposit any complaints.

19.8.5 Witness NGO

A Witness NGO will be hired for accompanying the implementation of the resettlement. The objective is to have an independent observer witness the relocation, compensation and resettlement process throughout the duration of the project. This is in order to verify the compliance of RAP implementation with Rogun HPP commitments. The RAP contains draft TOR for this organisation, outlining its duties.

20 CLIMATE CHANGE AND ITS EFFECT ON ROGUN HPP

20.1 Key Messages

Climate change is likely to influence water availability in the future, and can or will therefore have impacts on the uses of water resources, hydropower among others. For Central Asia and therefore the situation of Rogun HPP the following main effects can be expected:

- Mean air temperature will rise by about 1.7°C till 2050, and this will increase evapotranspiration.
- Mean annual precipitation will remain unchanged, but variability from year to year is likely to increase.
- Runoff of many rivers will increase due to the melting of glaciers until about 2080, and will then decrease.
- Higher temperatures and the retreat of glaciers will lead to an upward shift of permafrost, which can mobilise large amount of glacier sediments, increasing the sediment load in rivers.
- Peak flows in rivers will tend to occur earlier in the year due to more precipitation falling as rain instead of as snow, and due to earlier snow melt.
- Variability of flows from year to year, and therefore cases of dryer and wetter than average years, is likely to increase.

20.2 Analysis of Climate Change Effects on Rogun HPP

The Consultant is not required to conduct own basic research on the Climate Change effects, but to analyse them in a comprehensive, qualitative manner and supplement own best estimates whenever reasonably possible. The main sources of information are available in a series of scientific and technical reports and publications.

The review of the actual literature on potential results of climate change effects on the local level has indicated that most of the relevant aspects have been (and still are) examined within the Pilot Programme for Climate Resilience (PPCR): Tajikistan. Out of the various PPCR activities,

- Project A2: Climate Science and Impact Modelling Partnership,
- Project A4: Improving the Climate Resilience of Tajikistan’s Hydropower Sector and
- Project A6: Analysis of River Basin Approach to Climate Resilience

as well as related expertise resulting in a broad overview of estimations of climatic effects having an impact on hydropower facilities including the Vakhsh cascade.

The main results and outcomes of the various studies carried out in the PPCR framework are summarized in the following sections

20.2.1 Observed climate trends

This section presents an overview of recent changes in temperature and precipitation with specific attention to the upper Syr Darya and Vakhsh (Amu Darya) river basins.

Average annual temperatures for the whole of Tajikistan have increased by ~1.2°C since the 1950s whereas average rainfall across the country has varied by 1-2% over the same period. However, the rate of warming was found to be most rapid in the north of the country (Figure 20-1: Trends in temperature and precipitation

, particularly during winter and autumn.

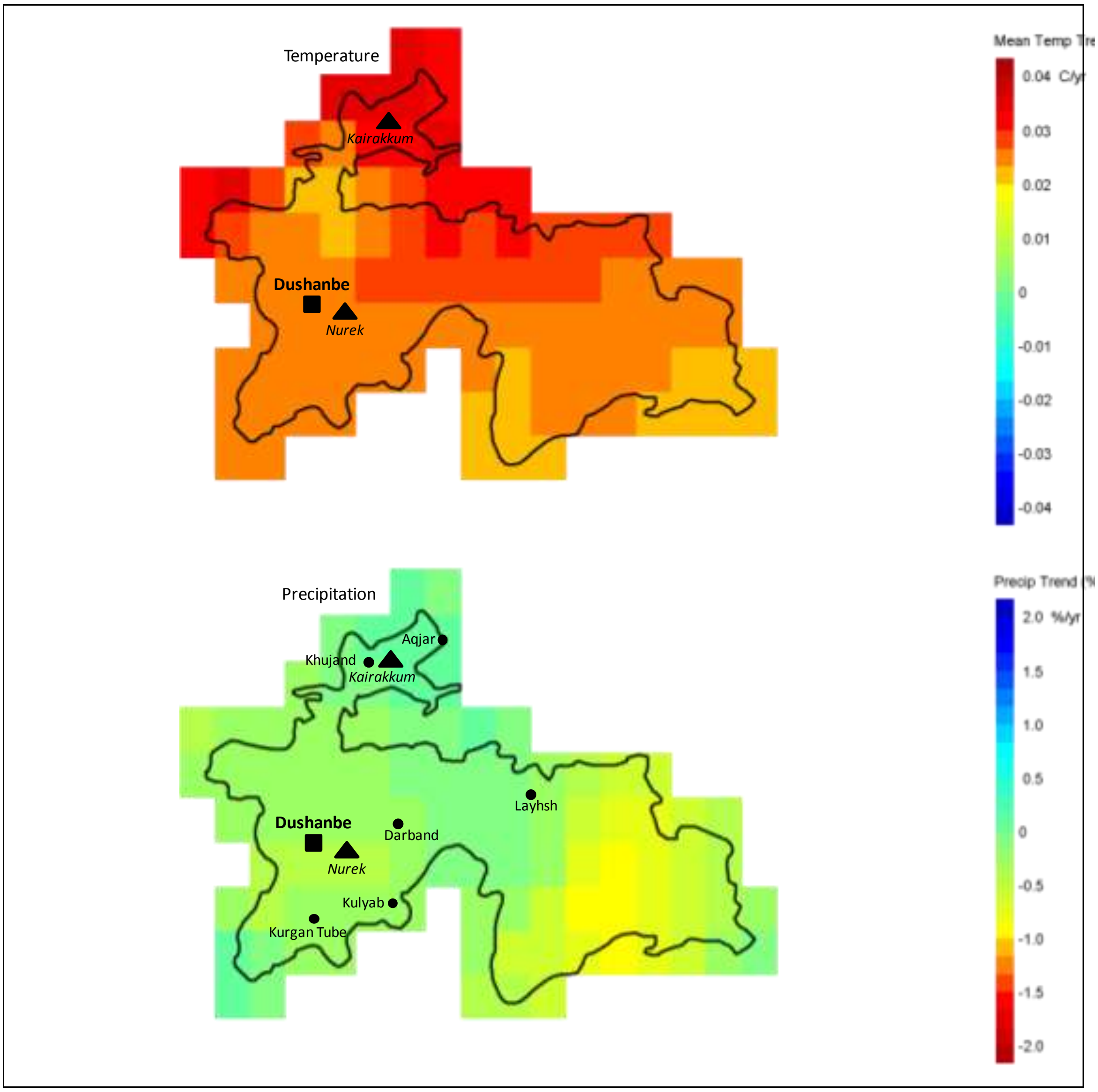


Figure 20-1: Trends in temperature and precipitation

Trends in annual mean temperature (top) and precipitation (bottom) across Tajikistan since the 1950s. Points of interest such as two major reservoirs and meteorological stations are also shown. [Wilby 2010].

Greater rates of warming have been observed in the headwaters of the Naryn (central and east Kyrgyzstan). Long-term temperature records around the Syr Darya basin (at Almaty, Bishkek, Fergana and Naryn) and closer to the Vakhsh (Khorog and Dushanbe) also show statistically significant (at the 90% confidence level, $p<0.10$) increases. Annual mean temperatures at Khujand, Kulyab, Kurgan-Tyube and Layhsh show no statistically significant change (see Figure 20-2).

Winter precipitation has not changed since the 1950s but there have been noteworthy reductions in precipitation totals during spring and autumn in the Pamir. Annual precipitation totals have increased in both basins since the 1960s but the trend is significant only for Layhsh. (It is noted that these annual increases are in contrast to the country-average decrease highlighted above.)

Conversely, the trend in annual discharge shows a statistically significant ($p<0.01$) increase at Aqjar but no change at Darband (see Figure 20-2). However, mean autumn discharge in the Vakhsh has declined significantly ($p<0.05$) since the 1950s.

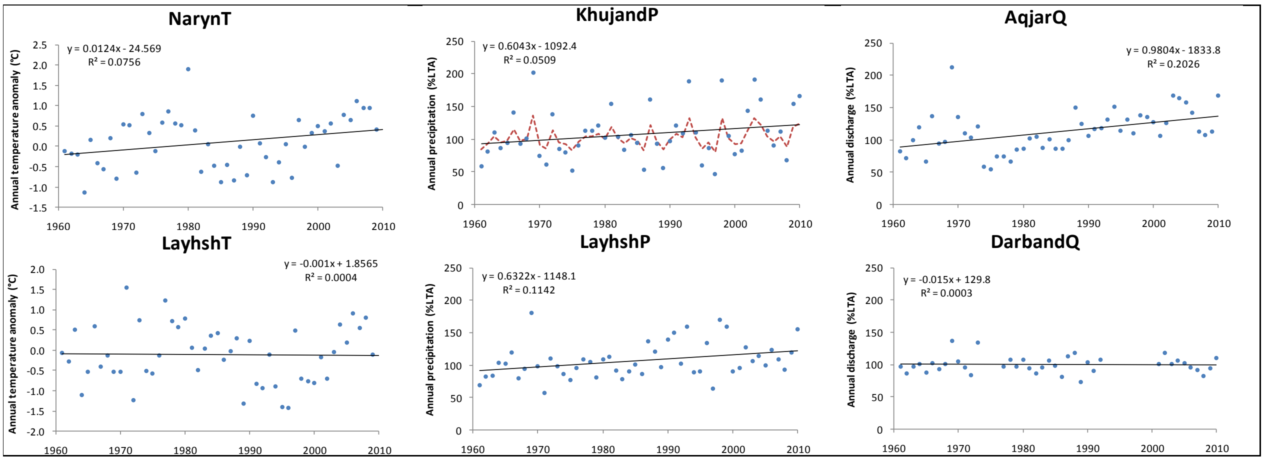


Figure 20-2: Trends in temperature, Precipitation and discharge

Observed trends in annual mean temperature [T], precipitation [P] and discharge [Q] for Kairakkum (top row) and Nurek (bottom row) relative to the 1961-1990 mean. The red dashed line for Khujand shows a hindcast of the Tropical Rainfall Measuring Mission (TRMM) area-average precipitation for the upper Syr Darya basin.

20.2.2 Climate Change Modelling

In PPCR Project the Vakhsh Valley and the Pamir Glacier Zone were selected as the two sub-regions for climate change impact assessment and climate hazard management.

Due to the inadequacy of the existing local data and the diversity of elevation in the project area, a statistical regression method with MOS (Model Output Statistics) corrections at every downscaling step was used in PPCR for downscaling the spatially-coarse Global Climate Model Projections (GCMPs) with respect to daily precipitation and air temperature to a 0.1 degree (about 11 km) spatial grid over the whole modelling domain. For MOS corrections, statistical relationships between monthly GCMP and observed data (precipitation and air temperature) during historical periods were developed and applied to both precipitation and air temperature data at every time step.

From the results of graphical and spatial comparisons, it may be concluded that the developed statistical downscaling method captures the characteristics of the spatial distribution of precipitation and air temperature over the target basins quite well, and the downscaled precipitation and air temperature values match the observations reasonably well.

The results of the statistical tests indicate that the simulated values by statistical downscaling are within acceptable accuracy. Hence, these results provide strong support for the application of the statistical downscaling method.

20.2.3 Climate Projections

The developed and validated statistical downscaling method was applied to the future period GCMPs. 9 future projection realizations from 3 GCMs (CCSM3, ECHAM5 and CSIRO) under 3 emission scenarios (A1B, A2 and B1) were downscaled for precipitation and air temperature.

GCMPs in the future period are expected to contain uncertainties due to various factors such as GCM model structure uncertainty, emission scenario uncertainty and uncertainty due to the internal variability of the nonlinear earth system. However, here these uncertainties are reduced and evaluated by taking several GCMs (to reduce GCM model structure uncertainty) and several scenarios (to reduce emission scenario uncertainty) in order to form an ensemble of projections, and then by averaging the ensemble of downscaled projections (to reduce internal variability uncertainty). Furthermore, the simulation results in the future are compared against the simulation results in the historical period.

A fundamental issue in the statistical downscaling method (as used for these projections) is the assumption that the statistical relationships of the historical period will stay the same during the future. Under a changing climate there is no guarantee that the statistical relationships between the local climate variables and the large scale climate variables will stay the same in the future. Only the dynamical downscaling method, since it is based on the hydrodynamic-thermodynamic simulation of a regional hydro-climate, would account rigorously for the changing climate conditions. However, results of the dynamic method to be used for the downscaling of the GCMPs are not yet available..

Figures 20-3 and 20-4 compare the historical and future annual basin average air temperature and precipitation with 95% confidence interval for Vakhsh and Pyanj River basins and Pamir Glacier Zone.

As shown in these figures, the magnitudes of annual precipitation (rain and snow) and of air temperature are different for each model and emission scenario.

It can be seen from Figure 20-3 that the annual mean air temperature in the future projections are clearly increasing at the three sub-regions. It should be emphasized that the annual mean temperature reaches 0° C around 2050 in the Pamir Glacier Zone. This implies that glacier melting is a significant issue in the region.

There is no significant difference in annual mean precipitation at Vakhsh and Pyanj River basins and Pamir Glacier Zone between the historical and future periods although some scenarios show high and low extreme annual precipitation in the future, as shown in Figure 20-4.

Although the downscaled climate projections do not indicate any trend in annual precipitation, they do indicate an upward trend in air temperature, which means that there will be less snowfall in the future. A separation between snow and rain was performed during the river runoff modelling based on the air temperature. Due to the increase in air temperature, the snowfall will decrease and rainfall will increase in the future. Such changes may result in the increase in flash floods and a significant change in the seasonal hydrologic cycle through a year in the future.

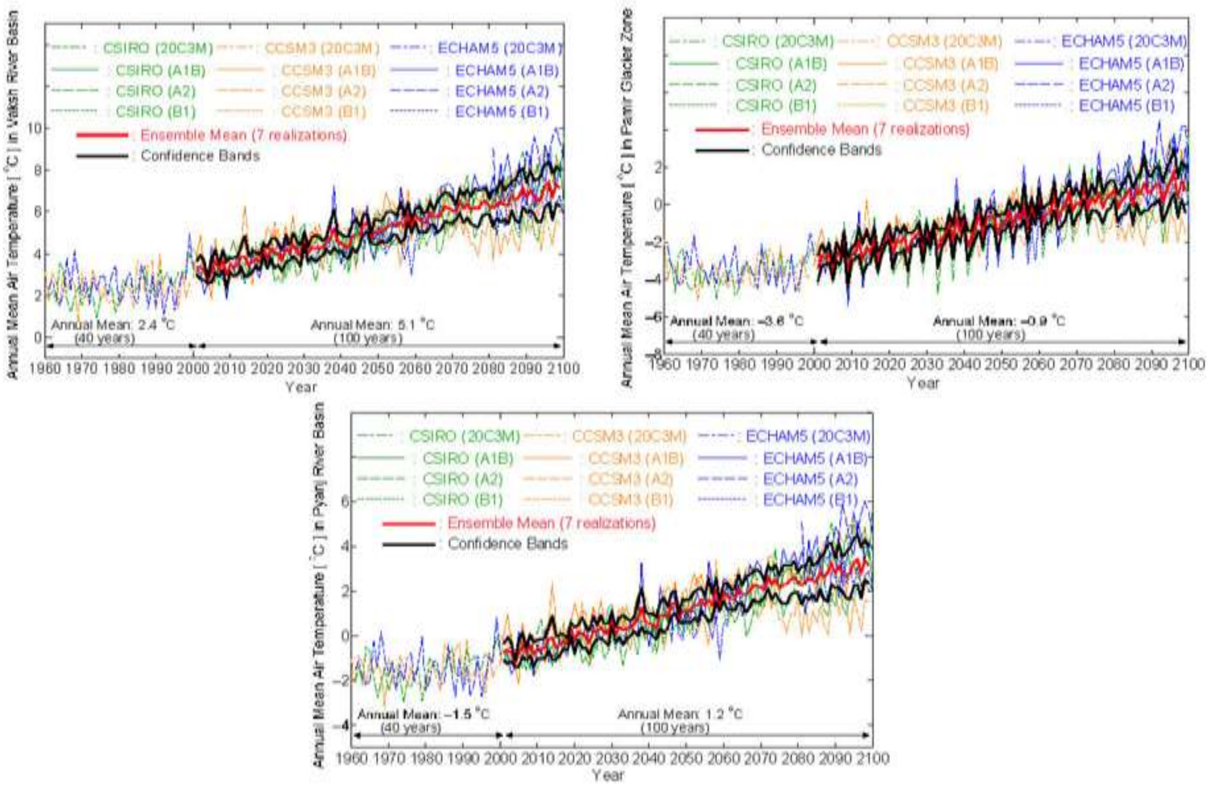


Figure 20-3: Historical and future annual air temperature

Historical and future annual basin-average air temperature in the Vakhsh and Pyanj river basins and the Pamir Glacier Zone

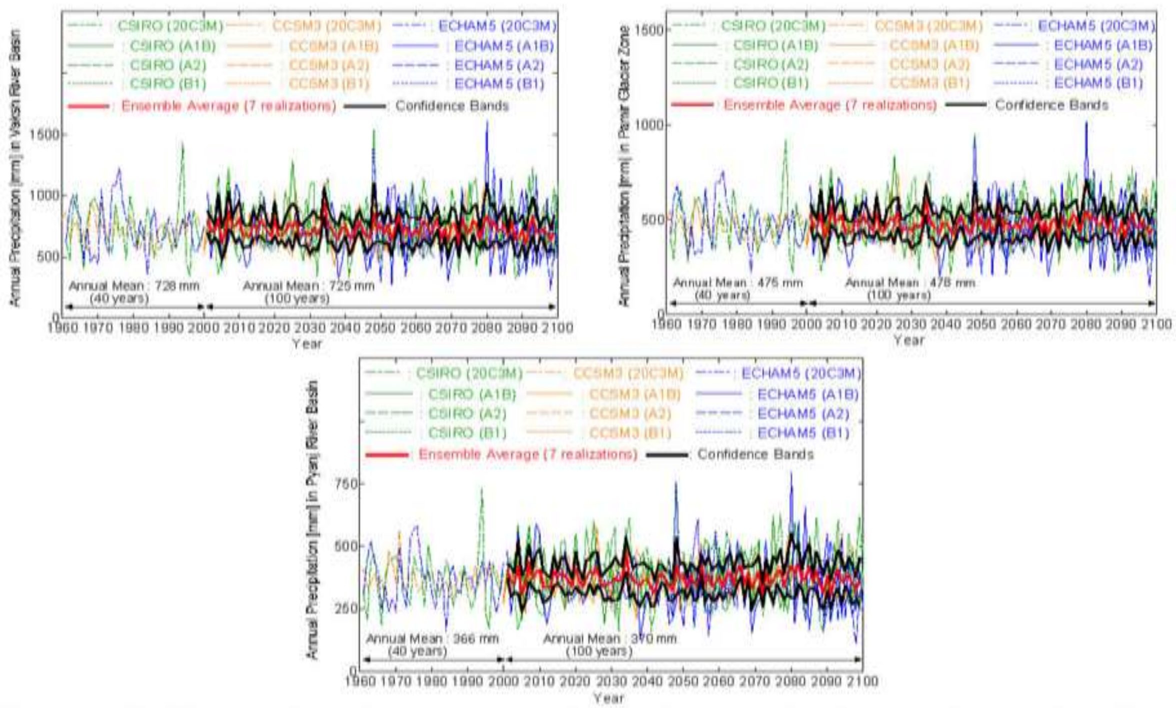


Figure 20-4: Historical and future annual precipitation

Historical and future annual basin-average precipitation in the Vakhsh and Pyanj river basins and the Pamir Glacier Zone

The following Figure shows the historical and future annual basin-average potential evapotranspiration with 95% confidence interval for Vakhsh and Pyanj River basins and Pamir Glacier Zone. It can be seen that the annual potential evapotranspiration is clearly increasing in the future due to the increase in the air temperature.

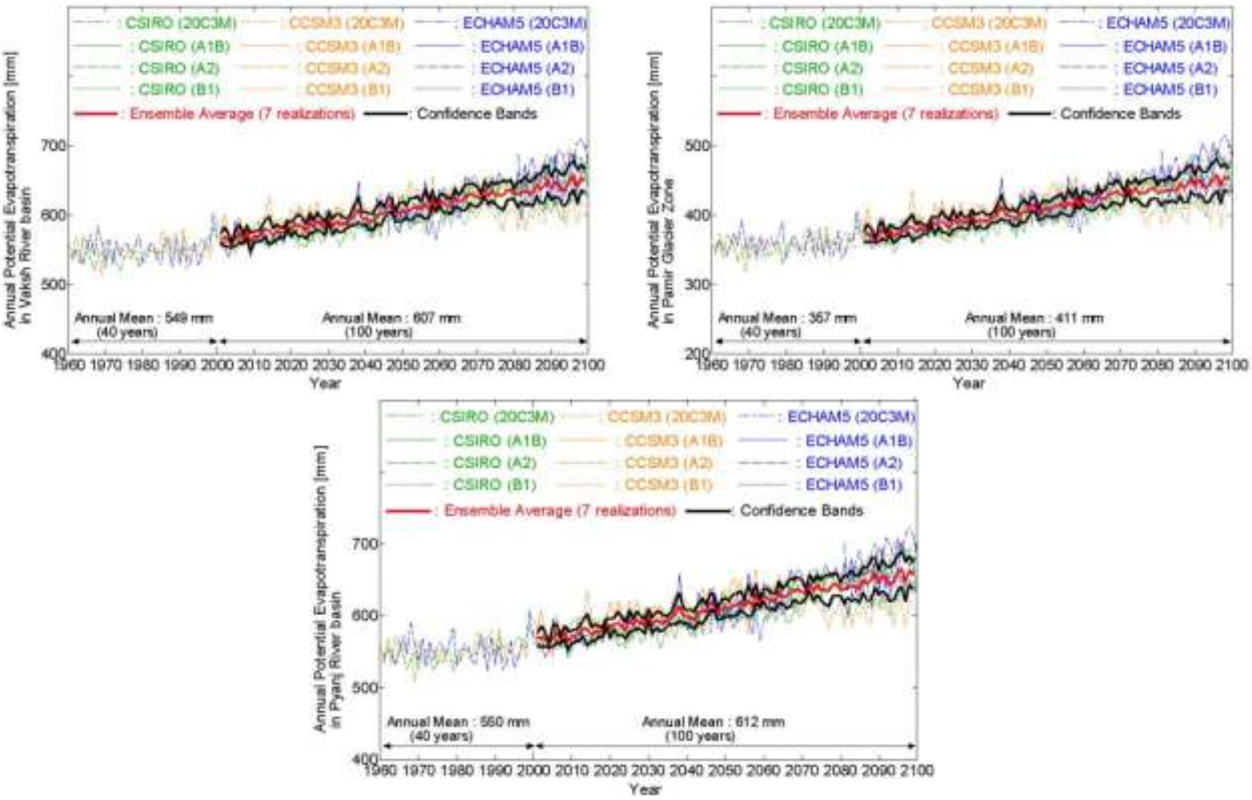


Figure 20-5: Historical and future evapotranspiration

Historical and future annual basin-average potential evapotranspiration in the Vakhsh and Pyanj river basins and the Pamir Glacier Zone

The following Figure shows the mean annual precipitation and air temperature change between the historical period (1980-2010) and future periods (2010-2040, 2040-2070 and 2070-2100). It can be that the mean annual air temperature is increasing at all of the sub-basins in the future. It is also noted that the air temperature increase in the central sectors of the Vakhsh and Pyanj River basins is slightly larger than in the other areas. It is also found that the mean annual precipitation at the lower Vakhsh and Pyanj River basins during 2010-2040 is slightly decreasing. However, these precipitation changes between historical and future periods are very modest (-2 - 7 %).

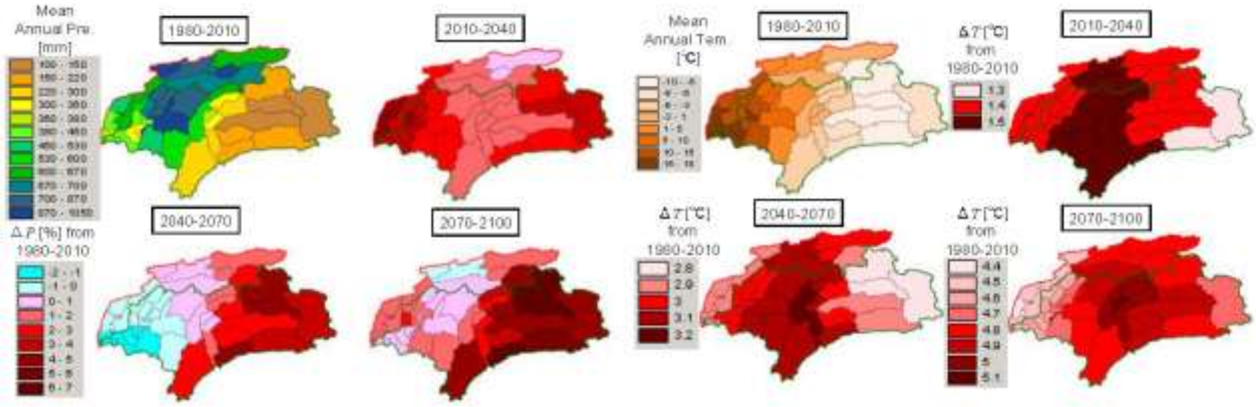


Figure 20-6: Changes in precipitation and temperature

Changes in mean annual precipitation (left) and mean annual air temperature (right) between 1980 - 2010 and future decades in modelled subbasins.

The Figure below shows the evapotranspiration (ET) change [mm] between the last decade (2000-2010) and the future periods (2030-2040, 2060-2070, and 2090-2100). Since the projected ET values are function of crop type (land cover type) as well as atmospheric conditions (air temperature), the distribution of the daily mean ET is different from that of the air temperature.

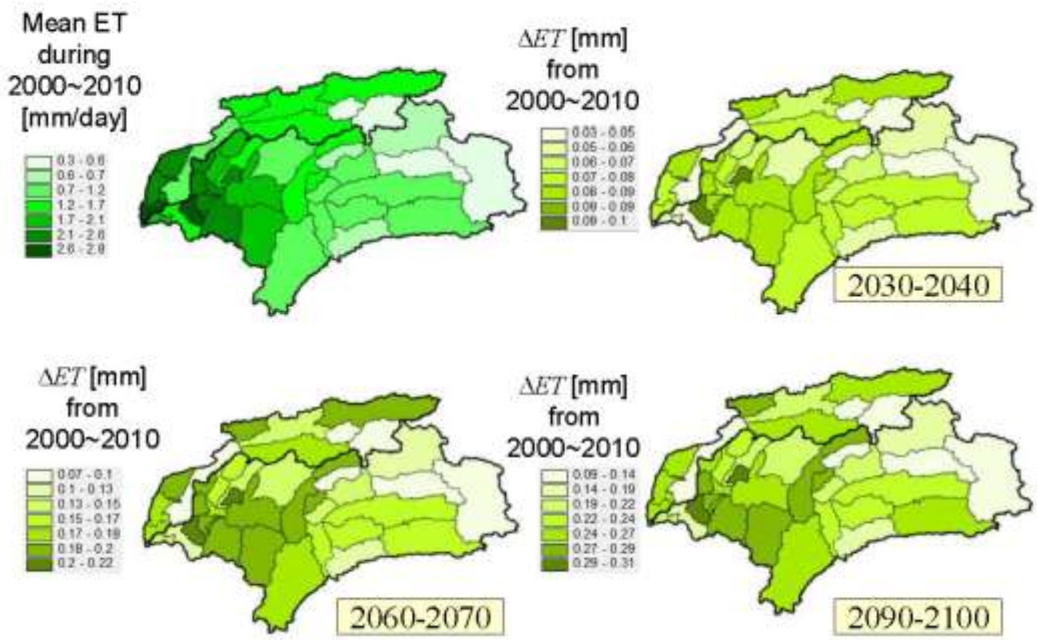


Figure 20-7: Evapotranspiration change between 2000-2010 and future decades

The main results of the climate projections using the statistically downscaled GCMPs are the following:

- The annual mean air temperature is increasing during the future period (2010-2100) at Vakhsh and Pyanj River basins and Pamir glacier zone when compared to its counterpart in the historical period (1960-2010).
- The ensemble means of the annual mean air temperature are increasing from 3.5°C (2010) to 5.0°C at Vakhsh river basin and from -2.6°C (2010) to -0.9°C (2050) at the Pamir glacier zone.
- The annual mean ET is increasing in the future period, based on the increase in the air temperature at the target areas.
- There is no significant difference in the ensemble mean annual precipitation at the target areas between the historical (1960-2010) and future (2010-2100) periods although some scenarios show extremely high and low values in the future.
- There is no significant change in basin-averaged mean monthly precipitation at the target areas between historical and future (2050-2060 and 2090-2100) periods.
- The maximum air temperature in a decade is likely to increase toward the future while the minimum one is likely to decrease.

These results indicate the importance of the snow and glacier melting for the future water resources and flooding in the study area since the air temperature has a clearly increasing trend toward the future. Glacial sediments currently stabilised by permafrost will be mobilised due to the rising zero-degree line by about 300 m in the next 40 years, and another 300 m in the subsequent 50 years. Therefore, the risks of floods and mudflows may be slightly increasing due to the increase in the frequencies and magnitudes of high daily precipitation and the increase in the rapid snowmelt with high air temperatures in Vakhsh river basin toward the future. This development could also lead to an increase in the already very high amount of sediment transported by the rivers, and reaching the reservoir.

Furthermore, due to the increase in air temperature, snowfall will decrease and rainfall will increase in the future. Such changes will probably induce significant changes in the annual hydrologic regime in the future. In order to estimate these hydrological changes a detailed analysis for the snow/ice melt, runoff and river flow discharge at the sub-basins was carried out within PCCR framework using a river runoff projection model that utilizes the downscaled precipitation and air temperature data as its inputs.

20.2.4 Hydrological Projections

A calibrated and validated river runoff model and seven future downscaled projections for precipitation, air temperature and evapotranspiration were used in PPCR as input data for river runoff simulations in the Vakhsh and Pyanj River basins.

The following Figure compares the historical and future annual mean discharge with 95% confidence interval for Bitchkharv, Shujand, Farkhor, Ninj Pyanj, Davsear and Kosmolobod in Vakhsh and Pyanj River basins.

It can be seen that the projected annual mean discharge is increasing toward the future until a certain time point due to increasing snow and glacier melting in consequence of the air temperature increase.

However, around 2060-2080, the annual mean flow starts to decrease because some small glaciers seem to be disappearing due to the increase in the air temperature. These results reveal that the timing of the disappearance of glaciers is crucial for the water balances in these two basins.

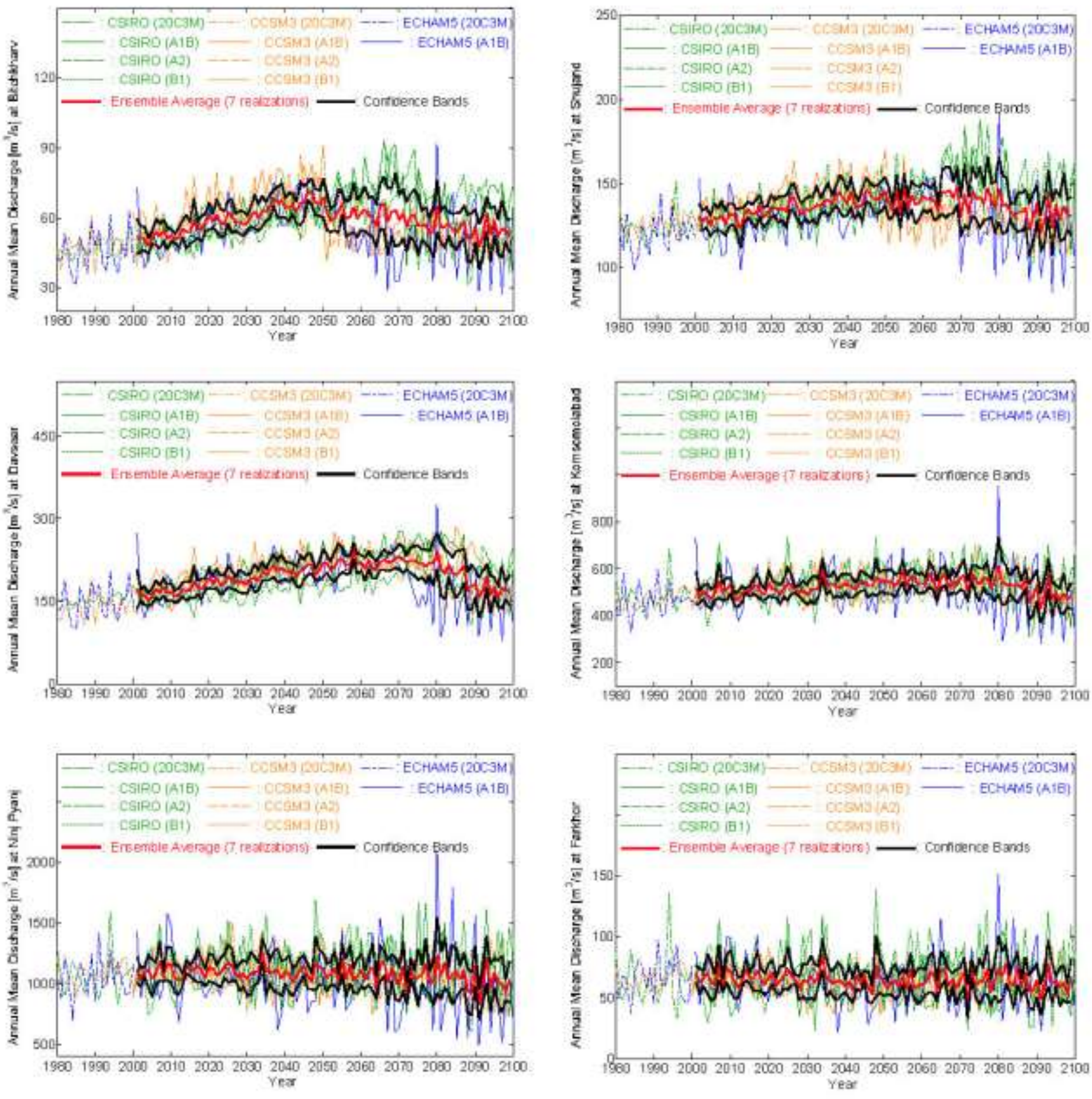


Figure 20-8: Annual mean discharge in Vakhsh and Pyanj

Historical and future annual mean discharge in the Vakhsh and Pyanj river basins.

These results basically agree with those of other studies recently performed. The A4 activity of PPCR (EBRD, 2011) cited results of the annual discharge cycle simulation by means of HBV-PRECIS for the present and 2080s climate under the assumption of three stages of glaciation in the Hunza and Gilgit river basins, Pakistan (Akhtar et al.

2008). Their annual discharge cycle changes are similar to those presented here. Shiklomanov (2009) computed the average seasonal flow changes in the Syr Darya and Amu Darya rivers. Although Syr Darya and Amu Darya rivers are much larger than the Vakhsh river, the changes in the annual hydrological cycle are similar. Therefore, the simulated flow projections of Figure 20-8 are considered to be reasonable.

Since the model results in the future are basically compared against the model results in the historical period, the impact of climate change on runoff conditions is quantified in relative terms, the future model-projected runoff conditions being compared relative to the same calibrated model-simulated historical conditions. This relative comparison is expected to minimize the influence of any model bias that remains after the model calibration.

However, the snow/ice accumulation and melting module in the HEC-HMS is a conceptual model, and constant values of the snow-related parameters were used in the simulations of the future conditions. HEC-HMS model also does not account for the coupling of infiltration/unsaturated soil water flow and groundwater flow and aquifer interactions which might be important in the long term hydrologic simulations. Also, the land cover/land use conditions were taken the same both in the historical simulations as well as in the future simulations. Furthermore, activities such as water supply for irrigation etc. have not been considered. So it would not be reasonable to present here more detailed quantitative information on the possible inflow changes to Rogun reservoir.

20.2.5 Glaciological Projections (Glacier Modelling)

Most of the climate change studies on the glaciers of Central Asia are analyses of the historical observations (e.g. Kayumov and Rajabov, and Aizen et al. 2010) or dynamic glaciation modelling, and very few existing studies are dealing with the projection of the glaciers under changing climate conditions.

A hydrologic modelling study, including the snow component, has been performed over the Vakhsh river basin, but it has not provided snow/glacier storage information (BETS Consultant 2010. This was because the study focused on flood forecasting and river flow modelling during the historical period for design purposes.

However, the glaciers in the Pamir Glacier Zone are crucial water resources for the downstream regions in the study area, and the estimation of the glacier disappearance timing at the watershed-scale is vital information for the future water resources planning and hazard management in the study area.

The first step in the glacier mass balance modelling is the estimation of the initial glacier water volume. There is inadequate glacier volume or depth information available locally, except for a few major glaciers (State Agency for Hydrometeorology, Republic of Tajikistan, 2003). So the initial glacier water storage was estimated from the existing world glacier databases: World Glacier Inventory (WGI), MODIS snow product, GLIMS (Global Land Ice Measurements from Space), and ground glacier survey data from the State Agency for Hydrometeorology. WGI database provides nearly complete individual glacier area information, but provides incomplete depth information in the Pamir Glacier Zone. The missing mean glacier depth is just interpolated by a regression analysis between the glacier area and the available mean depth. Additionally, the ground glacier survey information was utilized in this process

Based on the available information the total actual glacier water volume in the Pamir Glacier Zone was estimated to be 347~362 km^3.

The initial glacier distribution is estimated by an iterative model computation in order to reconstruct the equilibrium glacier condition that corresponds to the observation-based total glacier volume estimation. The simulated glacier distributions agree with the satellite driven glacier extent fairly well.

Figure 20-9 shows the simulated total glacier volume evolution over the Pamir Glacier Zone from 1960 through the end of the 21st century. Different colours denote different scenarios.

There are three realizations for the historical period: the control runs from CCSM3, CSIRO, and ECHAM5 (EH5) GCMs. Meanwhile, for the future period there are nine realizations from the combinations of 3 GCMs and 3 emission scenarios. However, since there is no continuous data for ECHAM5 A2 and B1 runs, these scenarios have not been used in the trend analysis. It is striking that the gradients of the glacier water storage, when compared between the historical and future periods, are very different. The modelled glacier volume change during 1960-2000 is about -0.019 km^3/yr whereas that during 2000-2100 is -2.023 km^3/yr. According to this assessment, nearly half of the glacier in the Pamir Glacier Zone may disappear by the end of the 21st century. This result indicates that some day it may not be possible to depend on the summer-snowmelt runoff in some of the sub-catchments.

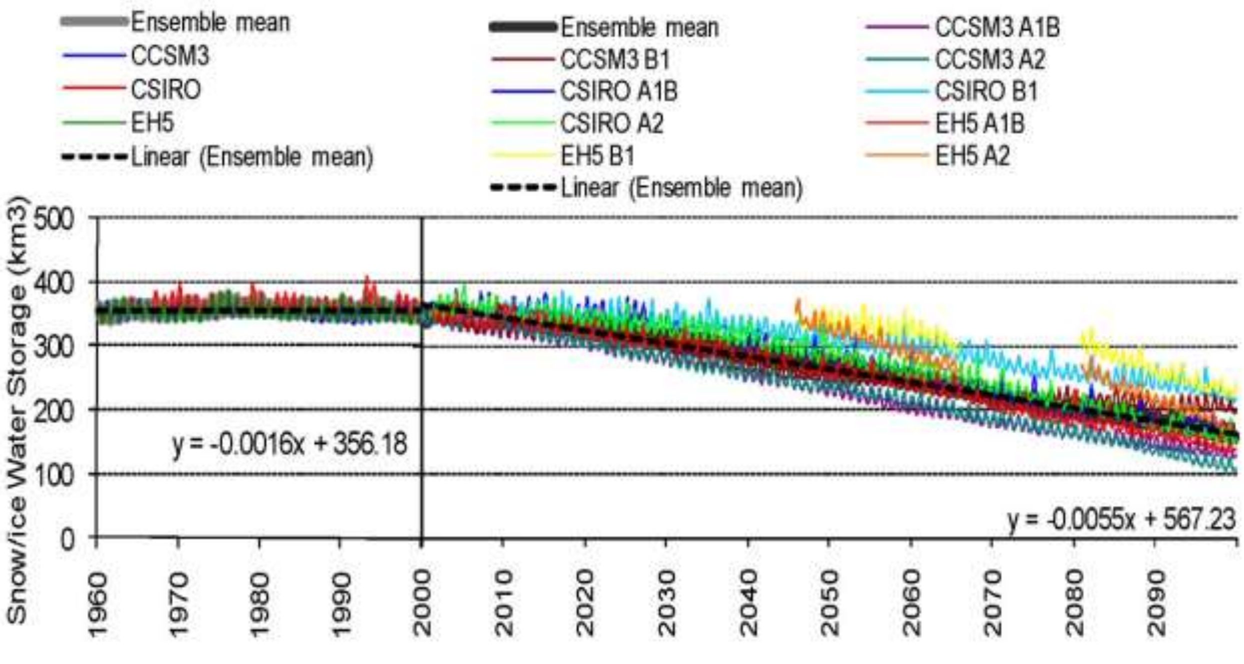


Figure 20-9: Projection of glacier volumes

Computed historical and future total glacier volume in the Pamir Glacier Zone.

20.3 Conclusion on the Estimated Climate Change Effects on Rogun HPP

As conclusion of the analysed results of the different model projections, the main Climate Change effects having an impact on Rogun HPP will be:

- Air temperatures in the Vakhsh river basin will increase by approximately 1.7°C between 2010 and 2050. Mean annual evapotranspiration will increase in line with air temperature. As evaporation is not a major issue for the Rogun area, no relevant impacts are expected.
- There is no significant difference in mean annual or monthly precipitation predicted although there may be greater variability from year to year. According to some greenhouse gas emission scenarios, the frequency of days with heavy precipitation may increase. Under the intended operation, available volume for flow retention after completion of Rogun will be the same as for the actual layout with Nurek. However, larger storage capacity offers a greater potential to mitigate adverse climatic impacts.
- There is no obvious trend in the mean annual flows in non-glacial river basins but maximum monthly flows will occur earlier in the year due to earlier melting in spring. Mean annual flow in glacier fed rivers are predicted to increase until about 2080 and then decrease because the small glaciers start to disappear in the study area. This increase of mean annual flow in the upcoming years may be useful for the filling phase.
- The variability of annual mean river flows is predicted to increase towards the end of the 21st century as hydrologic regimes become more influenced by rainfall-induced flows than by snow and ice melt. Maximum daily river flows are likely to increase. Higher regulation capacity due to Rogun offers the potential to manage such changes by adapted seasonal reservoir filling and flow release during summer period, as long as agreed on ICWC level. Larger storage is also an advantage for flood mitigation, as discussed in Section 21.3.6.
- Overall sediment load in rivers might increase due to mobilisation of glacial sediments caused by an upward shift of permafrost. However, any such increase in sediment load has been captured by the conservative estimate by TEAS.
- Based on the predictions of best available climate models, no significant adverse risks from climate change to the Rogun HPP project are expected. Furthermore the Rogun HPP provides opportunity to mitigate adverse effects of climate change on downstream areas.

The information gathered from the various sources does not allow forecasting changes in reservoir temperature and resulting stratification / mixing behaviour due to change of average ambient temperature as well as water temperature of Vakhsh river and other direct inflows or impacts on reservoir water chemistry, fauna and flora as these changes can’t be modelled by the available projection tools.

21 EFFECTS ON RIPARIAN COUNTRIES

21.1 Key Messages

As was highlighted repeatedly in earlier chapters, effects of Rogun HPP on downstream river discharge pattern, and therefore on riparian countries located in the downstream area, are one of the major issues to be addressed in this report. The basis for this evaluation was laid in Chapter 8, which describes and analyses the characteristics of water resources and their use in the Amu Darya basin.

Key messages of this chapter are:

- The TEAS recommended Rogun scheme will have a reservoir with an active storage capacity of 10.3 km^3. This implies the possibility of shifting additional water from summer to winter, with potentially serious effects on downstream riparians.
- There is an institutional framework in place regulating the principles of water allocation and water use in the Amu Darya basin, to which the member states of these agreements (Kyrgyzstan, Tajikistan, Uzbekistan and Turkmenistan) adhere, and current practices based on this framework are adequate for handling the present situation. However, Afghanistan, another producer and user of water in the Amu Darya basin, is not included in these agreements and mechanisms.
- The technical and environmental studies demonstrate that it is possible to operate the Vakhsh cascade with Rogun in a way that the river flow pattern downstream of the cascade will remain unchanged. For the initial filling of Rogun reservoir, Tajikistan will use its unused share of water allocated to it by ICWC, remaining in full compliance with Nukus Declaration, Protocol 566 and the limits set by the ICWC.
- Tajikistan intends to operate the cascade in this way. This means that building and operating Rogun HPP will not reduce water availability for irrigation by downstream riparians.
- Whereas changes in consumptive water use in the Amu Darya basin will have direct effects on the Aral Sea, operating Rogun HPP in this way will not negatively affect it.
- Rogun offers important flood control benefits, which have positive effects on the entire downstream area.
- Rogun HPP could benefit all downstream water users in the Amu Darya basin by providing additional water for irrigation in exceptionally dry years. It is recommended that the involved parties modify existing agreements and practices to allow for this improvement of the situation.

21.2 Issues

The main issue to be addressed here is the management and sharing of transboundary water resources in the Amu Darya basin. Mukhammadiev (2014) provides a very clear-cut analysis of the situation in his text entitled "Challenges of Transboundary Water

Resources Management in Central Asia" (in Micklin et al., 2014). The abstract of this text is reproduced here:

"Central Asian major river basins link the countries of Afghanistan, Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan. Water management in Central Asia continues to be the most important transboundary environmental issue and the biggest problem remains how to allocate water for upstream hydropower production and downstream irrigation. Disagreements between the upstream and downstream states have increased regional tensions and slowed development plans. National responses to existing cooperative opportunities are essentially driven by a policy of national self-sufficiency in energy and water. While it is reasonable to be concerned about water and/or energy security, it is also critical to understand that a policy of self-sufficiency incurs substantial costs for all. As long as self-sufficiency dominates the policy agenda, the benefits of cooperation will not materialise. International water law could provide a rational avenue toward achieving international consensus on both use and allocation of water resources in the basin, with international legal agreements to reinforce the consensus. Incentives to cooperate through the application of the benefit-sharing concept as a development model in the basin would include decreased costs and increased gains in many dimensions of regional cooperation, including the benefits that stem from better agricultural practices and its competitiveness, joint development of the region's energy resources, and better management of regional environmental risks."

Source: Mukhammadiev, 2014:233

21.2.1 Introduction to the Impact Assessment

The Rogun hydraulic scheme was identified rather a long time ago as a project with significant potential in terms of (i) contribution to the regulation of the Amu Darya river flow and (ii) production of energy using a hydropower plant.

The potential impact of Rogun HPP on water availability is a serious concern for downstream users in Tajikistan, in Afghanistan, in Turkmenistan and in Uzbekistan. This concern was raised during the preparation of the ESIA, and in particular during the public consultations, by stakeholders from these three countries.

At the same time, but to a lesser extent, concerns were raised regarding the risks of inundations associated with increased floods that could be generated by Rogun HPP operation.

In the following Sections, the above mentioned concerns are discussed, the nature of the risks and possible adverse impacts are addressed and quantified where possible, and related mitigation measures are proposed.

However, it has to be kept in mind that this is the ESIA Report for Rogun HPP. This means that the issues mentioned are addressed as far as they are relevant in the context of this project, i.e. as far as they are or can be influenced in any way by the project. This Chapter (as the entire study) is by no means an attempt to solve the full range of problems related to the Amu Darya basin management.

21.2.2 Potential Operation Patterns for Rogun HPP and Main Impacts

In a very general way, there are three main operation patterns according to which a hydropower plant with a large storage capacity like Rogun HPP could be operated under the given conditions, namely:

1. **Operation pattern 1:** Operation according to prevailing, accepted and currently applied rules and practices of water allocation and use, i.e. without shifting more water from summer to winter than is presently done by using Nurek reservoir. This is the operation pattern which is the guiding principle for the present impact assessment studies, technical as well as environmental and social, and Tajikistan has expressed its intent to operate the cascade in this way. Its conditions and effects are discussed in detail below.
2. **Operation pattern 2:** Maximising winter energy output, which would imply maximising a shift of water from the high flow (summer or, more precisely, vegetation period, April to September) to the low flow (winter, non-vegetation period, October to March) season. This would have a rather dramatic impact on water availability in summer, i.e. for irrigation, and would be to the detriment of downstream water users. This scenario is briefly discussed in the following Section.
3. **Operation pattern 3:** Maximising water allocation benefits to all users, i.e. operation not only for the benefit of producing electricity, but also for improving of water regulation and water allocation in the entire river basin, and especially in dry years. The potential for this, as well as the framework condition for implementing such a regime, are also addressed below.

Obviously, any of these three basic patterns could be varied and fine-tuned in a way as to optimise the outcome.

21.2.3 Maximising Winter Energy Output

This option would be a maximisation of winter energy production by using as much as possible of the storage capacity of the cascade for maximising the shift from summer to winter flows. Key figures for this option are summarised in Table 21-1. The Table shows what the overall consequences would be in terms of summer and winter flows in the lower reaches of Vakhsh river and in Amu Darya.

Following conditions are addressed for an average year:

- **Operation pattern**: Operation pattern 1 is according to prevailing, accepted and currently applied agreements and practices of water allocation and use, whereas operation pattern 2 makes the assumption that both reservoirs would be at their lowest level (Minimum Operation Level, MOL) by end of March; by then, Nurek HPP would only release the water needed for irrigation in the lower Vakhsh area, generating return flows.
- **Irrigation demand in the lower Vakhsh area:** Even in case of maximising winter energy output, Tajikistan would still use the water for irrigation, generating return flows to the Vakhsh river. Today's Tajik demand is lower than the full share of water allocated to it by ICWC. In the future, with or without Rogun, Tajikistan will use its full share, remaining in full compliance with Nukus Declaration, Protocol 566 and the limits set by ICWC.

Table 21-1: Theroetical potential for seasonal water shift in Vakhsh cascade and Amu Darya basin (km³)

	Case	Operation pattern (Chap. 21.2.2)	Irrigation demand in the lower Vakhsh area	Vakhsh: Summer withdrawal for irrigation (Tajikistan)	Vakhsh: Summer return flow from irrigation (Tajikistan)	Vakhsh: Transfer from summer to winter by Nurek reservoir	Vakhsh: Transfer from summer to winter by Rogun reservoir	Vakhsh: Winter flow at the confluence with Pyanj	Vakhsh: Summer flow at the confluence with Pyanj	Vakhsh: Annual flow at the confluence with Pyanj	Amu Darya at Kerki: Winter flow	Amu Darya at Kerki: Summer flow	Amu Darya at Kerki: Annual flow
Average year (1932-2008)													
1.	Natural (pre-Nurek)	-	-	0.0	0.0	0.0	0.0	3.7	16.5	20.1	16.6	44.5	61.1
2.	Nurek[1] without irrigation	-	-	0.0	0.0	4.2	0.0	7.9	12.3	20.1	20.8	40.3	61.1
3.	Nurek[1] with irrigation	1	today[3]	4.2	1.9	4.2	0.0	7.9	10.0	17.9	20.8	38.0	58.8
4.	Nurek[1] with irrigation (base case)	1	future[4]	4.9	2.0	4.2	0.0	7.9	9.3	17.2	20.8	37.4	58.2
5.	Nurek[1] + Rogun FSL 1290[2]	1	future[4]	4.9	2.0	0.0	4.2	7.9	9.3	17.2	20.8	37.4	58.2
6.	Nurek[1] + Rogun FSL 1220[2]	2	future[4]	4.9	2.0	4.2	3.9	11.8	5.4	17.2	24.7	33.5	58.2
7.	Nurek[1] + Rogun FSL 1255[2]	2	future[4]	4.9	2.0	4.2	6.5	14.3	2.9	17.2	27.3	30.9	58.2
8.	Nurek[1] + Rogun FSL 1290[2]	2	future[4]	4.9	2.0	1.3	10.3	15.2	2.0	17.2	28.2	30.0	58.2
Wet year (Average year +20%)													
11	Natural (pre-Nurek)	-	-	0.0	0.0	0.0	0.0	4.4	19.8	24.2	19.9	53.4	73.3
12	Nurek[1] without irrigation	-	-	0.0	0.0	4.2	0.0	8.6	15.6	24.2	24.1	49.2	73.3
13	Nurek[1] with irrigation	1	today[3]	4.2	1.9	4.2	0.0	8.6	13.3	21.9	24.1	46.9	71.1
14	Nurek[1] with irrigation (base case)	1	future[4]	4.9	2.0	4.2	0.0	8.6	12.6	21.2	24.1	46.3	70.4
15	Nurek[1] + Rogun FSL 1290[2]	1	future[4]	4.9	2.0	0.0	4.2	8.6	12.6	21.2	24.1	46.3	70.4
16	Nurek[1] + Rogun FSL 1220[2]	2	future[4]	4.9	2.0	4.2	3.9	12.5	8.7	21.2	28.0	42.4	70.4
17	Nurek[1] + Rogun FSL 1255[2]	2	future[4]	4.9	2.0	4.2	6.5	15.0	6.2	21.2	30.6	39.8	70.4
18	Nurek[1] + Rogun FSL 1290[2]	2	future[4]	4.9	2.0	4.2	10.3	18.9	2.3	21.2	34.4	36.0	70.4
Dry year (Average year -20%)													
21	Natural (pre-Nurek)	-	-	0.0	0.0	0.0	0.0	2.9	13.2	16.1	13.3	35.6	48.9
22	Nurek[1] without irrigation	-	-	0.0	0.0	4.2	0.0	7.1	9.0	16.1	17.5	31.4	48.9
23	Nurek[1] with irrigation	1	today[3]	4.2	1.9	4.2	0.0	7.1	6.7	13.8	17.5	29.1	46.6
24	Nurek[1] with irrigation (base case)	1	future[4]	4.9	2.0	4.2	0.0	7.1	6.1	13.2	17.5	28.5	46.0
25	Nurek[1] + Rogun FSL 1290[2]	1	future[4]	4.9	2.0	0.0	4.2	7.1	6.1	13.2	17.5	28.5	46.0
26	Nurek[1] + Rogun FSL 1220[2]	2	future[4]	4.9	2.0	4.3	3.9	11.2	2.0	13.2	21.5	24.5	46.0
27	Nurek[1] + Rogun FSL 1255[2]	2	future[4]	4.9	2.0	1.8	6.5	11.2	2.0	13.2	21.5	24.4	46.0
28	Nurek[1] + Rogun FSL 1290[2]	2	future[4]	4.9	2.0	0.0	8.3	11.2	2.0	13.2	21.6	24.4	46.0

[1] Active storage of Nurek 4.2 km^3 (TEAS);
[2] Active storage of Rogun FSL 1220 3.927 km^3, FSL 1255 6.454 km^3, FSL 1290 10.3 km^3 (TEAS);
[3] Factual average summer withdrawal and corresponding return flows of Tajikistan for 2005-2011 (GoT);
[4] Future average summer withdrawal and corresponding return flows of Tajikistan for 2005-2011 (GoT);
[5] Average summer and winter Vakhsh river flow at Rogun site for 1932-2008 (TEAS)
Note: "summer" in this Table stands for the vegetation period (April - September), winter for the non-vegetation period (October - March)

Description of the cases listed in the above Table for the average year:

1. Natural flow and seasonal distribution before construction of Nurek and any water abstraction along the Vakhsh river for irrigation.
2. Nurek without irrigation: this is a purely theoretical case, just showing the net effect of Nurek HPP: no consumptive water use, but shift from summer to winter flows by the live storage capacity of Nurek.
3. Nurek with irrigation: this is today’s situation, showing the seasonal shift caused by Nurek as well as the effect of today’s irrigation along Vakhsh river (Operation pattern 1); this is the average situation as it is today, without Tajikistan fully using the water allocated to it by ICWC.
4. Nurek with irrigation (base case): this is the relevant case for comparison, since it shows the seasonal shift caused by Nurek as well as the effect of irrigation along Vakhsh river (Operation pattern 1); this is the average situation as it will be in the future, i.e. once Tajikistan will fully use the water allocated to it by ICWC.
5. Nurek and Rogun, FSL 1290 (Operation pattern 1): this is the operation pattern developed by TEAS for the cascade including Rogun, which postulates no additional shift of water from summer to winter, and therefore no change in comparison to the base case. This case, and its implications, are discussed in detail in the following Sections.
6. Nurek and Rogun, FSL 1220 (Operation pattern 2: maximising winter energy output). As the Table shows, in an average year this would be sufficient for reducing present summer flow in Vakhsh by almost half.
7. Nurek and Rogun, FSL 1255 (Operation pattern 2: maximising winter energy output). As the Table shows, in an average year this would be sufficient for storing almost all of the present summer flow of Vakhsh; this however would not be the case in a wet year.
8. Nurek and Rogun, FSL 1290 (Operation pattern 2: maximising winter energy output). Under the assumption that irrigation in the lower Vakhsh area would go on unabated, the live storage of 10.3 km^3 would be sufficient for retaining the entire summer flow in an average year, which however would make only a marginal difference to FSL 1255. Since FSL 1290 is the TEAS recommended dam alternative, this case is therefore discussed below.

Today, Tajikistan withdraws in an average year 4.2 km^3 of water for irrigation in the lower Vakhsh area during the vegetation period (summer), called **withdrawal**. From this amount 1.9 km^3 are flowing back to the river, called **return flow**. Thus only 2.3 km^3 are consumed for irrigation in Tajikistan, called **consumptive use**.

In future, with or without Rogun, in an average year Tajikistan will withdraw 4.9 km^3 of water for irrigation in the lower Vakhsh area during the vegetation period (summer), using its full share of water allocated to it by ICWC. From this amount 2.0 km^3 will flow back to the river as return flow. Thus 2.9 km^3 will be of consumptive use.

Maximising winter energy output would have very serious consequences for the downstream water users Afghanistan, Uzbekistan and Turkmenistan. While Rogun and Nurek are not able to stop downstream flow, as Vakhsh contributes with approximately 30% to the overall flow of Amu Darya, it would still correspond to a very substantial reduction in flow, turning an average year into a situation as it can be observed now in an extremely dry year. Given the fact that under present conditions in an average year as good as all the water in Amu Darya is used for irrigation, reducing its summer flow by 7.4 km³ would mean that a surface of about 430'000 ha could not be irrigated, which would correspond roughly to 24% of the total area irrigated by Uzbekistan and Turkmenistan in the Amu Darya basin (assuming present water consumption rates for irrigation; see Section 21.4 for more details). This would be a drastic and thus unacceptable impact.

In a wet or dry year (±20% inflow) the downstream situation would change as follows:

- In wet years with more than 10 km³ of water above average in the whole Amu Darya basin (about +20%), see Table 21-1, and under the assumption of maximising winter energy (Operation pattern 2), summer flow of Vakhsh river would slightly increase to 2.3 km^3, whereas Amu Darya flow would increase to up to 36.0 km^3 for the same period, corresponding to a lower value than 37.4 km^3 for the base case in an average year. The FSL 1255 alternative has smaller storage potential and could reduce Amu Darya summer flow to only 39.6 km^3 in a wet year. In the period of 2001-2010, there were three such years (see Table 21-3).
- In dry years with more than 10 km³ of water below average in the whole Amu Darya basin (about -20%), see Table 21-1, and under the assumption of maximising winter energy (Operation pattern 2), summer flow of Vakhsh river would remain at 2.0 km^3 due to Tajik irrigation needs and corresponding return flows, whereas Amu Darya flow would decrease to 24.4 km^3 for the same period. For operation pattern 1, Amu Darya flow would be of 28.5 km^3. In the period of 2001-2010, there were three such years (see Table 21-3). Since today a dry year (corresponding to the situation described by operation pattern 1) already causes serious damage in irrigated areas in the Amu Darya basin, further reducing summer flows in such a case would increase the problem. All three dam height alternatives considered, even FSL 1220, would have the potential to cause a similar impact.

However, there are a number of reasons for not operating the cascade according or operation pattern 2, i.e. for not maximising winter energy output:

- Retaining the entire summer flow in Rogun and Nurek reservoirs could mean that there would not be enough water available for producing electricity in summer (limited to water flowing from Rogun to Nurek during Nurek filling, and water released from Nurek for irrigation of downstream Vakhsh area). However, Tajikistan needs to cover its own summer energy requirements, which are considerable; besides the consumption by industry and domestic userers, just for irrigation (pumps), up to 10 million kWh/day are required. Especially in early spring, at the beginning of the vegetation period, the lack of energy due to unavailable water resources in Nurek reservoir can postpone cultivation.
- Tajikistan plans to sell a considerable amount of electricity, and mainly summer electricity, to its neighbours, mainly Pakistan, which has a high summer demand.
- Reducing flows in Vakhsh to that extent would cause problems for operating the irrigation schemes in the lower Vakhsh area downstream of Golovnaya (given

their present layout). Currently, intake structures in this area only work as long as there is a minimum flow downstream of Golovnaya HPP of 350 m³/s, out of which 20-22 m³/s are being abstracted for irrigation. Still, there would be possibilities for adapting these structures for being able to operate under changed conditions, albeit at a high cost.

- This operation pattern would have a detrimental impact on the Tigrovaya Balka Strict Nature Reserve, leaving it with very little water in average and dry summers.
- Most importantly, this would also mean that Tajikistan would have to depart from prevailing agreements and practices with its neighbouring countries on water use and water allocations (ICWC allocates water seasonally and monthly).

For these reasons, Tajikistan does not intend to operate the cascade according to operation pattern 2.

21.3 Impact of Rogun HPP on Amu Darya

21.3.1 Scope

In this Section, after a very brief repetition of the existing agreements and practices and a short description of the basic assumptions for modelling cascade operation, outcome and impacts, both positive and negative, of the TEAS operation model (operation pattern 1) scheme are presented and discussed, as well as mitigation measures and potential for further improvement.

21.3.2 Water Use Regulations in the Amu Darya Basin

Here, only the main conditions as agreed upon among the riparian states are mentioned very shortly; see Section 8.5 for a more in-depth analysis of the situation.

At the level of BVO Amu Darya (which does not include Afghanistan), water shares are calculated and allocated seasonally to each member state on the basis of quotas. These quotas are prepared by the BVO using meteorological forecasts and requests from the four states, and are then subject to a finalization and approval by representatives of the four states as members of ICWC[3]. The water allocation to each state is established in accordance with schemes elaborated during the Soviet time. The allocation of water is done with a view on the vegetation period of the given year, without inter-annual considerations. The Aral Sea primarily receives the remaining unused water. The retention of water in Nurek reservoir during the summer for satisfying winter energy needs is not considered as a consumption by BVO Amu Darya. This is the current practice applied by ICWC member states, and it apparently works in a satisfactory way.

21.3.3 Vakhsh Cascade Operation: Scenarios and Simulations

Taking into account the regulatory limitations described in the previous Section, the TEAS consultant developed a model to simulate the operation of the Vakhsh cascade. This model was based on the following principles and objectives:

[3] In the absence of an agreement on a seasonal quota among ICWC members, member states use relevant data on previous allocations to determine their water share for that year.

- The operation of the Vakhsh cascade has to be studied as a whole; operation of Rogun HPP shall not be assessed separately. Therefore, the model was designed to assess the impact of Rogun on flows at the downstream end of the Vakhsh cascade.
- All project alternatives were defined within the strict constraint that the Vakhsh cascade operation principle downstream of Nurek remains unchanged during the implementation (filling) and operation of any of the Rogun alternatives.

  However, the water volume shift from summer to winter shall not exceed the present one, which is currently determined by the amount of active storage at Nurek.

  Future use of water share by Tajikistan was incorporated in the model, in strict compliance with water allocation mechanism on Vakhsh river. It should therefore be highlighted that all proposed dam alternatives can be operated under a regime which will not change water availability in the downstream area and will remain similar to the way the cascade is operated today. The only sizable change will be future use of the Tajik water share for irrigation, as per the agreements and practices currently in place.
- The following boundary conditions shall be always observed during the reservoir filling phase:
  - The only change in river flow pattern downstream of the cascade, which will happen in any case, will be the one caused by the fact that in future Tajikistan will make full use of the water share allocated to it, initially for filling the Rogun reservoir and subsequently for irrigation Other than that, Vakhsh river flow pattern downstream of the cascade remains unchanged: the objective of this condition is to ensure that the shape of the hydrograph of the Vakhsh river is unchanged compared to the present situation by the filling operation of Rogun scheme.
  - Reservoir filling will only be done within the water allocated to Tajikistan, by using the difference between the limit and the factual withdrawals. In terms of model simulations, due to the absence of explicit rules to calculate water share on the basis of natural river flows, a simplified version of this approach was used: a constant maximum annual volume is considered to be available to fill Rogun reservoir (1.2 km^3, which corresponds to the average unused water share of Tajikistan over the period 2005-2011). This rule is a first order simplification of the principle that will apply, i.e. "the difference between the limit and the factual withdrawals shall be used to fill Rogun".
  - According to the TEAS report on cascade simulation, filling of the reservoir is not influenced directly by the hydrological inflow series, only the energy production is. Rogun regulation capacity starts to be used after 6 years of filling. Nevertheless, extremely dry years may require specific measures, inducing a delay on reservoir filling progress.
  - Technical constraints such as triggered seismicity or other potential limiting factors were taken into account in defining the rate of filling of the reservoir during construction.

- The following boundary conditions shall be always observed during the operation phase (after the reservoir will be filled, corresponding to Scenario b “Base line – Future use of Tajikistan water share” of TEAS):
  - Seasonal flow pattern of Vakhsh downstream of Nurek shall remain unchanged and shall mimic for the future years the outflow recorded at Nurek outlet for the period January 1991 to July 2011. The objective of this condition is to ensure that the hydrological regime of the Vakhsh river is substantially unchanged compared to the present situation by the operation of Rogun scheme, both in terms of quantity as well as in terms of seasonal and monthly distribution.
  - The monthly irrigation water uses between Rogun and the end of Vakhsh cascade shall remain within the limits set by the ICWC in application of Nukus declaration and Protocol 566 for the Vakhsh river.

Practically, the team in charge of technical studies has first worked out together with Barki Tojik a Nurek operation algorithm that could be used for the model and would represent the way Nurek is presently operated. The principle of keeping the same river pattern mainly imposes not to regulate more than presently, i.e. not to increase the shift from summer to winter, but also not to fill the reservoir more rapidly in spring, and not to draw it down more rapidly in winter than at current state.

The results of the calibration can be seen in the following Figure, which provides a comparison of historical and simulated outflows from Nurek, without Rogun. The differences between historical and calculated values are a result of the applied reservoir rule curve, balancing each year the same amount of water from summer to winter, independent from inflow pattern, and thus resulting in hydrograph deviations mainly in summer.

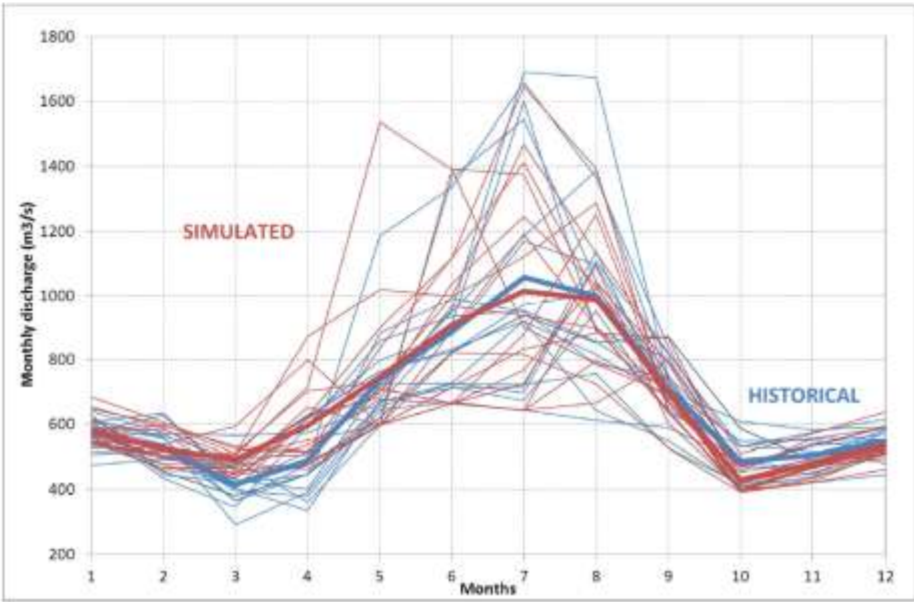


Figure 21-1: Comparison of simulated and historical outflow from Nurek reservoir

Case without Rogun, for the period 1991-2008
Source: TEAS: Reservoir Operation Simulation Studies - Final Report - November 2013
Thin lines: actual (blue) and simulated (red) situation for the years of the simulation period.
Thick lines; average over the period.

Under the proposed conditions, the results of the simulations show the absence of significant influence of Rogun on outflows from Nurek (see following Figure), which was exactly the objective of these conditions. The future cascade outflow with Tajikistan using its whole water share for irrigation, would be the same with or without Rogun.

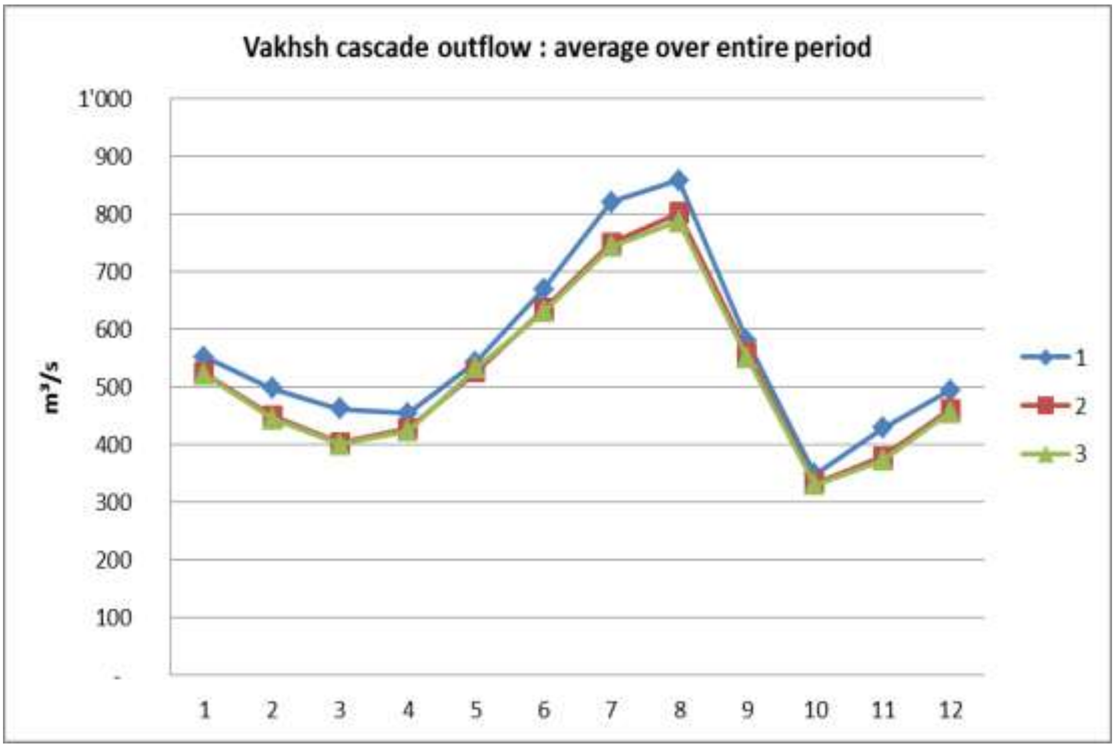


Figure 21-2: Present and future outflow from Vakhsh cascade

Comparison of simulated monthly average outflow from Nurek reservoir without and with Rogun for the period 1932-2008:

1. Present situation without Rogun
2. Future situation, Tajikistan using its full water share for irrigation, without Rogun
3. Future situation, Tajikistan using its full water share for irrigation, with Rogun

Source: TEAS: Reservoir Operation Simulation Studies – Model output data - November 2013

The future situation (Vakhsh cascade outflow with Tajikistan using its whole water share for irrigation) would be the same with or without Rogun.

21.3.4 Impacts on Downstream Water Availability and Mitigation Measures

The potential impacts on downstream water availability associated with the construction and operation of Rogun scheme are presented hereafter.

21.3.4.1 During Reservoir Filling Period

Taking into account all the technical and construction constraints, according to the simulation the reservoir filling period for the TEAS recommended alternative FSL 1290 is estimated to last up to 16 years. Considering that the total storage volume is 13.3 km^3, the average annual rate of water retention to fill Rogun reservoir would be 0.83 km^3, which represents 69% of the average unused water share of Tajikistan over 2005-2011 (1.2 km^3).

However, this annual rate is not evenly distributed in time. The volume of water that can be retained to fill the reservoir is limited by the dam raise during the first 7 years. During the last 6 years of the reservoir filling period, the capacity of the created reservoir is large enough to potentially store annually more than the limit of 1.2 km^3. This shows that:

- there will be a physical limit (= the dam raise speed) during the first years of reservoir filling that will prevent Tajikistan from using more than its water share;
- during the last years of the filling period, the non-exceedance of Tajikistan water share assumes Tajikistan's compliance with existing agreements and practices.

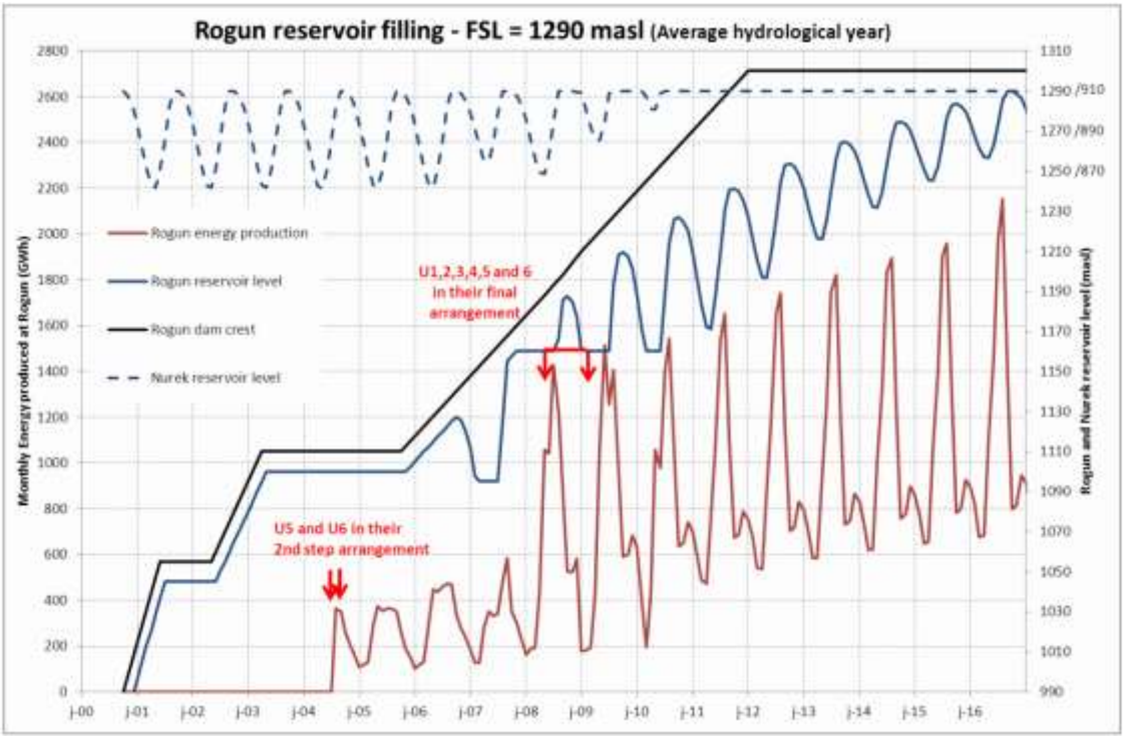


Figure 21-3: Simulated Rogun reservoir filling

Reservoir filling assuming inflow series of the average year 1937
Source: TEAS Reservoir Operation Simulation Studies - Final Report - November 2013

The simulation model clearly demonstrates that it is technically feasible to fill the reservoir of Rogun by using not more than the unused water share of Tajikistan.

The filling of the reservoir can be seen as representing a net loss for the downstream area of 13.3 km³ distributed over a period of 16 years. However, it has to be stated again that this reduction, as long as it is done within the ICWC water allocation, corresponds to the base case situation and will arise in any case when Tajikistan uses its full water share.

The situation is different when comparing average or wet years with dry ones. This leads to the following conditions for filling Rogun reservoir:

- In years, when there is sufficient water available for irrigation, Tajikistan intends to retain in Rogun reservoir a volume of water that never exceeds the difference between its allocated water share and its factual water use; the combined water use for irrigation and reservoir filling will remain within the total water share allocated to Tajikistan by ICWC[4].
- In years, when there is a water shortage for irrigation, using the full water share of Tajikistan to fill Rogun reservoir would result in exacerbating these problems for downstream users. Very dry years materialize when, for meteorological reasons and independently from the willingness of each state, the Amu Darya flow is considerably below average; the problem can be even worse if, in addition to this, water availability forecast for such a year was too high, since in such a case available storage might not be used in an optimal way. Such a dry-year situation can be easily identified because it depends on measurable facts. Therefore, in order to avoid adverse impacts of Rogun scheme on downstream irrigation during the filling period, it is recommended that during this period Tajikistan should commit itself not to retain additional water in Rogun reservoir, or to reduce retention depending on the severity of the drought, if such a dry-year situation occurs. Such a commitment would benefit downstream users, without necessarily affecting Tajikistan who will have the possibility to retain more water than expected in average during wet years. However, this could potentially be to Tajikistan's disadvantage, especially in the case of consecutive dry years. Therefore, as a compensation it should be allowed to retain more water in a wetter than average year. It would be best to define these issues in an agreement among the riparian countries, as recommended in Section 21.6.5.

If these two principles are applied, during the filling period no impact on water availability (as per the water share defined by ICWC) for downstream users, and in particular for irrigation in Afghanistan, Turkmenistan or Uzbekistan, will result. Still, the real situation will not be as simple as the two points as presented here, since there are not just wet, average and dry years, but all types of intermediate situations, which will need to be addressed specifically.

The important statement is that Tajikistan will remain within the water share allocated to it by ICWC. This presents a certain risk for Tajikistan if during the filling phase Tajikistan's share would be smaller than it is today. In this case, Tajikistan would have to decide whether to extend the period of filling Rogun reservoir, or to reduce water consumption for irrigation. Given the present trend of increasing annual flows, and the forecast of the climate change induced increase in river flow during the next 80 years due to melting of glaciers, this risk seems rather small.

21.3.4.2 Operation Phase

After the Rogun reservoir will have been entirely filled, the downstream impact of Rogun will fully depend on the way it is operated. According to the Reservoir Operation Simulation Studies (TEAS, Chapter 5, November 2013), Vakhsh cascade will be operated in a way that seasonal flow patterns downstream of Nurek remain unchanged with Rogun (TEAS Scenario A – Current status extrapolated).

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[4] In the absence of an agreement on a seasonal quota among ICWC members, Tajikistan may use relevant data on previous allocations to determine its water share for that year.

In addition, simulations have been run to test the applicability of these requirements on the long-term, taking into account the effect of full use of Tajik water share of Vakhsh, respecting the downstream water requirements as ruled by ICWC and agreed in the Nukus declaration and Protocol 566 (TEAS Scenario B – Base line – Future use of Tajikistan water share). Furthermore, the impact of sedimentation of Rogun reservoir has been studied for Scenario B.

All of these simulations have confirmed that it is technically possible to operate the Vakhsh cascade in a way that mimics its present operation, i.e. without increasing the present shift of flows from summer (vegetation period) to winter (non-vegetation period).

21.3.4.3 Potential of Rogun for Mitigating Consequences of Adverse Climatic Conditions

The operation of Rogun reservoir will not hydrologically impact countries which are upstream or outside of the Vakhsh basin: Namely, Kyrgyzstan cannot expect any benefit or risk related to Rogun reservoir operation.

The situation is different for Afghanistan, Turkmenistan and Uzbekistan, which are located downstream from the Vakhsh cascade and therefore could potentially be positively or negatively impacted by the operation of the Vakhsh cascade with Rogun.

Although the proposed mitigation measures aim at ensuring that Rogun will be operated in a way that does not change the seasonal flow pattern, the objective of this section is to identify and analyse the consequences of modifications from the proposed operation mode in order to mitigate the potential impacts of adverse climatic conditions.

In practice, impacts to downstream users will be minimized if the Vakhsh cascade is operated in the same way with and without Rogun. This corresponds to the proposed operation mode. In practical terms, this means that:

- Nurek reservoir level will be kept constant during normal operation.
- Rogun reservoir will be drawn down during the non-vegetation period for electricity production. However, the total drawdown volume shall not exceed the present active storage of Nurek, which is 4.2 km^3 according to TEAS although in total the cascade would have a much higher regulating capacity.
- Rogun reservoir will be progressively filled during the vegetation period, respecting the downstream water requirements as ruled by ICWC as agreed in the Nukus declaration and Protocol 566.

Deviations from these principles can be envisaged, as long as they are managed in a way that preserves the mutual interest of the Amu Darya basin countries. Adverse climatic conditions are the main reasons that might lead to such deviations. Three probable scenarios were developed and are described hereafter.

21.3.4.3.1 Scenario 1: Higher Electricity Demand in Cold Winter

The first scenario refers to the situation where, due to an increased need for energy in a very cold and/or long winter, electricity demand in Tajikistan would exceed the production capacity of the Vakhsh cascade under the proposed operation rules.

Some information on cold winter situations was received from Barki Tojik and is shown in the following Table.

Table 21-2: Electricity consumption in winter

Winter (Dec.-Feb.)	Electricity consumption (MWh)	Notes
1999/2000	4'267'447	
2000/2001	4'037'712	Cold winter
2001/2002	3'939'043	Cold winter
2002/2003	3'974'723	
2003/2004	3997681	Cold winter
2004/2005	4'295'392	
2005/2006	4'266'561	
2006/2007	4'091'189	
2007/2008	3'881'800	Cold winter
2008/2009	3'780'610	Cold winter
2009/2010	4'329'018	
2010/2011	4'675'043	
2011/2012	4'508'091	
2012/2013	4'189'200	
Average over 14 winters	**4'159'536**	

The Table quite clearly shows that under present conditions there is no increase in energy consumption in cold winters; on the contrary, in all the cold winters mentioned consumption was below the average value for the period on record. However, this does not mean that energy demand is not higher under such circumstances; it simply means that under present conditions energy supply is not sufficient. The strategy used by Tajikistan under such conditions is to cut off consumers, mainly in rural areas, from the grid, and to apply a scheme of load shedding even in the capital. Present supply, even in average winters, does not meet the demand.

In future, i.e. with Rogun, under this scenario Tajikistan could turbine more water than in an average year during the low flow season (September-April), and would therefore have to store more water during subsequent summers (or reduce water use in subsequent winters) in order to fill Rogun reservoir again.

As an example, an over-consumption in an average winter, corresponding to an increased water release of 20%, would decrease stored water in the Rogun reservoir by 1.5 km^3 at the end of the winter period, as shown in the following Figure. Full compensation of this storage deficit during the next summer would decrease summer flow downstream of Rogun by 12% for average inflow conditions. Such a compensation would only be acceptable for downstream water users in case of a wet year with high inflow to Rogun, e.g. in 1994, 1998 or 2007 (see Figure 21-6). Otherwise, compensation has to be done during a subsequent winter, decreasing released water by 20% for average inflow conditions. Total electricity production would slightly decrease, by ~1% for compensation in the following summer and ~2% for compensation in the following winter, due to reduced head.

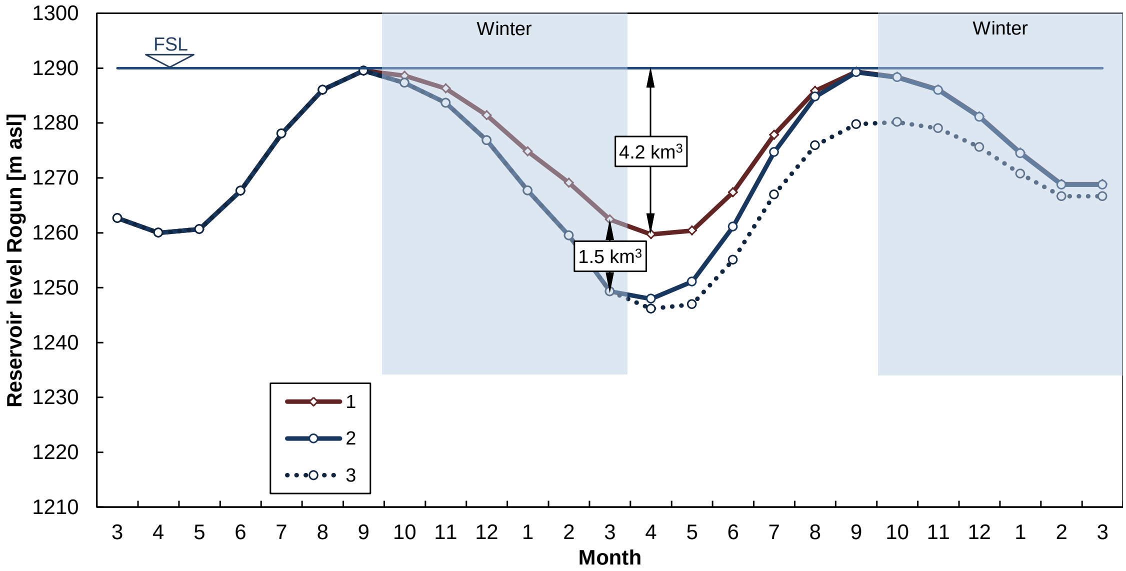

Figure 21-4: Consequences of increased energy production in a cold winter

Reservoir level over two average years without and with a 20% over-consumption in winter
1 = Average over the1932-2008 period (TEAS)
2 = 20% over-consumption in winter and compensation in following summer
3 = 20% over-consumption in winter and compensation in following winter
Source: adapted from TEAS Reservoir Operation Simulation Studies - Final Report - November 2013

The consequence for downstream users (essentially those who irrigate in Tajikistan, Afghanistan, Uzbekistan and Turkmenistan) might be a reduction in water available for irrigation, if Rogun reservoir is refilled without consideration for downstream users.

The definition of the refilling process of Rogun after a very cold winter would have to be included in the existing agreements, which would have to be modified for this purpose, addressing exceptional situations upfront in a transparent and preliminarily defined manner. The key objective is that downstream users in Afghanistan, Turkmenistan and Uzbekistan would not face a lack of irrigation water as a result of an exceptional drawdown of Rogun reservoir during a cold winter: there are several ways to reach this objective, for example (i) by fully refilling Rogun reservoir only when a wet year occurs, (ii) by reducing the consumption of water for irrigation in Tajikistan during the years following the winter over-consumption, (iii) by turbining less water during the following winter or (iv) through a combination of all of these measures.

Turbining more water than planned in winter and compensating this over-consumption later will in any case have to be done following an agreed, well defined and transparently monitored procedure at BVO level.

21.3.4.3.2 Scenario 2: Lack of Water at the Basin Level in a Dry Year

When planned in the Soviet Union context, Rogun was designed as a regulation scheme (before being a hydropower scheme) that was expected to bring additional regulation capacity in the Amu Darya Basin in order to improve the guaranteed volumes of water for irrigation. Protocol 566, which is one of the planning documents where Rogun is referred to, stated that Rogun could bring an additional guaranteed delivery of

4.5 km^3/yr (if coordinated with Nurek, Tyuyamuyun, and Zeid reservoirs, the latter having been built in 2000).

Practically, Rogun and even Nurek reservoirs could be considerably emptied for downstream irrigation in drought years. In theory, the whole available live storage volume of the two reservoirs could be released, as long as technically feasible by the spillway and turbine outlets of the schemes.

As mentioned above, lack of water arises due to adverse climatic conditions, as for example in 2002, when the actual flow in Amu Darya reached only 70% of the average annual flow. This can even be exacerbated if in such a condition water availability is over-forecasted, as e.g. in 2008 when water availability was overestimated by 42% (49 km^3 instead of 35 km^3). Over the period 2000-2010, BVO has generally more often over-forecasted that under-forecasted water availability (see following Table).

Table 21-3: Water availability and forecast accuracy at basin level

Vegetation period	Amu Darya basin total flow			Estimation	
	Prevision	Real	Difference		
	[km^3]	[km^3]	[km^3]	%	
2001	50	**35**	15	43%	over
2002	37	**36**	1	3%	correct
2003	59	**62**	-3	-5%	correct
2004	64	52	12	23%	over
2005	63	**66**	-3	-5%	correct
2006	58	54	4	7%	correct
2007	53	50	3	6%	correct
2008	49	**35**	14	40%	over
2009	58	48	10	21%	over
2010	60	**69**	-9	-13%	under
Average	**55**	**51**	**4**	**9%**	

Source: BVO
Figures in **bold red**: dry years (-20%: 10 km^3 or more below average)
Figures in **bold green**: wet years (+20%: 10 km^3 or more above average)

Note that the combined live storage of Rogun alternative FSL 1290 and Nurek is 14.7 km^3, which is in the order of magnitude of the deficit observed in 2001, 2002 and 2008 compared to the average.

Yet, Rogun has the capacity to bring measurable complementary volumes of water for downstream users in difficult years: considering an average consumption rate of 17'000 m^3/ha/yr for irrigated agriculture in the Amu Darya basin, an additional volume of 2 km^3 discharged from Rogun during the vegetation period of a dry year would allow irrigating 116'000 ha (see Section 21.4.4 for more details on this issue).

As an example, a 20% extra release of water in an average summer, for instance for compensating in a case of over-forecast of water availability, would decrease stored water in the Rogun reservoir by 2.5 km^3 at the end of the growing season, as shown in the following Figure. Full compensation of this storage deficit during winter would decrease winter release of Rogun by 19%, with a corresponding reduction of winter energy production. Such a compensation would only be acceptable for Tajikistan in case of financial or energy compensation by downstream countries to meet its energy demand. Otherwise, compensation, i.e. retention of the corresponding quantity of water, would have to be done during a subsequent summer Total electricity production would slightly decrease, by ~1.5% for compensation in the following winter and ~3% for compensation in the following summer, due to reduced head.

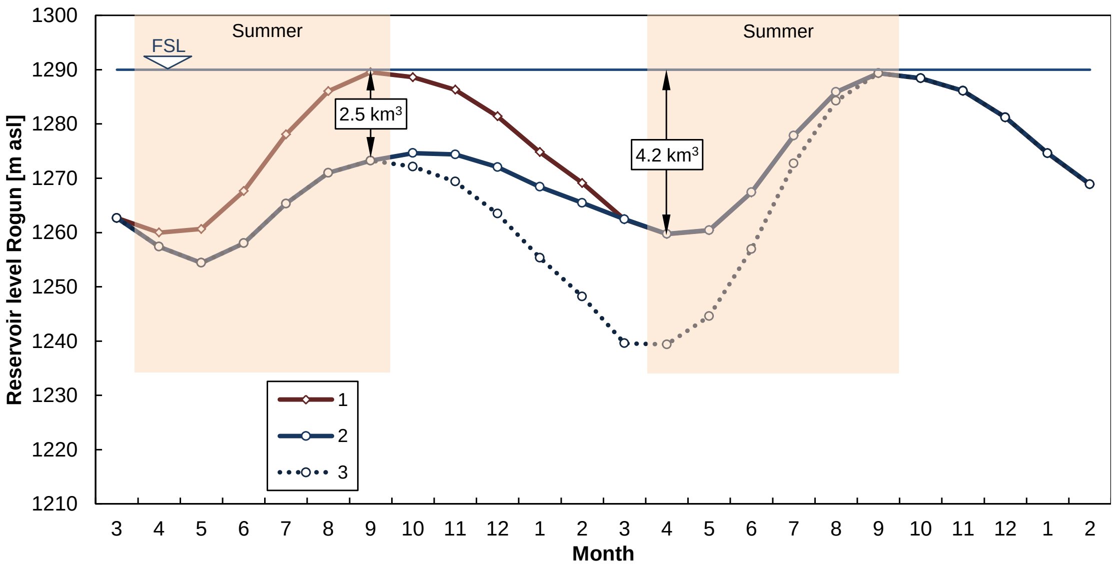

Figure 21-5: Effects of higher summer discharge on reservoir level

Reservoir level over two average years without and with a 20% over-consumption in summer
1 = Average over the 1932-2008 period (TEAS)
2 = 20% over-consumption in summer and compensation in following winter
3 = 20% over-consumption in summer and compensation in following summer
Source: adapted from TEAS Reservoir Operation Simulation Studies - Final Report - November 2013

The principle of such complementary releases would need to be agreed between all concerned countries at ICWC level. Since it would result in an economic loss for Tajikistan (due to the resulting reduction of energy production), such complementary releases could well be agreed as a compensation to cold winter over-consumptions by Tajikistan.

A procedure should define the context and limits of such complementary releases. Again, this procedure will have to be done following an agreed, well defined and transparently monitored mechanism at ICWC level.

According to data provided by GOT, Tajikistan has already occasionally discharged complementary volumes of water at the riparian countries' request in the recent past, e.g. in 2010 when Nurek downstream flow was decreased due to flood risk or in 2013 when Nurek downstream flow was increased due to a drought situation. Similar requests were also received in the Syr Darya basin, with the same type of reaction from Tajikistan, in these cases using Kairakum reservoir as means for regulation.

21.3.4.3.3 Scenario 3: Combination of the Two Previous Scenarios

A combination of the previous scenarios is possible: a dry year might well be followed by a cold winter, or a cold winter might be followed by a dry year, or one might observe a succession of cold winters or dry years (as happened in 2001-2002).

The following Figures give the annual, as well as summer and winter period flow distribution at Rogun over the period 1933-2007.

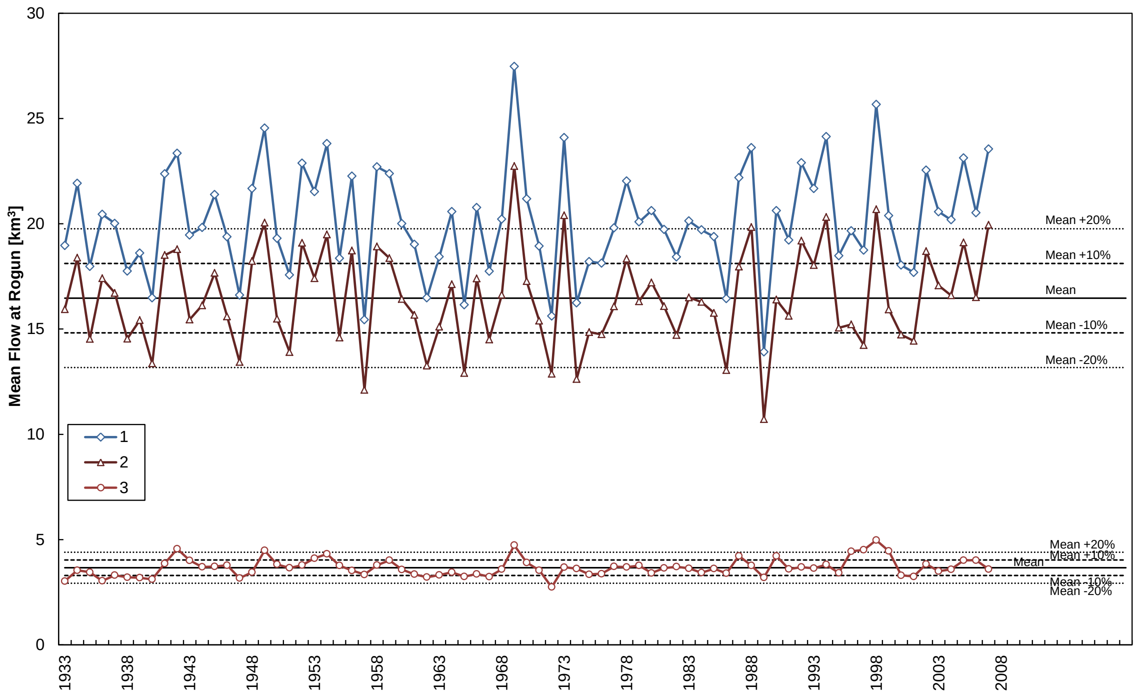

Figure 21-6: Annual flow at Rogun for 1933-2007

1 = Annual flow
2 = Summer flow (April to September)
3 = Winter flow (January to March and October to December)
Source: TEAS Reservoir Operation Simulation Studies - Final Report - November 2013

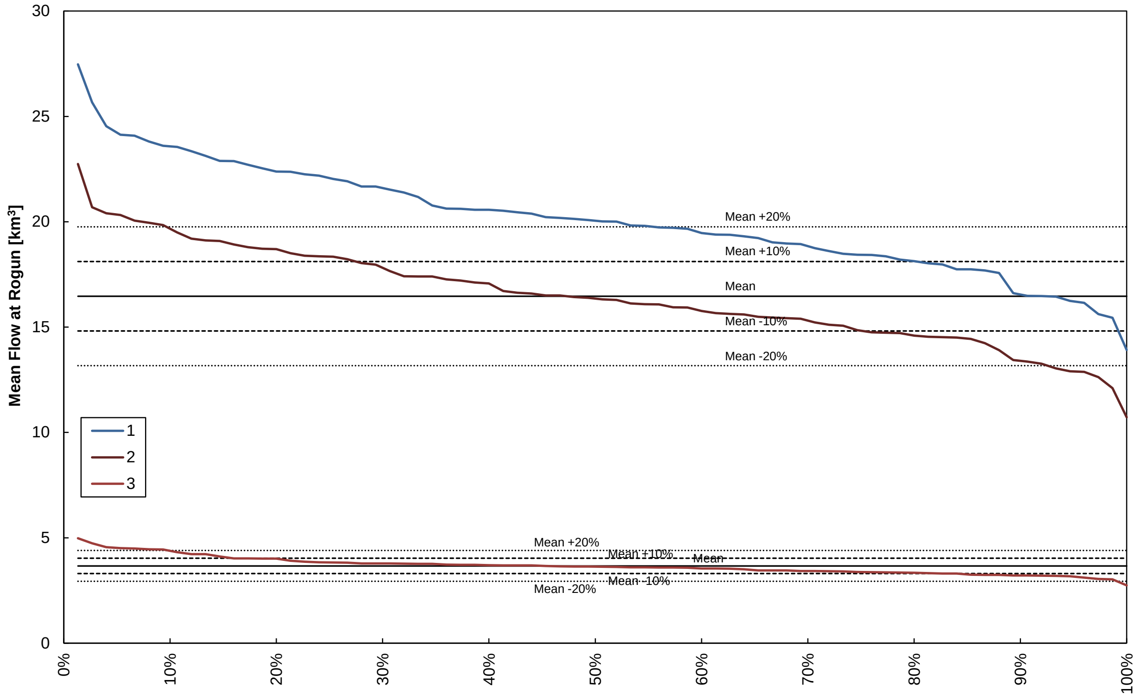

Figure 21-7: Flow distribution at Rogun for 1933-2007

1 = Annual flow
2 = Summer flow (April to September)
3 = Winter flow (January to March and October to December)
Source: TEAS Reservoir Operation Simulation Studies - Final Report - November 2013

Inter-annual compensation of over-consumption in an average year is possible within the given variability, depending on the amplitude of the extra release. Nevertheless, lower inflow to Rogun generates lower flow release and lower energy production under normal operation conditions.

As discussed above, cold winter or dry year conditions might to some extent be compensated by exceptional releases of water during the winter or the summer period. These exceptional releases would translate into a lack of water in Rogun (and possibly Nurek) reservoirs. In case of a sequence of cold winters and dry years, as shown in Figure 21-6, the possibility to use the regulating capacity of Rogun and Nurek might well reach its limit, and low energy demand in winter or wet seasons would be required before the regulating capacity can be used again to its full extent. Electricity losses for Rogun and Nurek HPP due to reduced head would then become more and more relevant.

For this reason, it is intended that the operation of Rogun would only deviate from the recommended operation mode (where Vakhsh hydropower cascade outflow is the same with and without Rogun) under very specific circumstances that need to be agreed upon at the ICWC level.

21.3.5 Flooding Due to Rogun Operation

Rogun dam provides several flow regulation facilities. Flood management has been addressed by TEAS for both construction and operation phase of Rogun. Studied concepts are discussed in TEAS Chapter 3.3 (Alternatives design) in the appendices 3

(Flood Management during Construction), 4 (Hydraulics of the Project Components) and 5 (PMF Management). The various facilities on different levels are designed according to high safety standards, taking into account construction progress, operation head as well as sediment issues, and operated by redundant control-command systems. The planned facilities consist in:

- Diversion tunnels 1, 2 and 3;
- Middle level outlets 1 and 2;
- High level outlets 1 and 2;
- Surface spillway with four gates.

The latter is compulsory in case of gate opening problems of the outlets. All facilities are independently built and operated, reducing the failure risk due to interdependency. As an example, fault crossing are avoided regarding earthquake and creeping risks. Nevertheless, undesired gate manoeuvres may lead to downstream flow release.

Downstream flooding risk due to inappropriate operation of release facilities is higher than for today’s situation without Rogun, as presently Nurek reservoir is regulated according to seasonal water storage. In future, Nurek reservoir will be generally at FSL. Undesired gate opening has higher impact due to increased loss potential as a result of generally higher water levels. In addition to increased risk at Nurek dam, also Rogun may contribute to higher inflow. Therefore, potential gate operation problems have to be addressed by appropriate security and surveillance systems, to be addressed in a further stage of the project development.

Dam break scenarios and the downstream impacts are to be studied in the framework of the emergency preparedness plan, which will be carried out at a subsequent stage. However, flood wave propagation would have dramatic impacts on downstream areas in any case and under all scenarios. Occurrence probability and amplitude have therefore to be reduced to minimise the risk. This has been done, since very stringent design criteria have been adopted by TEAS, including PMF and MCE.

21.3.6 Flood Reduction Due to Rogun

According to TEAS, the Vakhsh cascade as presently operating, including Nurek dam, is not designed to handle a Probable Maximum Flood (PMF). Thus Rogun has been designed as a multipurpose scheme, allowing safe PMF evacuation. Appropriate operation of Rogun’s spillway facilities would provide protection of Nurek and the downstream areas.

Along the Vakhsh cascade, the Rogun reservoir can contribute to improved flood routing and therefore to lower downstream flow peaks, as shown by TEAS for extreme floods. As Vakhsh river has a snow and glacier melt influenced flow pattern, high flows are related to the thaw season with peaks in July and August. Thus it is possible to forecast high floods by monitoring the snow cover in the catchment area in winter and spring time. In April Rogun reservoir level would be generally at its lowest level at 1260 m asl, providing a volume of approximately 4.2 km^3 for potential flood retention. For normal operation, the water level in Nurek would be at FSL of 910 m asl during the whole year. A preliminary drawdown of the water table to 860 m asl, as assumed in the TEAS studies for certain scenarios, would make another 4.2 km^3 storage available for flood attenuation. Thus appropriate management before and during flood peak can increase flood reduction efficiency thanks to the available volume in Rogun and Nurek reservoirs.

- A flow forecast system should be developed allowing preventive drawdown of water levels for Rogun as well as Nurek reservoirs to maximise peak flow retention.
- A flood study should be implemented for the downstream area of Nurek in order to assess the flood wave propagation in space and time in the Vakhsh river valley in case of high floods.
- An early warning plan should be developed to warn downstream population in case of high flood from Nurek.

Independently from the development of Rogun project, it is strongly recommended to assess the flood routing capacity of the existing reservoirs, to implement a flood study for the downstream area and to prepare an early warning plan in order to keep the population and authorities informed about the flood exposure of the Vakhsh flood plains.

Overall, the effects of Rogun HPP on the flood risks in the downstream area would be as follows:

- As compared to the present situation, adding Rogun HPP to the cascade would considerably reduce risks related to floods of high magnitude (e.g. PMF); today’s cascade is not designed to handle PMF.
- It would also reduce risks during floods of lower magnitude, but higher probability of occurrence (like one in ten or one in one hundred year floods), thus offering the potential to reduce inundations in the downstream areas.
- Equipping the cascade with a monitoring system which would allow lowering the reservoir level before a flood peak arrives would further increase the positive effect of the cascade on flood mitigation.

Nevertheless, these positive effects will be limited to the Vakhsh, as the Pyanj River on which Rogun dam has no influence is presently the main threat for downstream countries in terms of floods. An early warning system should be implemented in any case.

21.4 Impact on Irrigation

21.4.1 Irrigation Now and in the Future

Main water use - and, more importantly, main consumptive water use - in the Amu Darya basin is irrigation. While, as was shown in Chapter 8, the largest part of the water flowing in Amu Darya stems from the mountainous areas of Tajikistan and Afghanistan, water consumption for irrigation takes place mostly in Uzbekistan and Turkmenistan. This fact makes these two countries vulnerable to additional (consumptive) use of water in the headwater regions of the river basin. Some relevant figures on water consumption and availability are shown in the following Table.

Table 21-4: Water consumption presently and in the future (without Rogun)

	Water consumption			**Irrigation**		
	1 **average year**	**2** **dry year**	**3** **deficit in dry year**	**4** **water needed**	**5** **area irrigated**	**6** **loss in dry year**
	km³/yr	**km³/yr**	**km³/yr**	**m³/ha**	**ha**	**ha**
1. Today	**1**	**2**	**3**	**4**	**5**	**6**
Tajikistan	7.89	6.26	1.63	15'780	500'000	103'576
Afghanistan	2.50	1.98	0.52	13'000	192'308	39'837
Uzbekistan	28.12	22.29	5.83	17'000	1'654'118	342'655
Kyrgyzstan	0.21	0.17	0.04	13'000	16'154	3'346
Turkmenistan	20.56	16.30	4.26	17'000	1'209'412	250'533
Total	59.28	47.00	12.28		3'571'991	739'947
Total flow*	75.00	47.00				
Surplus / deficit	15.72	-12.28				
%	126.52	79.28				20.72
2. Future	**1**	**2**	**3**	**4**	**5**	**6**
Tajikistan	9.50	6.61	2.89	15'780	602'028	182'838
Afghanistan	6.00	4.18	1.82	13'000	461'538	140'171
Uzbekistan	29.60	20.61	8.99	17'000	1'741'176	528'802
Kyrgyzstan	0.40	0.28	0.12	13'000	30'769	9'345
Turkmenistan	22.00	15.32	6.68	17'000	1'294'118	393'028
Total	67.50	47.00	20.50		4'129'630	1'254'184
Total flow	75.00	47.00				
Surplus / deficit	7.50	-20.50				
%	111.11	69.63				30.37

Sources: Ahmad and Wasiq (2004), Jalilov (2010 and 2011)
* = total flow in the Amu Darya (see Section 8.4.1 and Table 8-1)

The Table shows the following:

- Situation today: this shows the average water consumption of the BVO countries according to Table 8-4 (**Column 1**).
- The values for Afghanistan, which is not a member of the ICWC, were taken from Ahmad and Wasiq (2004). According to this source, before 1980 Afghanistan consumed about 5 km³ of water for irrigating 385'000 ha of land in the Amu Darya basin; due the consequences of the war, this dropped considerably, to about the level of 1965, which was estimated at 2.5 km³/yr.
- According to this same source, total average yearly flow in the Amu Darya is 75 km³. In an extremely dry year (Q_{95}, a once in 20 year event), this drops to 47 km³. The values in **Column 2** show the amount of water which would be available for each country under the assumption that the deficit would be shared

according to the percent distribution of water between the countries . For each of the countries, this would result in the deficit shown in **Column 3**.

- This can then be expressed as the number of hectares which could not be irrigated in such a case due to a lack of water. **Column 4** indicates the amount of water used per hectare per year, and **Column 5** indicates the total land area under irrigation (values for Afghanistan from Ahmad and Wasiq (2004) assuming the same ratio for water use for Kyrgyzstan; for Uzbekistan according to Jalilov (2010 and 2011), assuming the same ratio for Turkmenistan; and for Tajikistan calculated from the figures on irrigated areas and water use). Finally, **Column 6** indicates the number of hectares which could not be irrigated in a dry year due to lack of water.
- The future situation shows the expected outcome under the following conditions and assumptions:
    - BVO states will use their full share of water allocated to them (average values according to Protocol 566, see Table 8-4).
    - Values for Afghanistan again according to Ahmad and Wasiq (2004), who state that Afghanistan will restore the 385'000 ha of irrigated land in the Amu Darya basin and expand irrigation by 15-20 %, bringing total water consumption to 6 km³/yr. It is important to note that this includes only irrigated areas which take water from rivers which actually reach the Amu Darya, and does not take into account water abstracted from "blind" rivers, which do not or no longer reach the Amu Darya.
    - Increase in irrigated areas is calculated on the basis of the same water consumption as today.
- Obviously, this would lead to a considerable increase in the water deficit in a very dry year, and with this to an increase in losses in agriculture (**Column 6**).

Definition of the impact as "lack of water for a certain number of hectares" is the way of actually quantifying the impact. In practice, however, this will be a little bit less clear-cut. In a case where a water shortage is forecasted by BVO, and water allocations are reduced right from the start, it might be possible to actually limit the area to be irrigated, and to manage available water resources in a way as to irrigate the remaining area; this would require the presence of a strong centralised organisation for all irrigated areas on a national level, in each of the countries affected. However, if water availability forecast is too high, it is easily imaginable that cultivation would start on the entire irrigated area, and then there would be a water shortage, leading to more or less severe harvest losses, in this entire area. This impact, however, could be addressed only on the basis of harvest data and cannot be forecasted (see also observation on coping with dry years in Section 21.4.4). For these reasons, the number of hectares which cannot be irrigated under specific conditions have to be seen as a quantification of the impact, but cannot be interpreted as a one to one loss in area.

This shows that, while in an average year there is a surplus of water, and there will still be a surplus under "future" conditions with the anticipated increase in water consumption, there is already now a considerable lack of water in a dry year, leading to very substantial losses, and this will be aggravated further in the future, when Tajikistan will make use of all the water allocate to it, and when Afghanistan will rehabilitate and possibly expand its irrigated agriculture. It should be noted that, if there is a "surplus", this does not mean that all this water will reach the Aral Sea (see Section 21.5), since considerable parts of this water end up in drainage basins in Uzbekistan and Turkmenistan.

Under the intended operation scheme as described and discussed in Section 21.3.3, Rogun HPP will not have any influence on this situation, and it will not lead to a further water shortage.

The conclusions from this are rather clear and straightforward:

- It is important that Afghanistan is included in the agreements and efforts undertaken for water allocation in the Amu Darya basin.
- The outcome would be the same, independently of whether Rogun HPP will be built or not. However, Rogun HPP presents a risk for shifting additional water from summer to winter, which would reduce water availability for irrigation, as discussed in Section 21.2.3. On the other hand, Rogun has the potential, not for compensating totally the water deficit in an exceptionally dry year, but at least for providing additional water in such a case for minimising the damage caused otherwise (see example in Section 21.4.4).
- For this, it is recommended to modify the agreements between the riparian states in a way to define the operation of the Vakhsh cascade with the purpose of optimising the situation for all parties concerned in mind, and the compensation to which Tajikistan would be entitled for applying such an operation scheme.

21.4.2 Impacts on Downstream Riparians

Changes in water availability in Amu Darya will impact the downstream riparian countries Afghanistan, Uzbekistan and Turkmenistan. As shown in Table 8-7, average annual water allocation is about equal for Uzbekistan with 21.4 km^3 and Turkmenistan with 21.0 km^3. Assuming that the relative shares will remain the same, any reduction in water availability would therefore result in a similar impact on both countries. As demonstrated in Section 21.2.3, a shift in seasonal flow pattern from summer to winter would have considerable negative impacts on downstream water users, since irrigated agriculture depends on summer flow in the main rivers.

Main concerns of downstream riparians are that Rogun would be operated in the same way as Nurek today, i.e. by using the live storage of its reservoir to full capacity in winter and to fill it in summer.

Downstream riparians have concerns that Rogun HPP would reduce summer flows. Those concerns are illustrated by Jalilov (2010) and Jalilov et al. (2011) who discuss the impact of Rogun HPP on the economy of Uzbekistan assuming a reduction in summer flow by 8.6 km^3, and by further assuming that the entire reduction would be to the detriment of Uzbekistan. They estimated a loss of an irrigated area of 506’000 ha, which would be a very substantial loss for the Uzbek economy.

However, in compliance with current agreements and practices, the intended mode of operation of Rogun HPP does not entail any change in the summer release pattern. Furthermore, as discussed above a maximum shift of water from summer to winter would create a number of difficulties for Tajikistan itself (see Section 21.2.3). Still, it is suggested that existing agreement between the riparian countries should be modified for taking into account the entire potential benefit of the project for all parties concerned.

There will still be a loss of annual flow of about 1.2 km³ in an average year (see Figure 21-2). However, this is entirely due to the fact that in future, Tajikistan intends to use its full water share in any case. Given the potential for improving irrigation efficiency, it should be possible to reduce water consumption in the downstream area by this amount. Furthermore, Afghanistan might increase its annual water consumption for irrigation by 3.5 km³. This will be a change in water availability for which there is no agreement in place, and which is not controlled in any way by BVO.

21.4.3 Potential for Improvement Through Resource Management

Water shortage regularly causes severe problems in dry years, especially in the lower reaches of Central Asian rivers. This situation could worsen in the future, given the fact that climate change is expected to have some negative effects, although overall precipitation will probably not diminish. However, rising temperatures will lead to an increase in evapotranspiration, the expected higher irregularity in precipitation could lead to an increase in the number of extremely wet and extremely dry years, and earlier snow melt will mean more water in spring and less in summer. Given this situation, a good resource management will be even more important than it is today.

According to UNDP (2005: 92), in Central Asia "water shortages are predominantly a management and incentive problem, not a resource problem". Four national policy areas of main importance are identified for improving water resources management, namely:

- maintenance of irrigation infrastructure,
- water pricing,
- increased reliance on ground water resources, and
- the engagement of communities in water management.

The need for better management of water resources is emphasised e.g. by the fact that overall in Central Asian irrigation schemes water consumption per hectare is 30% higher than e.g in Pakistan and Egypt.

The same UNDP report identifies annual losses in agricultural production in the Central Asian republics due to inefficient water management at 1.75 billion USD, as shown in the following Table. These losses are due to inadequacies in water availability, salinity, poor weed control and cultivation practices, soil compaction, leaching water, drainage problems and land abandonment.

Table 21-5: Estimated losses in agriculture due to inefficient irrigation (M USD/yr)

Country	Syr Darya basin	Amu Darya basin	Aral Sea basin	% of 2003 GDP
Kazakhstan	206	0	206	0.7
Kyrgyzstan	81	0	81	4.3
Tajikistan	58	112	170	10.6
Turkmenistan	0	378	378	6.1
Uzbekistan	390	529	919	9.3
Total	735	1'019	1'754	3.6

Source: UNDP 2005: 93

These figures clearly show the importance of an improved water resources management. It is also pointed out that, since many consequences of inefficient water management are shared with neighbouring countries, regionally concerted action by all countries would achieve maximum benefits for everyone.

21.4.4 Potential for Improvement Through Rogun HPP

As shown above, present water use systems are based on water availability in a normal year, i.e. in a year with approximately average flow. This inevitably leads to difficult situations in dryer than average years, and especially in extremely dry years, since there is no buffer for coping with this situation; Tyuyamuyun reservoir, which has a large storage capacity, is located far downstream and therefore of use only for a fraction of the irrigated areas (see Figures 8-8 and 8-20). This leads to severe losses in the agriculture, and therefore in the economy, of the affected countries (see calculation for areas lost in dry years in Table 21-4). In practice, in Uzbekistan such losses are especially severe in the lower lying parts of the irrigated areas, since schemes located more upstream have the tendency to use the water they require, irrespective of water availability further downstream. This means, that a dry year does not only cause impacts on agriculture, but also creates considerable regional differences, with increased difficulties and hardship for the population in regions located towards the downstream end of the entire system.

As was also mentioned already (Section 21.3.4.3), Rogun was originally planned for adding regulating capacity to the entire system, and especially for reducing problems in dry years by making additional water available under such conditions. Rogun HPP would have this potential, as already mentioned and as illustrated and discussed briefly below.

As mentioned, problems arise in dry years. "Dry year" always means reduced precipitation (mainly snowfall) in the catchment area, and therefore reduced flow of water from snow melt in the following vegetation period. When talking about dry years, three possibilities have to be considered, namely:

1. reduced precipitation in the Pyanj catchment;
2. reduced precipitation in the Vakhsh catchment; and
3. reduced precipitation in both catchments.

The most severe drought has to be expected in case 3; however, Rogun can only influence the flow in Vakhsh river, therefore only this part is taken into consideration here. The following Figure shows the situation for the year 1989, the driest year on record (when according to the TEAS cascade operation model the total Vakhsh cascade outflow was 12.2 km^3 as compared to the average value of 16.3 km^3).

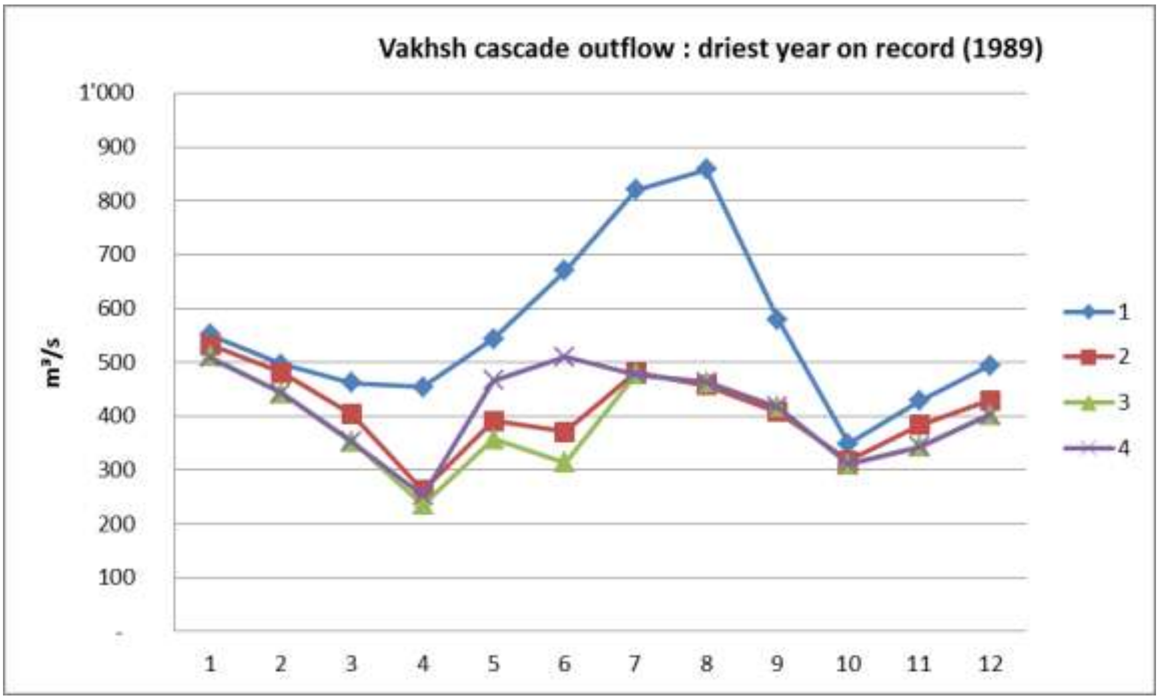

Figure 21-8: Vakhsh river flow, driest year on record

Cases shown:
1 = Flow in average year
2 = Flow in driest year, present situation
3 = Flow in driest year, future situation (Tajikistan fully using allocated water)
4 = Flow in driest year, with Rogun HPP in place. All cases include Nurek HPP

The Figure shows that in such a dry year, while winter flow changes only marginally, summer flows are reduced by a very considerable amount, which then translates directly into water shortage in the d/s areas.

The following Figure illustrates, to what extent Rogun HPP could provide compensation in such a situation. The basis for this are the flow figures from the same year as above, i.e. 1989.

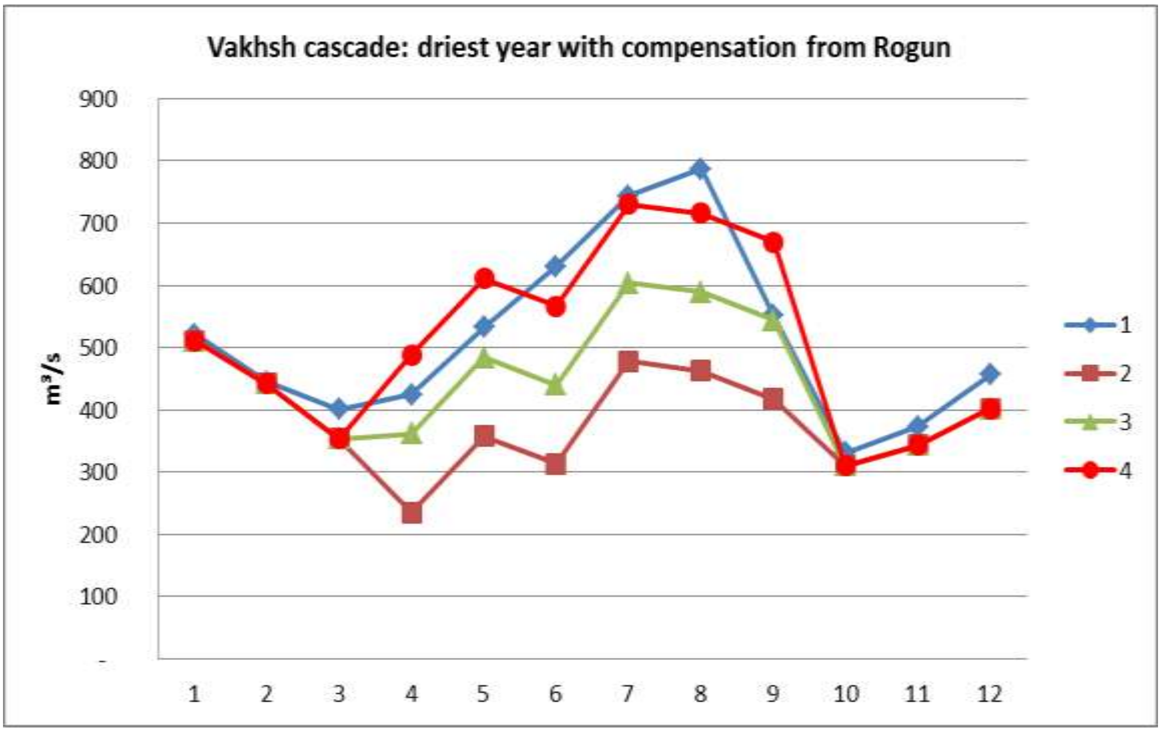

Figure 21-9: Dry year, compensation from Rogun HPP

Cases:
1 = Vakhsh flow in average year
2 = Vakhsh flow in dry year
3 = Vakhsh flow in dry year, additional 2 km³ made available from Rogun reservoir
4 = Vakhsh flow in dry year, additional 4 km³ made available from Rogun reservoir

Calculations for this Figure were made assuming that the additional amount of water made available by Rogun would be evenly distributed over the entire vegetation period April - September, with the same amount each month. Obviously, the system would allow for a better fine tuning according to requirements.

The Figure shows that Rogun HPP, if operated accordingly, would allow for a compensation of the water shortage in the Vakhsh catchment, either in part or fully, depending on the additional amount of water made available.

Two conditions need to be considered:

- This can only be done if at the beginning of such a dry season enough water is stored in the reservoir.
- It can compensate the effect of a drought in the Vakhsh catchment, but it would not be sufficient for completely compensating water shortage in the case of a similar drought in the (much larger) Pyanj catchment.

Even so, the Figure shows that Rogun HPP has the capacity of reducing negative impacts of a dry year to a considerable extent.

However, it has to be seen clearly that this could be disadvantageous to Tajikistan for the following reasons:

- Making available more water during one summer would require a different operation pattern, and it could potentially reduce winter energy generation.

- It would also require the possibility for refilling the reservoirs after such a dry year, which might require an amount of water which would be outside of current ICWC allocations.

This clearly shows that the Vakhsh cascade with Rogun, if operated accordingly, could have considerable advantages for all parties concerned, but that this would require modifications of existing agreements and practices between the states in the Amu Darya basin to efficiently manage flow between the countries. It is recommended to include Afghanistan in this process.

This seems all the more necessary in the light of a probable future development where, under changing climatic conditions, years with extremely high and extremely low flows are likely to occur more frequently than this was the case in the past.

21.5 Impact on the Aral Sea

21.5.1 Situation

The situation of the Aral Sea and the development that led to this situation was described in detail in Section 8.4. Only a few basic facts (derived mostly from Micklin et al., 2014) are shortly repeated here:

- Inflow: the total inflow (i.e. from Amu and Syr Darya combined) was stable (around 56 km³/yr) for the period 1911-1960. After that, with the construction of the Karakum Channel and the start of operation of the major irrigation schemes, inflow started to drop.
- This led to a shrinking of the surface of the Aral Sea, and at the same time to an increase in water salinity.
- The northern part located in Kazakhstan and receiving inflow from Syr Darya, the Small Aral Sea, was separated from the (originally much larger) southern part by a dam; it has been partly restored. Since it is now separated from the Amu Darya basin, it is no longer referred to here.
- In recent years, annual inflow to the "Large Aral Sea", the southern part, was between 0 (in dry years) and about 8 km³ (in wet years), with an average of about 5 km³. In dry years, all the water remaining in the Amu Darya downstream of the offtake of the Karakum Channel is used in the irrigation schemes in Turkmenistan and mainly Uzbekistan. In normal and wet years, surplus water reaches the Aral Sea.
- This inflow to the Aral Sea of 5 km³/yr on average is not sufficient for maintaining its present state; it is still shrinking.
- Since over 10 years, due to the increase in salinity, no more fish live in the Large Aral Sea. The only animals which survive so far are a few invertebrate species (crustaceans, brine shrimps) which are adapted to very saline water. The Large Aral Sea is on the way to turn into a water body like the Dead Sea.
- The only way to rehabilitate the Aral Sea would be by closing the major diversions and most irrigation schemes, in this way restoring former inflows. This would affect millions of people and the economy of Uzbekistan and Turkmenistan which depend on this water and its use.

21.5.2 Effect of Maximising the Shift from Summer to Winter

One argument sometimes brought into the discussion is the possibility that shifting summer to winter flows could contribute to an improvement of the situation in the Aral Sea, since in this case a larger overall amount of water might reach it, water that would otherwise be used in summer. However, this argument is not valid for the following reasons:

- While under such a regime more water than now might actually reach the Aral Sea in winter, it would also mean that summer inflows would certainly be reduced (from an average of 5 km^3/yr to 0, as is now the case in a very dry year, see Section 21.5).
- While the Large Aral Sea is almost dead, this is not (or at least not yet) the case for the remaining wetland areas in the former Aral Sea delta (see Chapter 8.3.2). However, this ecosystem can only survive as long as it receives water in summer.
- Under the present conditions it could well be that most of the water transferred to winter would be retained by reservoirs further downstream, for being used in the following summer. It seems possible that under such a changed regime the large Tyuyamuyun Reservoir, with its live storage capacity of 5.4 km^3, could be operated in a way as to be empty at the end of the vegetation period, for then being filled in winter so that the water could be used in the following summer in the irrigated areas downstream of it.
- In any case, even if the inflow to the Aral Sea were to increase by approximately 7.5 km^3/yr, this would still not be sufficient to noticeably improve the situation (see Section 8.4.5.3 for details).

21.5.3 Impacts of Filling and Operation

During the whole filling period a net loss of water for the Aral Sea equal to the volume of water retained in Rogun reservoir would result, corresponding to 0.83 km^3 out of 5.58 km^3/yr (average annual inflow to the Aral Sea over the last ten years). However, it has to be noted that this water will not reach the Aral Sea in any case as soon as Tajikistan will use its water share to full extent.

After the filling period, average net loss for the Aral Sea due to additional evaporation in Rogun reservoir is estimated by TEAS to only 4.6 m^3/s, which corresponds to 0.15 km^3/yr. Arguably, this loss can be considered as a consumptive water use by Tajikistan, which therefore needs to be comprised within its allocated share.

Assuming that irrigation practice (see Section 21.3) will remain the same as today, the three dam height alternatives that were studied would, in terms of impacts, only result in different volumes of water not discharged to the Aral Sea, as shown in the following Table.

Table 21-6: Water retention during filling period

Rogun Full Supply Level (FSL)	Stored volume at FSL	Filling duration	Average reduction of Amu Darya flow expressed as:		Average reduction of inflow to Aral Sea	
	(km^3)	(years)	volume[1] (km^3/yr)	% of average Amu Darya flow[2]	% of average present flow	% of natural (pre-1960) flow
1290	**13.3**	**16**	**0.83**	**1.35 %**	**15 %**	**1.6 %**
1255	8.5	13	0.65	1.06 %	12 %	1.3 %
1220	5.2	9	0.58	0.94 %	10 %	1.1 %

[1] Volume of water not released to the Aral Sea during the filling period under the three dam height alternatives
[2] without Zeravshan and Surkhandarya
in bold: TEAS recommended alternative

This means that for the TEAS recommended alternative, filling of Rogun reservoir will lead to a reduction of inflow to the Aral Sea by about 0.8 km^3/yr, and the full use of the water share by Tajikistan will reduce inflow by about 1.2 km^3/yr; this latter value includes the amount required for filling Rogun reservoir. Effects are shown in the following Figure.

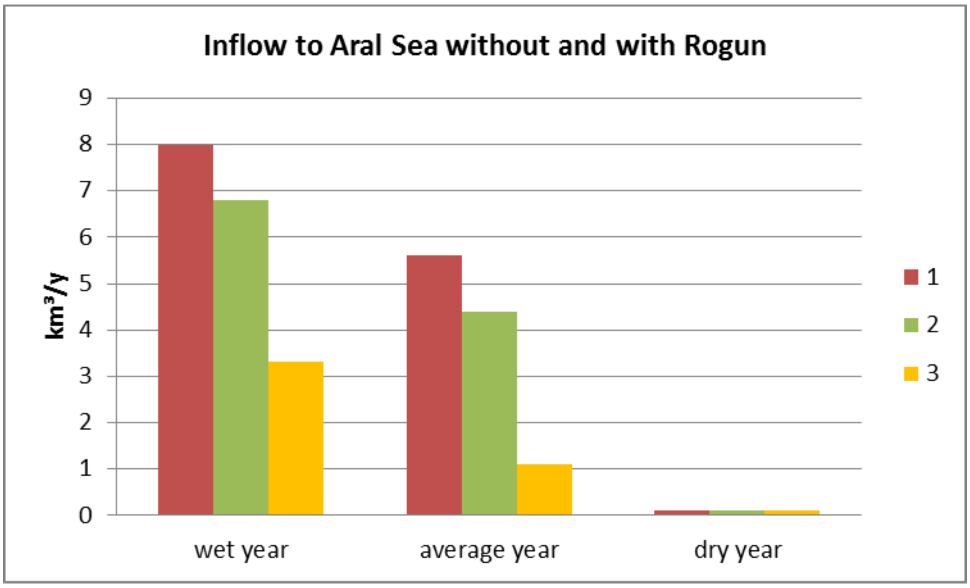

Figure 21-10: Impacts on Aral Sea inflow

1 = Present situation, with Nurek, Tajikistan not fully using its water share
2 = Future situation, Tajikistan fully using its water water share, **with or without Rogun**
3 = Future situation with Afghanistan increasing its irrigation from 2.5 km^3 to 6 km^3

This Figure shows the following:

1. Present situation, with Nurek in place and Tajikistan not using its full water share. Under these circumstances, the Aral Sea, over the last 10 years, has received about 5.4 km^3/yr on average, with up to 8 km^3 in a wet year and 0 in a

dry year (when the water not used by Tajikistan is used by the downstream countries).

2. Future situation, Tajikistan using its full water allocation. This would reduce flow in Amu Darya, and therefore inflow to the Aral Sea, by about 1.2 km³ in a wet or an average year, no difference in a dry year. It was mentioned above that during filling of Rogun reservoir (retention of 0.8 km³/yr) inflow to the Aral Sea would be reduced by about 15%. Full water use by Tajikistan (1.2 km³/yr) would result in a reduction by 22%. Under the proposed conditions for the Project, there will be no difference whether in this moment Rogun will exist or not.
3. It is anticipated that Afghanistan, which is not a member of ICWC, will in the middle term expand its irrigation activities in the Amu Darya basin, increasing its water consumption from now 2.5 to 6 km³ annually. This would result in a direct decrease of water inflow to the Aral Sea by 3.5 km³/yr (wet and average year).

This might seem like a rather enormous impact on the Aral Sea. However, for actually recognising the importance of the impact these figures must be seen taking into consideration the present situation of the Aral Sea. This was done in the last column of Table 21-6 and is illustrated in the following Figure (keeping in mind that here only the southern part, the "Large" Aral Sea is addressed).

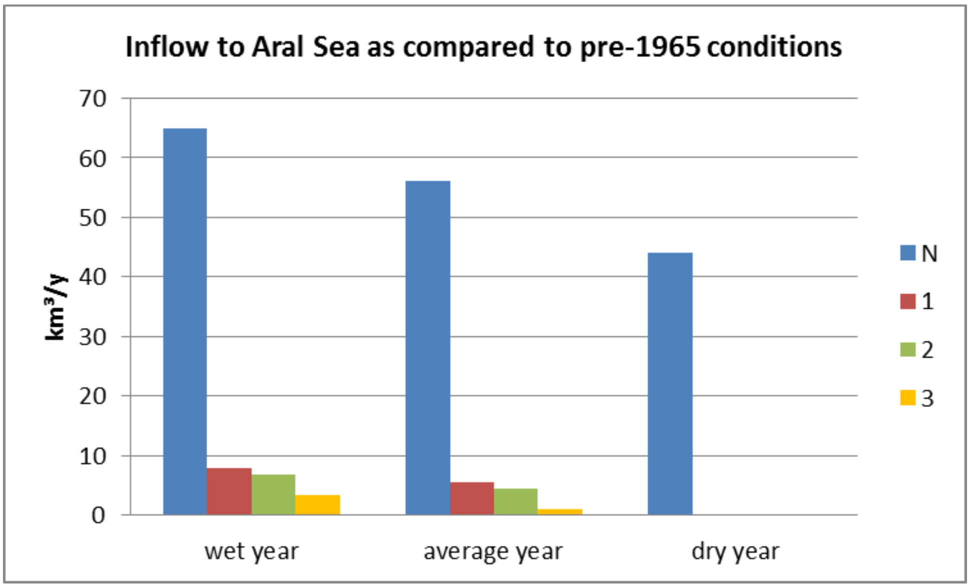

Figure 21-11: Impacts on Aral Sea inflow, comparison to pre-1965 conditions

N = Natural inflow (= pre-1965) conditions
1 = Present situation, with Nurek, Tajikistan not fully using its water share
2 = Future situation, Tajikistan fully using its water share, **with or without Rogun**
3 = Future situation with Afghanistan increasing its irrigation from 2.5 km³ to 6 km³

The Figure shows that presently, the Aral Sea receives, in wet and average years, about 10% of its former, natural inflow from Amu Darya (and considerably less in dry years). As explained in Section 8.4.5.3, this is not even enough for keeping it from further shrinking. A reduction as predicted here, as a consequence of increased water consumption in Tajikistan (within ICWC agreements) and Afghanistan (not covered in

ICWC agreements) would obviously not improve the situation of the Aral Sea, but it would also not make a relevant difference to the worse.

The main conclusions here are:

- Water inflow to the Aral Sea will be reduced by increasing water use; development in Afghanistan will play an important role in his respect.
- The reduction due to Tajikistan will take place independently of the question whether or not Rogun HPP will be built. Rogun HPP as such will have no influence.
- The reduction will not change the situation of the Aral Sea in any relevant way.
- It seems very important to include Afghanistan in the water allocation agreements of the Amu Darya basin, and this independently of the question whether Rogun would be built or not.

21.6 Conclusions and Recommendations

The two most important facts to be considered for the future water resources management in the downstream area are the following:

- In the mid-term, Tajikistan will be developing its irrigated agriculture, and it will use all the water allocated to it by the relevant international agreements, i.e. according to Protocol 566 and ICWC water allocation. This will take place with or without Rogun.
- As explained in detail in Section 21.3.3, Tajikistan intends to operate the cascade in a way as not to change the present Vakhsh seasonal flow pattern.

As was shown in Section **Error! Reference source not found.**, the main premises for ater use in the context of international river basins are the "equitable use" and the "no harm" principles. Future water use policies should consider:

- Tajikistan will use its full water share, i.e. the amounts of water allocated to it. Since these are agreed upon rules, which are accepted by all parties, this can certainly be considered as equitable use of the water resources, since this is exactly the purpose of allocating water shares to the parties of the agreements. And since this was agreed upon, this is without any doubt also in compliance with the "no harm" principle.
- Rogun HPP, and the entire Vakhsh cascade, will be operated within these accepted agreements and practises, and it will not affect water availability. Therefore, Rogun HPP will also be in compliance with the equitable use and the no harm principle of international water shares.

An additional dimension is maximising the benefits of Rogun for all involved parties. This would mainly consist in an improved regulation of floods by retaining surplus water under flood conditions, and, even more important, by making additional water for irrigation available in drought years, i.e. under conditions of acute water shortage. Such a regulation would be more efficient in Rogun than it could be in a downstream reservoir, e.g. in new reservoirs in Uzbekistan, for two main reasons:

- Being located upstream of all irrigated areas, it would offer the possibility of using the surplus water wherever needed most in the entire system; the opposite example here is Tyuyamuyun reservoir in Uzbekistan, which by capacity is the largest reservoir in the Amu Darya basin, but which due to its location near the lower end of the basin serves only a small part of the entire irrigated area.

- Given the fact that Rogun reservoir, like Nurek, is narrow and very deep, its surface in relation to the volume is rather small. In addition, it is located at elevations with comparatively low temperatures. These two facts lead to an evaporation from the reservoir surface which is considerably smaller than evaporation from large, shallow reservoirs located in desert areas with high ambient temperatures, as e.g. Tyuyamuyun.

Offering these services to the riparian countries could come at a cost to the operation of the cascade, and hence to the economy of Tajikistan. This could be managed by an agreement between the involved parties. Such agreements exist elsewhere, and apparently work well.

Independent of whether Rogun will be built or not, in the future conditions for the downstream countries Afghanistan, Turkmenistan and Uzbekistan could change due to the following development:

- Tajikistan may use its full water share of Vakhsh (approximately 1.2 km³ in addition to what it uses now), which would entail a "net loss" to them, not in the sense of existing regulations, since this is an accepted use by current ICWC allocations, but in practice, since this water so far could have been, and actually was used, at least in dry years. In normal and wet years, this would not be a problem, since this amount is far smaller than the "surplus water" which ultimately flows into the Aral Sea (5 to 8 or more km³ under normal and wet conditions).
- A possibly greater problem would have to be faced in the case where Afghanistan would increase its water consumption for irrigation, from now on average 2.5 to up to 6 km³ in the future (Table 21-4). This would mean another reduction in available water by 3.5 km³.
- This means that water availability for Turkmenistan and Uzbekistan could be reduced by up to 5 km³/yr. In a wet year, this would not really be a problem, since there would still be a sufficient amount of water; however, the inflow to the Aral Sea, under the same regime as now, would be reduced by that amount. In a normal year, there might still be a sufficient amount of water for irrigation, reducing the inflow to the Aral Sea to zero. In a dry year however, which already now is a problem, there would be an acute shortage of water. 5 km³/yr, under the present conditions (consumption of 17'000 m³ of water per ha) would correspond to the water needed for irrigating almost 300'000 ha, 18% of Turkmenistan's and Uzbekistan's irrigated area in the Amu Darya basin.
- This situation is likely to be aggravated over time by climate change effects, since the main expected impacts are earlier yearly peak flows (which can mean water shortage in late summer even in normal and wet years), and higher irregularities in overall precipitation (which could mean a more frequent situation of extremely wet and extremely dry years).

Rogun HPP, operated under the conditions defined in the present technical, environmental and social assessment studies, will not change this situation in any way. Mainly, it will not lead to an additional reduction in summer flows. On the other hand, it has a potential for regulating flows which could mitigate, at least to some extent, the impacts caused by dry years and climate change.

The point was made above that the conditions for water use and water distribution among riparian countries are given, are being followed and that Rogun HPP can be built, commissioned and operated within these rules. This, however, cannot be understood as the best possible solution. It was also pointed out that Rogun HPP will offer a potential for improving the situation, and that there is a need for changing the rules especially by including Afghanistan in the framework. In this situation, the following actions are recommended by the Consultant:

- The ICWC member states Kyrgyzstan, Tajikistan, Uzbekistan and Turkmenistan should modify existing agreements and practices to include operation of Rogun HPP in a way as to maximise benefits for all parties, like flood protection, additional water releases during dry summers and additional hydropower generation during exceptionally cold winters. Such an agreement would have to specify the use of the regulating capacity of the Vakhsh cascade for optimising downstream flows under extraordinary conditions.
- Efforts should be made to extend such an agreement by including Afghanistan, for being able to cope with water distribution and use issues in the Amu Darya basin in the future, for irrigation as well as for the possibility where Afghanistan would want to develop its own hydropower potential in its part of Amu Darya headwaters.

Although not related to Rogun HPP, the Consultant recommends that all parties (Tajikistan, Uzbekistan and Turkmenistan) could undertake efforts for improving the efficiency of their irrigation systems, e.g. by reducing seepage and infiltration losses, increasing efficiency of field irrigation, improving drainage for re-using drainage water, increase the use of ground water, switching to less water consuming cultures, etc., as also recommended by other authors as UNDP 2005, Khudaiberganov 2007, FAO 2013, Jalilov et al. 2011.

Since work on potential downstream effects (see Section 21.3) has clearly demonstrated the importance of the existing agreements, a number of elements to be considered in this respect are provided by the ESIA Consultant.

21.6.1 Proposed Operation Pattern for Vakhsh Cascade

The Vakhsh cascade, with Rogun HPP in place, can be operated in a way as not to change the present river flow pattern in the downstream area, and especially not to change the seasonal distribution of flows. Tajikistan intends to operate the cascade in this way. This means that building and operating Rogun HPP will not reduce water availability for irrigation by downstream riparians, considering that Tajikistan intends to use its full water share in any case. The importance of this measure for preventing damage to downstream riparians has been demonstrated above.

21.6.2 Conditions for Filling and Operation Phase

As demonstrated in the previous Sections, it is possible to develop and operate Rogun project in a way that the Vakhsh river seasonal flow pattern downstream of the cascade will remain unchanged, except that in the future, with or without Rogun, Tajikistan will use its full share of water allocated to it by ICWC, remaining in full compliance with

Nukus Declaration, Protocol 566 and the limits set by the ICWC. This means that building and operating Rogun HPP does not require any changes in presently applied agreements and practices.

Nevertheless, in order to avoid adverse impacts on downstream water availability during and after the reservoir filling period, a number of operation principles that were used to run the model need to be translated into a transparent and clear operation mode:

1. To commit officially to the following for the Rogun reservoir filling period:
    a. to fill Rogun in full compliance with its water share allocated by ICWC;
    b. to manage flow retention in Rogun in exceptionally dry years.
2. To commit officially to the following for the Rogun operation phase:
    a. to prepare management procedures of the Vakhsh cascade with Rogun that translate into operational terms the objectives to operate the cascade without changing the downstream seasonal flow pattern. These procedures should focus on not increasing the effect of the cascade on lower summer flows and higher winter flows;
    b. to consult the neighbouring countries through ICWC on these management procedures and adapt them if necessary in order to ensure transboundary adherence to the proposed procedures;
    c. to open discussions with neighbouring countries on (i) improving transboundary cooperation in the energy sector and (ii) the possibility to use Rogun for inter-annual regulation.
3. For both filling and operation periods, to strengthen hydrological monitoring and develop a transparent real-time Vakhsh cascade monitoring system publicly available from the internet[5] aimed at:
    a. demonstrating that the Vakhsh cascade and in particular Rogun is operated according to the commitments of Tajikistan;
    b. providing the public with these hydrological data as per the Aarhus convention;
    c. contributing to a stronger regional water management system.

21.6.3 Installation of an On-line Hydrological Monitoring

The strengthening of the hydrological monitoring system should include the following activities:

- To perform an independent technical and operational audit of the present Vakhsh basin hydrological monitoring system aimed at improving its reliability. The audit should (i) review the existing tools and the methods used to calculate Tajikistan's actual water use in comparison to ICWC water allocations, (ii) audit the accuracy and relevance of the existing tools and methods, (iii) propose an

[5] Example of large energy infrastructure releasing real-time environmental data on the web:
- Three Gorges dam, China, world's largest hydropower scheme: http://www.ctg.com.cn/inc/sqsk.php
- Grande Dixence dam, Switzerland, world's tallest concrete dam:
http://www.grande-dixence.ch/energie/hydraulique/valais/multimedia.html
- Zaporojie Nuclear Power Plant, Ukraine, world's second largest nuclear power plant: http://www.npp.zp.ua/ascro

"improved Vakhsh hydrology monitoring network" to bring the precision and the reliability of water use calculation to the level of international best practices. It is recommended that the auditors' team includes independent international experts, as well as one recognized hydrology expert from each of the ICWC countries.

- To consult the neighbouring countries through ICWC on the proposed "improved Vakhsh hydrology monitoring network" and adapt it if necessary in order to ensure transboundary adherence to the proposed network.
- Construction of the "improved Vakhsh hydrology monitoring network".
- The release of information to the public and to BVO (real-time and daily/monthly/annual statistics automatically calculated) shall in particular focus on the following data:
    - water level and volume stored in Nurek and Rogun reservoirs;
    - flows in the Vakhsh basin, at key points of the "improved Vakhsh hydrology monitoring network" identified by the auditors as critical for calculating the actual water use.

21.6.4 Flood Protection

As explained in Section 21.3.6, Rogun dam would have considerable positive effects on flood mitigation. On the other hand, risks, and mainly the case of a dam failure, need to be addressed. This has to be done in the form of an emergency plan, as outlined in Section 24.4 and in ESIA Vol. III (ESMP), Section 7.2.

21.6.5 Adapting the Amu Darya Basin Agreements

As demonstrated in the previous sections, it is **clearly possible to operate Rogun HPP in accordance with established rules and practices**, without creating any negative effects for riparian water users, **but there is also a considerable potential for operating it in a way that would enhance benefits to all water users**.

Enhancing the benefits, however, would likely require modifications in the existing agreements. The main points are the following ones:

- The possibilities, addressed shortly in Sections 21.3.4.3 and 21.4.4, should be evaluated in detail, and possibilities and consequences should be analysed and explained.
- The conditions under which such modified operation patterns would be applied need to be defined. This must include, but is not necessarily restricted to, water requirements of downstream riparians in dry years, losses incurred by Tajikistan when making available more water under such conditions, possibilities for retaining more water during wet years, etc.
- It is recommended that these new conditions be included in existing mechanisms, and that Afghanistan should be a partner in these negotiations and agreements.

- The institutional requirements for such mechanisms would have to be analysed; it can be assumed that ICWC could still be the main regulatory body, but modifications to its procedures and structures might be required.

22 ANALYSIS OF ALTERNATIVES

22.1 Key Messages

- Tajikistan has a high unmet demand for electricity, especially in winter, and should consider long-term security of supply through changes in energy policy and development of the hydropower resource.
- Tajikistan has a huge potential for hydropower, much of which has not yet been developed. On the other hand, it has very limited reserves of fossil fuels. Thus hydropower is the preferred option for generating electricity in the country.
- TEAS analysis established that the benefits of Rogun exceed those of other feasible HPPs and thermal plants. Regardless of which design option is chosen, Rogun will significantly enhance security of supply in Tajikistan throughout the entire forecasted period, contributing an average of approximately 30% of electricity needed to meet demand between 2020 and 2050.
- Concerns of downstream riparian countries regarding Rogun project would be applicable to other storage HPPs. Rogun HPP is preferable to other storage alternatives, as Rogun is located on the same river as Nurek, already operated to shift water from summer to winter.
- TEAS studies, which include environmental and social costs, recommend to take the FSL 1290 alternative (335 m high dam) with an installed capacity of 3200 MW (TEAS recommended alternative) forward for detailed consideration.
- The FSL 1220 alternative has a reduced energy output, a relatively short life span and it does not mitigate the Vakhsh cascade’s inability of handling PMF. Thus it offers no comparable advantages to the two higher dam alternatives.
- FSL 1290 and FSL 1255 alternatives differ considerably in the main environmental and social impacts and risks. In addition to the best economic results, the longer life span and the better flood and drought mitigation potential are strong arguments in favour of the FSL 1290 alternative. On the other hand, the lower potential for adversely influencing the downstream flow conditions, and mainly the fact that resettlement would be reduced by more than half are similarly strong arguments for the FSL 1255 alternative.
- Thus from an environmental and social point of view, there are strong arguments for and against each of these two alternatives, and important trade-offs have to be considered.
- Given the considerably longer life span of the FSL 1290 alternative, the higher electricity production and that the incremental environmental and social impacts can be appropriately mitigated, the ESIA consultant recommends to take the FSL 1290 alternative forward for detailed consideration.

22.2 Scope and Objectives of the Chapter

This chapter considers the strategic, technical and operational alternatives to the TEAS recommended project from an environmental and social point of view. After providing a general introduction discussing various energy supply options in order to eliminate winter shortages and meet growing demand for Tajikistan, the results of the technically and economically driven decision-making are briefly explained. Identified environmental and social concerns are highlighted and discussed. Thus the Chapter compares the TEAS recommended alternative FSL 1290 to a set of possible alternatives, including the No Rogun alternative.

22.3 Long Term Electricity Demand and Supply

22.3.1 Demand

In the TEAS studies (Phase II: Economic Analysis, March 2014) electricity demand is defined as required generation i.e. electricity consumption plus unserved demand and losses. The annual electricity demand of Tajikistan is estimated to grow from 21.85 TWh/yr in 2013 up to 53.9 TWh in 2050, taking into account demand side management as proposed in the World Bank study (Tajikistan’s Winter Energy Crisis: Electricity Supply and Demand Alternatives, November 2012). The total demand of Uzbekistan, Turkmenistan, Kyrgyzstan and Pakistan will increase from 239.1 TWh/yr in 2013 to 1'818.7 TWh/yr in 2050.

22.3.2 Supply Options

The World Bank study discusses various energy suppliers in order to eliminate winter shortages and meet growing demand:

- **Rehabilitation of hydropower plants**: rehabilitation or even upgrading of the 4950 MW existing installed capacity in the Tajik energy system is an effective and economic measure to mitigate power losses.
- **Thermal power plants**: thermal power plants operate independently of seasonal variation so that firm capacity is equal to the installed capacity. They can become operational faster, as long as the linked fuel reserves are ready to be exploited. However, thermal options are limited due to the fuel availability issues.
    - **Coal**: in Tajikistan there are at least three coal mines which can be used for fuel supply in the near future, a reason why GoT included coal-fired plants in the priority list to add much-needed firm capacity and support self-sufficiency.
    - **Natural gas**: a superior fuel for thermal generation is offered by natural gaz. Combined Cycle Gas Turbine (CCGT) plants show lower environmental impacts than coal-fired plants and can be built close to urban centers. At present there are no known, commercially viable reserves of natural gas in Tajikistan. Some prospecting is underway. Currently, the only source of natural gas to Tajikistan is imports.
- **Imports**: Tajikistan used to be part of the Central Asia Power System with a number of interconnections with Uzbekistan and the Kyrgyz Republic and, through Uzbekistan, to Turkmenistan. The possibility of imports from Uzbekistan is limited by difficult political and commercial obstacles. Imports from Turkmenistan are not possible at the given stage, as transiting electricity through Uzbekistan could not be agreed in the past. The transmission line via

Afghanistan could provide alternative electricity imports to Tajikistan. This supply option depends on the timely availability of the transmission infrastructure in Afghanistan and the construction of one or more gas-fired plants in Turkmenistan for electricity export.

- **Non-hydro renewable energy**: wind and solar, while options being developed in an increasing amount, are still rather expensive and not suitable for producing the requested amount of energy. It also has to be considered that the energy requirements of the country are highest in winter, which makes solar energy seem even less suitable. No information is available concerning the potential for geothermal energy.
- **Hydropower development**: Tajikistan has an enormous hydropower potential of which so far only 5% of the estimated technical potential has been developed. 22 run-of-river HPPs have been identified for development with an estimated total installed capacity of 13 GW. These are located in the Vakhsh, Zeravshan, Obi-Hingou and Pyanj river basins. Due to the low winter flows of these rivers, the contribution of such HPPs to meeting winter peak demand is limited, as firm capacity is equal to only about 25% of installed capacity.

Nevertheless, hydropower will remain the main supplier to the Tajik energy system for the long-term, but new approaches for identification, design and operation are needed for maximum value, including storage hydropower.

The TEAS studies (Phase II: Economic Analysis, March 2014) identified three different combinations of generation sources:

a) **No Rogun**: in the event the Rogun HPP would not be built, Dashtijum HPP could be developed. This storage HPP on the Pyanj River with a final installed capacity of 3200 MW would start to supply 800 MW in 2030. Thus early deployment of run-of-river HPPs would be needed. In the final years, several new run-of-river HPPs are required to meet the peak demand, as shown in **Error! Reference source not found.**a.

b) **No large storage hydro, with imported gas**: in the event that neither Rogun HPP nor Dashtijum HPP would be built, an alternative with imported gas for gas-fuelled generation was analysed, but this results in considerably higher system costs. (**Error! Reference source not found.**b).

c) **Rogun**: capacity development in Tajikistan relies mainly on Rogun in the early years, with both run-of-river and storage hydropower being added as peak demand increases above 7 GW from 2039 onwards, shown in **Error! Reference ource not found.**c.

For all scenarios, increases in demand would be mainly met by new hydropower capacities. However, the availability of the HPPs varies throughout the year due to varying water levels and is generally very low in winter for run-of-river schemes leading to a shortfall of supply. For the alternatives without Rogun there is more electricity production from run-of-river HPPs, generating a surplus of summer energy available for export.

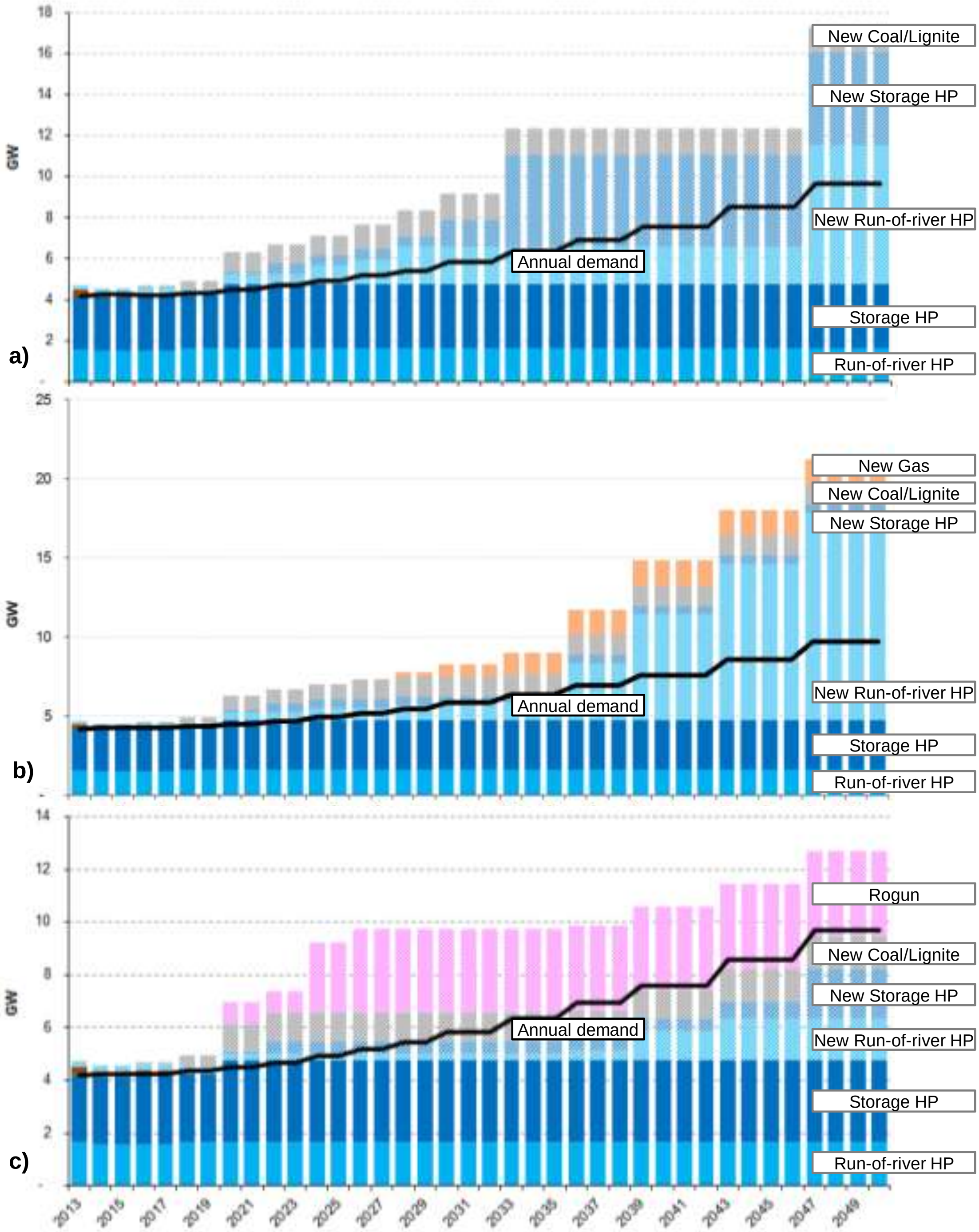

Figure 22-1: Tajikistan capacity mix by technology type

a) No Rogun
b) No large storage hydro, with imported gas
c) Rogun
Source: TEAS: Phase II: Economic Analysis, March 2014

22.3.3 Least Cost

TEAS studies (Phase II: Economic Analysis, March 2014) analysed what the Least Cost option is for meeting the domestic demand between 2014 and 2050. They used a regional power market modelling approach to quantify Total System Costs (TSC) in the interconnected Central Asian Power System and to determine the economic return of Rogun. A scenario in which Rogun is built and two scenarios in which it is not have been assessed. TSC for Tajikistan was defined as the sum of annualised capital expenditure repayments, non-fuel operating and maintenance costs, fuel costs and flood protection benefits, less the net financial benefits from net exports.

The TSC savings provided by Rogun compared to the no Rogun case range from approximately 1 to 1.5 billion USD, depending on the project configuration. Since Tajikistan has negligible known indigenous gas resources, an overall increase in the TSC for the “No large storage hydro, with imported gas” scenario compared to Rogun case results. Hence, the savings from Rogun are comparatively greater.

TEAS analysis established that the benefits of Rogun exceed those of other feasible HPPs and thermal plants. Regardless of which design option is chosen, Rogun will significantly enhance security of supply in Tajikistan throughout the entire forecasted period, contributing an average of approximately 30% of electricity needed to meet demand between 2020 and 2050.

22.4 TEAS Discussion of Alternatives of Rogun Project

This section analyses alternatives of the Rogun project with respect to varying dam heights and generating capacities.

22.4.1 TEAS Selection of Alternatives

According to TEAS studies (Phase II Report – Volume 1: Summary – Chapter 3.2: Selection of Site, Powerhouse, Dam Type and Alternative, April 2014), the dam site has not been reconsidered since 1981, as several reasons justify the selected dam site:

- **Topography**: the very narrow valley at the chosen dam site allows the construction of a high dam with a minimum quantity of filling material.
- **Seismicity**: the active Ionakhsh Fault along the river axis upstream of the chosen dam site precludes the implementation of a dam core across it. Moving the dam axis would place the dam in a tectonically less stable, and thus higher risk, area.

Besides, construction has already started. Alternative dam sites are not under discussion any longer and thus technically not considered as an option. Having considered the sensitivity to seismic events, possible mitigation measures, the risk related to salt dissolution in the Ionakhsh Fault, the sensitivity to Argillites / Siltstones / Mudstones, the sensitivity to differential settlement as well as the sensitivity to flood underestimate or inefficient spillway, TEAS recommends an earth fill dam with a central impervious core at the dam site considered in HPI 2009. Thus TEAS has undertaken a techno-economic assessment of three different dam heights and three different installed capacities for each of them:

Table 22-1: Alernatives for Rogun HPP studied by TEAS

Alternative	**FSL 1290**	**FSL 1255**	**FSL 1220**
Dam crest level	1300 m asl	1265 m asl	1230 m asl
Dam height	335 m	300 m	265 m
Total reservoir capacity	13’300 hm^3	8’550 hm^3	5’220 hm^3
Reservoir active storage	10’300 hm^3	6’450 hm^3	3’930 hm^3
Investigated installed capacities	2800 MW 3200 MW 3600 MW	2400 MW 2800 MW 3200 MW	2000 MW 2400 MW 2400 MW

TEAS studies have further investigated the proposed alternatives considering a number of design criteria:

- **Natural context**: all dam alternatives are designed according to international standards taking into account geological, seismic (including Maximum Credible Earthquake, MCE), hydrological (including Probable Maximum Flood, PMF) as well as sediment issues.
- **Existing assets**: existing facilities have been incorporated where appropriate.
- **Water sharing institutional framework**: HPP operation during filling phase as well as during operation was defined in accordance within the existing legal and institutional framework and established practices.
- **Environmental and social impact**: All environmental and social impact costs (Infrastructure Replacement and Resettlement Costs for Dam Alternatives, March 2014) had been taken into account for the estimation of the overall capital cost and are therefore reflected in the economic comparison of the alternatives.
- **Electricity demand forecast and market**: all alternatives allow electricity to be generated both to meet domestic demand and to provide export capacities. A detailed forecast of domestic demand growth, including assessment of currently unmet demand, ensured the adequacy of the alternatives for existing markets and their future trends.
- **Least cost expansion plan and economic analysis**: all alternatives provide significant Total System Cost Savings (TSCS) and generate positive Net Present Value (NPV) for assumed circumstances. All Rogun alternatives are well suited for meeting the electricity demand, especially in winter, and provide export potential.
- **Early generation concept**: due to the long construction period, each dam alternative requests an adapted sequence of commissioning of the power units to provide early generation of benefits during filling phase.
- **Project life span**: The annual inflow of sediments to the reservoir has been estimated to 62 to 100 hm^3/yr. The resulting ultimate reservoir life span, when no regulation is anymore possible, has been defined for all alternatives and taken into account in several technical assessments, as flood management, reservoir operation, economic evaluation etc.

22.4.2 TEAS Recommended Alternative

Potential future risks of all alternatives have been studied and addressed by TEAS. All projects generate the same list of risks, to be mitigated by adequate measures according to the indicated quality, safety, performance and sustainability requirements. Following reasons lead TEAS studies to the determination of the recommended project configuration:

- **Economic evaluation**: all alternatives are economically viable. FSL1290 alternative with an installed capacity of 3200 MW generates highest TSCS and NPV and thus is, from a purely economic point of view, the most beneficial.
- **Life span and economic analysis**: according to the least cost expansion plan as well as the economic analysis, FSL1290 alternative with the longest life span is the best option for low cost energy production to comply with Tajik power demand as well as potential regional energy exportation for the longest period.
- **Sustainability and long-term management**: alternatives with a longer life span are preferred. A de-commissioning fund is recommended for such a large asset, fed by a part of the benefits.
- **Water sharing institutional framework opportunities**: the operation of all alternatives complies with existing water sharing agreements and practices. FSL 1290 alternative provides highest potential for improved regional benefits in the water sector; this, however, might require modifications in existing agreements and practices.
- **Extreme flood safety of Vakhsh cascade**: today’s Vakhsh cascade is not capable of handling PMF. Only FSL 1290 and FSL 1255 alternatives can protect downstream assets against the PMF.
- **Climate change and carbon release avoidance**: the additional reservoir capacity for flow regulation available for FSL 1290 alternative has the greatest potential to bring more flexibility to handle increasing hydrological variability in future. Maximum hydropower output is estimated to bring highest carbon emission savings, when hydropower substitutes thermal based generation.
- **Installed capacity and peaking**: according to the least cost expansion plan the 3200 MW capacity is the most attractive, despite the reduced peaking and maintenance potential.

Considering the techno-economic assessments, TEAS recommends FSL 1290 alternative with an installed capacity of 3200 MW to be taken forward for detailed consideration.

Table 22-2: Main parameters of alernatives for Rogun HPP studied by TEAS

Parameter	Unit	FSL 1290			FSL 1255			FSL 1220		
TEAS studies[1]										
Technical										
Dam height	m	335			300			265		
Maximum head	m	320			285			250		
Rated head	m	285			210			190		
Reservoir active storage	hm^3	10'300			6'450			3'930		
Total reservoir capacity	hm^3	13'300			8'550			5'220		
Area at FSL	km^2	170			114			68		
Dam construction time	yr	~14			~12			~10		
Filling period	yr	16			13			9		
Minimal operating lifetime[2]	yr	115			75			45		
Cascade PMF mitigation[3]		yes			yes			no		
Total installed capacity	MW	3600	3200	2800	3200	2800	2400	2800	2400	2000
Number of units	N	6	6	6	6	6	6	6	6	6
Energy (average year)										
Annual energy production										
Rogun (Scenario a[4])	TWh	14.4			12.4			10.1		
Cascade (Scenario a)	TWh	35.3			33.3			31.0		
Rogun (Scenario b[4])	TWh	14.4	14.3	14.1	12.4	12.3	12.1	10.1	10.0	9.8
Cascade (Scenario b)	TWh	34.4	34.3	34.1	32.5	32.4	32.2	30.2	30.1	29.8
Annual firm energy[5]										
Rogun (Scenario a)	TWh	9.3			7.9			5.9		
Cascade (Scenario a)	TWh	22.8			21.7			20.1		
Rogun (Scenario b)	TWh	9.3	9.3	9.3	7.9	7.9	7.9	5.9	5.9	5.9
Cascade (Scenario b)	TWh	22.4	22.4	22.4	21.2	21.2	21.2	19.6	19.6	19.6
Economy										
IProb. weight. Economic NPV	M$	795	835	825	699	722	701	618	613	575
ESIA studies										
Effects on riparians[6]										
Annual flow Vakhsh	km^3	17.2			17.2			17.2		
Annual flow Amu Darya	km^3	58.2			58.2			58.2		
Intended operation										
Summer flow Vakhsh	km^3	9.3			9.3			9.3		
Summer flow Amu Darya	km^3	37.4			37.4			37.4		
Maximising winter energy										
Summer flow Vakhsh	km^3	2.0			2.9			5.4		
Summer flow Amu Darya	km^3	30.0			30.9			33.5		
Resettlement										
Villages	N	77			36			25		
Households (HH)	N	6'035			2'433			1'825		
Persons (PAPs)	N	42'000			18'000			13'000		
CO_2 emission[7]										
Hydropower 8 t CO_2/GWh [8]	Mt CO_2	0.11	-	-	0.10	-	-	0.08	-	-
LNG CC 466 t CO_2/GWh [8]	Mt CO_2	6.71			5.80			4.71		
Petrol 691 t CO_2/GWh [8]	Mt CO_2	9.95			8.57			6.98		
Coal 949 t CO_2/GWh [8]	Mt CO_2	13.67			11.77			9.58		
Relations										
Submerged area per MW	ha	4.7	5.3	6.1	3.6	4.1	4.8	2.4	2.8	3.4
PAPs per MW	N	11.7	13.1	15.0	5.6	6.4	7.5	4.6	5.4	6.5
Submerged area per GWh/yr	ha	1.2	-	-	0.9	-	-	0.7	-	-
PAPs per GWh/yr	N	2.9			1.5			1.3		

[1] TEAS: Phase II Report – Volume 1: Summery, April 2014;
[2] see explanations in Section 21.4.1;
[3] FSL 1220 can handle PMF, but cannot not assure safety of the Vakhsh cascade without considerable further investments;
[4] Scenario a = current status extrapolated , Scenario b = furture total use of Tajikistan's water share (see Section 21.3.4.2);
[5] Firm energy = guaranteed available energy generation (95% of exceedance power);
[6] GoT: Future Tajik withdrawal of 4.9 km^3 and return flow of 2.0 km^3 in summer for an average year (2005-2011);
[7] CO_2 emission if the same amount of energy would be produced by alternative energy sources;
[8] Emission coefficients (IPCC 2011, Central Research Institute of the Electric Power Industry of Japan)

22.5 Environmental and Social Assessment of Alternatives

The evaluation procedures and resulting statements by World Bank and TEAS studies cited above remain to be assessed from an environmental and social point of view:

- **Long Term Electricity Demand and Supply:** World Bank’s recommendation to Tajikistan to create a new basis for long-term security of supply through changes in energy policy and development of the hydropower resource is supported from an ESIA point of view. Thermal power plants would result in a considerable consumption of the selected fossil fuel and thus in an increase of greenhouse gases (GHGs) emission. Table 22-1 shows the roughly estimated average annual CO_2 emissions for different energy suppliers, including corresponding life cycle. Emissions from hydropower stem mainly from construction (manufacturing steel and cement, transports including on-site transport of dam material) and from decomposing submerged biomass in the reservoir area. It can be seen that hydropower ranks very favourably in comparison to all fossil fuel options, causing annual CO_2 emissions of about 1000 t/yr or less as compared to emissions between 5 and 14 million t for the fossil fuel options. Using hydropower to generate future energy is therefore an effective way for preventing GHG emissions. Furthermore, hydropower is a locally available energy source, while most fossil fuels would need to be imported, causing high fuel acquisition costs as well as a dependency of Tajikistan from its suppliers.

  No Rogun would incur significantly higher costs to meet Tajikistan’s medium and long-term energy needs. Taking into account the lack of identified fossil fuels and the abundance of water resources, hydropower is the obvious option. Important considerations related to power supply with Rogun HPP are the following:

  - With a construction period of 16 years Rogun HPP is not a short-term solution to mitigate the energy supply problems of Tajikistan. Still, in the fourth year after the start of construction, the units 5 and 6 in their first step arrangement would start producing electricity, in this way contributing to reduce the supply deficit in winter. As soon as Rogun regulation capacity will start to be used in the seventh year after construction start, the winter energy produced will progressively increase.
  - Shurob HPP, a run-of-river HPP envisaged to be built between Rogun power house and Nurek reservoir of about 850 MW, cannot be built without Rogun in place, since its small reservoir would be filled in a very short time. With Rogun, Shurob would be an additional power source in the Vakhsh cascade with almost no negative environmental and social impacts.
  - Projects located on border rivers, as the Pyanj River, require coordination with the neighbouring countries, which adds an element of uncertainty about timing as well as legal framework for these projects.
  - Tajik rivers have a seasonal flow pattern with high flow in summer and low flow in winter. As Tajikistan is not well interconnected to other potential suppliers, only storage HPPs can address the electricity supply

problem in winter in an efficient way. Thus run-of-river HPPs should be implemented downstream of storage facilities.

  - Given the hydrography of Central Asia, all Tajik hydropower facilities are in the headwaters of one of the tributaries of the Aral Sea, and most of them in the Amu Darya basin, as e.g. Dashtijum HPP envisaged as a potential storage plant to be built on Pyanj River. Thus every storage project in Tajikistan has the potential to influence the seasonal distribution of downstream flows, leading to the risks and opportunities for riparian countries discussed in Chapter 21.

  Concerns of downstream riparian countries regarding Rogun project would be applicable to other storage HPPs. Rogun HPP is preferable to other storage alternatives, as Rogun is located on the same river as Nurek, already operated to shift water from summer to winter. Winter energy output can be considerably increased by using today’s storage capacity, the Vakhsh river flow pattern remaining unchanged and in full compliance with Nukus Declaration, Protocol 566 and within the limits set by the ICWC. Any new storage capacity on another river, e.g. the Dashtijum HPP on Pyanj River, would result in additional transfers from summer to winter in order to meet similar winter energy output as generated by Rogun HPP, asking for reconsideration of today’s agreements and practice.

- **TEAS selection of alternatives:** alternative dam sites were investigated during the feasibility study, when the project was originally developed. Namely, potential dam sites further upstream were evaluated at that time. Main reasons for the choice of the site were seismic risks, which would be greater at locations further upstream. According to TEAS studies, the dam site has not been reconsidered since 1981, as topographic and seismic reasons justify the given dam site. Besides, construction has already started. Alternative dam sites are not under discussion any longer and technically not considered as an option. There are no major concerns from ESIA about the dam site selection, as neither environmental, nor social impact could be reduced by another site.

- **TEAS recommended alternative:** as mentioned in Section 22.4.2, TEAS recommends FSL 1290 alternative with an installed capacity of 3200 MW to be taken forward for detailed consideration. The FSL 1220 alternative, even though economically viable, can be excluded from further assessment. Besides the reduced energy output and the short life span, it does not mitigate the Vakhsh cascade’s inability to handle the PMF.

  No Rogun, FSL 1255 and FSL 1290 alternatives are assessed from the environmental and social point of view in the following sections, reflecting mainly reservoir sedimentation, flood safety, resettlement issues as well as potential effects on riparian countries.

22.5.1 No Rogun Alternative

Apart from the impacts associated with the construction and operation of substitute projects, not building Rogun, which corresponds to the present situation as described in Part A of this report, would have the following consequences:

- **Energy production**: in the absence of Rogun higher cost electricity would be needed to meet Tajikistan's demand. Furthermore, Tajikistan could not receive income from energy export.
- **Sedimentation**: a benefit of Rogun dam is the retention of sediments in order to increase the life span of Nurek scheme. Without Rogun dam, no mitigation for sedimentation of Nurek reservoir would be in place.
- **Probable Maximum Flood**: today's Vakhsh cascade is not designed to handle PMF. TEAS studies estimate the overall investments for immediate implementation of large upgrading works on the existing spillway structures of the cascade up to 1 billion USD, if Rogun would not be built.
- **Biological environment:** without Rogun, terrestrial habitats in the reservoir area would remain without impact and no offset would be required. Rogun is not expected to have an impact on the downstream hydrological regime and thus no change for downstream protected areas, e.g. Tigrovaya Balka, and fish habitats would be expected in any case. The potential for fisheries development in Rogun reservoir could not be developed.
- **Local population and socio-economy**: without Rogun reservoir, none of the infrastructure in the reservoir area would be affected, and there would be no need to replace them. Investments already made in the past (Soviet period and recently), when construction of the HPP and the connection roads started, would be lost. The (remaining) jobs on site would be lost, and the expected economic boost for the region would not take place. Rogun town would probably be abandoned. As a majority of the population of Tajikistan is shareholder of the project, a compensation strategy would have to be considered.
- **Rogun site decommissioning**: as there would be no need for further investment in this project, funds earmarked for Rogun HPP could be used for other purposes. There would remain a need for some extra activities, as e.g. securing and dismantling of the construction site. As there has been a considerable amount of preparatory work already undertaken at the Rogun site, and in the event that the project does not proceed, the construction site would have to be safely decommissioned. The cost of doing so has been estimated by TEAS studies at up to 356 million USD, including 133 million USD for resettlement and environmental costs.
- **Resettlement**: without Rogun, resettlement in the reservoir area would not be required. Costs for resettlement undertaken so far would be lost. The situation of a number of persons, already resettled during Stage 1, would have to be reconsidered. There would still be a need for support by the Resettlement Unit, as abandoning the Project Affected Persons (PAPs) would not be an acceptable strategy. Furthermore, the possibility of postponing the Rogun project for another not defined number of years would again create a situation of high uncertainty for the local population. Considerable investigations would be required in the area to allow it to catch up on the almost 30 years without development activities in the entire region.
- **Effects on riparian countries**: The Vakhsh river flow pattern downstream of the cascade will remain unchanged for all alternatives, under the intended operation regime, except that in the future, with or without Rogun, Tajikistan

will use its full share of water allocated to it by ICWC. In this way, water use by Tajikistan, with or without Rogun, will in any case remain in full compliance with Nukus Declaration, Protocol 566 and the limits set by the ICWC. However, no Rogun would prevent, on the one hand, the risk of an unilateral change of the Vakhsh river flow pattern by storing more water in summer to produce more energy in winter and, on the other hand, the opportunity for improved transboundary cooperation in the Amu Darya basin by increasing flow in drought periods and reducing it during flood season, as discussed in Chapter 21.

The No Rogun alternative has the main advantages of not increasing today's potential to change downstream flow regime, unless the alternative project is a storage HPP, and thus the potential negative effects on riparian countries, as well as the potential of reducing resettlement and submergence of agricultural land. However, Vakhsh river is already highly regulated, since the effects of Nurek dam on the same river will persist in any case. The opportunity for improved transboundary cooperation in the Amu Darya basin due to the increased storage capacity cannot be achieved without Rogun, unless an alternative storage project is constructed. Furthermore, the cascade life span and PMF concerns are not addressed and would ask for alternative interventions. Given the Tajik need for electricity supply, an alternative solution for the energy problem would have to be sought, and the potential impacts compared to the Rogun project therefore would have to be considered. Furthermore, job losses and the lack of creation of new jobs in case Rogun construction would be abandoned would have negative impacts on local economy.

22.5.2 In-depth Comparison of FSL 1290 and FSL 1255 Alternatives

The Rogun alternatives only differ by their reservoir size as well as installed capacity, whereby the latter is less relevant from the point of view of environmental and social impacts. As shown in Table 22-2, the two alternatives

- FSL 1290 of 13'300 hm^3 total reservoir capacity, 170 km^2 surface area at FSL,
- FSL 1255 of 6'450 hm^3 total reservoir capacity, 114 km^2 surface area at FSL

present a different potential for causing environmental and social impacts:

- **Hydrology:** the larger reservoir with a higher storage capacity has a higher potential to influence downstream flow pattern.
- **Sediments:** the smaller the reservoir, the smaller is its capacity for sediment retention and the shorter the life span of the scheme as well as the cascade.
- **Biological environment:** the higher the FSL is, the larger the area submerged, and accordingly the effect on vegetation and fauna. However, the area to be submerged is strongly influenced by human use (settlements, agriculture, and livestock husbandry) and does not contain any especially valuable or rare habitats. Thus the impact on fauna and vegetation is of minor importance. Both alternatives do not affect protected areas. Still, an offset will be required for both alternatives. In any case, as the investigations have shown, the local fish fauna is very poor in terms of biomass and diversity, and of marginal economic importance. Any fish migration, which might have taken place in the past, was stopped by Nurek dam.

- **Human environment and resettlement:** as was already stated in the Screening Report, a major issue of the Rogun project is the impact on the human environment. Reservoir size will have a direct effect on the magnitude of the socio-economic impact (including the loss of additional agricultural land, already taken into account in the economic evaluation) and the required resettlement. For Rogun, this effect is marked since in the higher area of the reservoir, around Komsomolobod and Nurobod, the valley is wider and more densely populated. An increase in reservoir size will lead to an increase in resettlement from 18'000 to 42'000 persons.
- **Energy production:** FSL 1290 alternative results in an increase of electricity production of about 2 TWh/yr compared to the FSL 1255 alternative.

From geological, seismic and climate change perspectives there is not a significant difference between the two alternatives.

22.5.2.1 Reservoir sedimentation

TEAS (Phase II: Project Definition Options – Volume 2: Basic Data – Chapter 6: Sedimentation, March 2014) has determined the yearly sediment input into the reservoir to be in the order of magnitude of 62 to 100 hm³. This range of uncertainty could not be narrowed at the present stage of the studies. To be on the safe side, for the economic analysis the most conservative, i.e. highest, value was used, which led to the estimated life span of the alternatives mentioned in Table 22-2. Considering a 100 hm³/yr sediment inflow, the life expectancy would be 45, 75 and 115 years respectively for the three dam heights. Considering a 62 hm³/yr sediment inflow, the life expectancy would be 80, 120 and 200 years respectively for the three dam heights.

Both alternatives are economically viable and provide acceptable life spans. The life span difference between the two alternatives would be between 40 and 80 years. From an economic point of view, TEAS states that FSL 1290 alternative, providing the longest life span, is the best option for low cost energy production to comply with Tajik power demand as well as potential regional energy exportation for the longest period. In this respect again, alternatives with a longer life span are preferred.

22.5.2.2 Flood Safety Issues

The presence of a large reservoir with corresponding operation and spillway capacities provides flood mitigation opportunities, but increases the risks of artificial floods due to inappropriate operation, and would have the potential to cause larger damage in the worst case scenario of a dam failure. According to TEAS, the Vakhsh cascade as presently operating, including Nurek dam, is not capable of handling a Probable Maximum Flood (PMF); the FSL 1220 alternative would not be able to protect the cascade in case of a PMF, significant investment on the cascade would have to be made for this purpose. However, both the FSL 1290 and the FSL 1255 alternatives allow safe PMF evacuation for the entire cascade.

The construction of Rogun reservoir improves flood routing capacity for the area downstream from the Vakhsh cascade. This positive effect can be increased by appropriate flood management. Besides PMF, adding Rogun to the cascade would also reduce risks of floods of lower magnitude, but higher probability of occurrence. Under the intended operation mode, the flood routing capacity of floods of an occurrence probability of 1/10 or 1/100 would be the same for both alternatives since the winter drawdown of the Rogun reservoir would be 4.4 km^3 in both cases. However the FSL 1290 alternative might offer a greater flood retention potential in case of appropriate flood management measures, including preventive drawdown

As already discussed in Chapter 21.3.5 about flooding due to Rogun operation, dam break scenarios and the downstream impacts are to be studied in the framework of a the emergency preparedness plan. Flood wave propagation from a dam break scenario would have dramatic impacts on downstream areas for all alternatives.

22.5.2.3 Resettlement

The increase in reservoir size has a considerable effect on resettlement. As shown in Table 22-2, the two alternatives

- FSL 1290 requesting a resettlement of 42’000 PAPs or 6’065 households,
- FSL 1255 requesting a resettlement of 18’000 PAPs or 2’433 households

generate social impacts of considerably different magnitude, as emphasised in the following Figure.

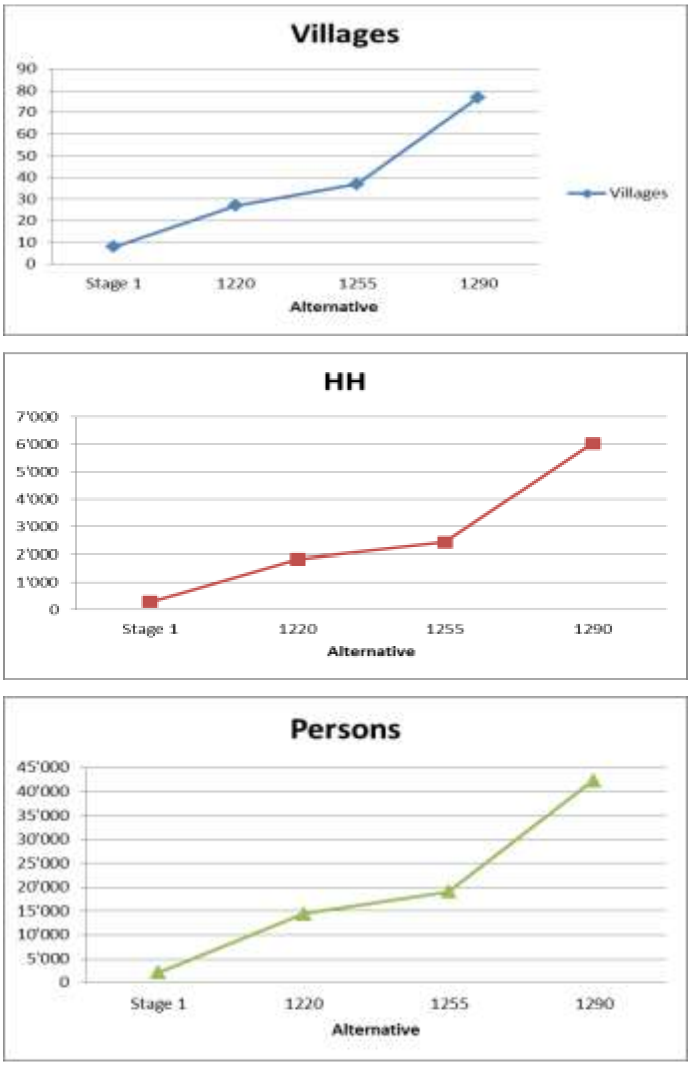

Figure 22-2: Differences in resettlement depending on alternatives

For the definition of the resettlement of the alternatives, all villages below the respective FSL of the reservoir have been included in the assessment. A resettlement of a number of villages above the FSL will be required due to expected flood level as well as issues related to accessibility; this was also taken into account.

The number of PAPs raises with increasing FSL. For Rogun reservoir this increase is not linear. While the difference between FSL 1220 and FSL 1255 is of about 5’000 PAPs, a resettlement of an additional 24’000 PAPs is caused by the FSL increase from 1255 to 1290 m asl. This is due to the valley shape, being wider in the upper part, with gentler slopes, and thus more densely populated. The FSL 1255 alternative would therefore result in reduced resettlement. By contrast, the FSL 1290 alternative will require a significant institutional commitment over a longer period of time.

22.5.2.4 Effects on Riparian Countries

Under the intended filling and operation mode of Rogun (as described in Chapter 21), there will be no significant difference between the FSL 1290 and FSL1255 alternatives.

Nevertheless, a larger storage volume would allow higher flow transfer from the high flow season (summer, vegetation period) to the low flow season (winter, non-vegetation period) for maximising winter energy output, as addressed in Section 21.2.3. Table 22-2 indicates vegetation and non-vegetation period flows in the lower reaches of Vakhsh river and in Amu Darya for the given scenario for an average year. Regarding the future Vakhsh summer flow without Rogun of 9.1 km^3, both alternatives

- FSL 1290 with a potential to reduce average Vakhsh summer flow to 2.0 km^3,
- FSL 1255 with a potential to reduce average Vakhsh summer flow to 2.7 km^3

would have a high potential to generate adverse impacts on Vakhsh flow pattern and thus on water availability for irrigation along the Amu Darya. Even though there would be little difference between FSL 1290 and FSL 1255 for low or average summer flows, the potential to modify downstream flow pattern is higher for FSL 1290 than FSL 1255 for wet summers.

While FSL 1290 alternative constitutes a higher risk for retaining more water in wet summers, it also offers a higher potential for improving the situation by making its regulative capacity available for providing additional water for irrigation in dry years, as addressed in Section 21.3.

22.5.3 Comparison of Environmental and Social Impacts of Rogun Alternatives

Table 22-3 compares in detail a wide range of environmental and social impacts of the No Rogun as well as the FSL 1290, FSL 1255 and FSL 1220 alternatives.

Table 22-3: Comparison of environmental and social impacts of alternatives

Positive impact: lowest / intermediate / highest — Negative impact: lowest / intermediate / highest — Relevance of topic: low / medium / high

No.	Rel.	Topic	General comments	No Rogun	FSL 1220	FSL 1255	FSL 1290	Conclusion
1	**Geology**							
1.1		Sedimentation, erosion	Mobilization of alluvions along reservoir: increase with reservoir size	no	lowest	intermediate	highest	In favour of no Rogun; no rel. difference between FSL
			Loose construction material (gravel) piled up and exposed to erosion	Increase of sedimentation in Nurek	no impact on Nurek	no impact on Nurek	no impact on Nurek	In favour of 1220, 1255 and 1290; no relevant difference between alternatives
1.2		Reservoir sedimentation	Minimum life span of Rogun reservoir (sediment supply of 62 to 100 hm^3/yr)	no impact on Nurek	~45 to 80 years	~75 to 120 years	~115 to 200 years	In favour of 1255 and 1290
			Life span of Nurek reservoir (9 km^3) (sediment supply of 62 to 100 hm^3/yr) [2]	~90 to 145 years	~135 to 225 years	~165 to 265 years	~205 to 345 years	In favour of 1255 and 1290
1.3		Seismicity	Reservoir triggered seismicity: Higher damage potential for high dam	no	lowest	intermediate	highest	In favour of no Rogun; increasing risk with increasing FSL
2	**Climate**							
2.1		Impact on local climate	Reservoir too small for impact on local climate in any case	no	no	no	no	No argument for either alternative
2.2		GHG emissions	No relevant GHG emissions from reservoir to be expected in any case	no	no	no	no	No argument for either alternative
			CO_2 emssions for substitution of Rogun HPP FSL 1290 alternative (14.4 TWh/yr):	Substit. of 14.4 TWh/yr	Substit. of 3.5 TWh/yr	Substit. of 2.0 TWh/yr	Substit. of 0.0 TWh/yr	In favour of 1220, 1255 and 1290
			Rogun HPP	0.0 Mt/yr	0.1 Mt/yr	0.1 Mt/yr	0.1 Mt/yr	
			Rogun substitution by other hydropower	0.1 Mt/yr	~0.0 Mt/yr	~0.0 Mt/yr	0.0 Mt/yr	
			Rogun substitution by LNG CC	6.7 Mt/yr	2.0 Mt/yr	0.9 Mt/yr	0.0 Mt/yr	
			Rogun substitution by petrol	13.8 Mt/yr	4.1 Mt/yr	1.9 Mt/yr	0.0 Mt/yr	
			Rogun substitution by coal	13.7 Mt/yr	4.1 Mt/yr	1.9 Mt/yr	0.0 Mt/yr	
2.3		Climate change	Performance to mitigate irregular inflow conditions due to climate change	low	low	high	high	In favour of 1255 and 1290

Positive impact: lowest | intermediate | highest   Negative impact: lowest | intermediate | highest   Relevance of topic: low | medium | high

No.	Rel.	Topic	General comments	No Rogun	FSL 1220	FSL 1255	FSL 1290	Conclusion
3	**Water**							
3.1	high	Vakhsh flow pattern during reservoir filling phase	Changes in river flow d/s of the cascade according to Reservoir Operation Studies (remaining share <1.21 km^3/yr)	no	Partial use of Tajik share (+0.58 km^3/yr)	Partial use of Tajik share (+0.66 km^3/yr)	Partial use of Tajik share (+0.83 km^3/yr)	In favour of no Rogun; no relevant difference for d/s users, as TJK using full share in any case
	high	Vakhsh flow pattern during operation phase	Changes in river flow d/s of the cascade according to Reservoir Operation Studies (remaining share <1.21 km^3/yr)	Full use of Tajik share (+1.21 km^3/yr)	Full use of Tajik share (+1.21 km^3/yr)	Full use of Tajik share (+1.21 km^3/yr)	Full use of Tajik share (+1.21 km^3/yr)	No argument for either alternative
3.2	low	Residual flow	Need for a residual flow between Rogun and Nurek	no	need	need	need	In favour of no Rogun
3.3	low	Water quality	Risk for water pollution during construction	depends on site restoration	lowest	intermediate	highest	Slightly increased risk with increasing FSL
3.4	high	Flood protection	Mitigation of cascade's PMF deficit	no	no	yes	yes	In favour of 1255 and 1290
	high		Flood routing potential	no	lowest	intermediate	highest	In favour of 1255 and 1290
4	**Vegetation**							
4.1	low	Vegetation types and habitats	Submergence of already degraded habitats in project area	no	68 km²	114 km²	170 km²	In favour of no Rogun
4.2	low	Flora	Impact on protected, rare or endemic species	none	small negative	small negative	small negative	In favour of no Rogun; no relevant difference between alternatives
5	**Terrestrial fauna**							
5.1	low	Species	Impact on terrestrial fauna in project area	none	small negative	small negative	small negative	In favour of no Rogun; no relevant difference between alternatives
5.2	medium	Habitats	Submersion of floodplains: Komsomolobod (small) Nurobod (large)	 no no	 yes partially	 yes yes	 yes yes	In favour of no Rogun
6	**Aquatic fauna**							
6.1	low	Fish species	Impact on (largely reduced) fish fauna	no	no	no	no	No argument for either alternative
6.2	low	Fish migration	Reduction of fish migration u/s of Nurek	no	small	small	small	Sligthly in favour of no Rogun
6.3	low	Fishing in Nurek reservoir	Potential impact on trout population in Nurek	no	yes	yes	yes	Sligthly in favour of no Rogun

Positive impact: lowest | intermediate | highest   Negative impact: lowest | intermediate | highest   Relevance of topic: low | medium | high

No.	Rel.	Topic	General comments	No Rogun	FSL 1220	FSL 1255	FSL 1290	Conclusion
6.4		Fishing in Rogun or Nurek reservoir	Potential for aquaculture	low	intermediate	intermediate	intermediate	No argument for either alternative
7	**Protected areas**							
7.1		Protected areas in project area	Flooding or degradation of protected areas	no	no	no	no	No argument for either alternative
7.2		Nature reserve of Tigrovaya Balka	Changes in river flow d/s of Nurek according to Reservoir Operation Studies	no	no	no	no	No argument for either alternative
7.3		Nature reserves d/s of Tajik border	Changes in river flow d/s of Nurek according to Reservoir Operation Studies	no	no	no	no	No argument for either alternative
8	**Socio-economy**							
8.1		Resettlement	Project affected Persons (PaPs) due to impoundment	2'200 PaPs[1]	13'000 PaPs	18'000 PaPs	42'000 PaPs	In favour of no Rogun; argument against 1290
8.2		Land use	Loss of agricultural land (of relatively low productivity) in project area	no	971 ha	1'409 ha	3337 ha	In favour of no Rogun; increasing impact with increasing FSL
9		**Archaeology**						
		Archaeological sites	Excavation before impoundment	no	no	no	yes	In favour of no Rogun, 1220 and 1255
10	**Effects on riparian counties**							
10.1		Risks	Risk of changing Vakhsh flow pattern affecting downstream water users (e.g. maximising winter energy)	no	lowest	intermediate	highest	In favour of no Rogun; marginal difference between 1255 and 1290
10.2		Opportunities	Opportunity to mitigate flood and draught situations in Amu Darya basin	no	lowest	intermediate	highest	In favour of 1255 and 1290; highest potential benefits for 1290
10.3		Aral Sea	Impact on Aral Sea due to less water during reservoir filling	no	Partial use of Tajik share (-0.58 km^3/yr)	Partial use of Tajik share (-0.66 km^3/yr)	Partial use of Tajik share (-0.83 km^3/yr)	In favour of no Rogun; no relevant difference for d/s users, as TJK using full share in any case

[1] It is asssumed that if Rogun dam would not be built, resettlement done already (stage 1 resettlement) would not be "undone".
[2] Acordding to TEAS studies, sediment supply to Rogun is estimated between 62 and 100 hm^3/yr. The total reservoir capacity of Nurek is not exactly known. In the Reservoir Operation Simulation Studies of TEAS values between 7.98 and 10.50 km^3 are indicated. In the framework of the ESIA, Nurek’s life span has been roughly estimated considering the same sediment supply as for Rogun and a total reservoir capactiy of 9.0 km^3. When Rogun is built, life span of Nurek will by increased by Rogun’s life span.

22.6 Conclusions and Recommendations

As the TEAS studies demonstrate, run-of-river hydropower alone is not efficient for adding the needed winter power supply to Tajikistan. Thus a storage HPP is required to meet domestic demand. Concerns of downstream riparian countries regarding Rogun project would be applicable to other storage HPPs. Rogun HPP is preferable to other storage alternatives, as Rogun is located on the same river as Nurek, already operated to shift water from summer to winter. Winter energy output can be considerably increased by Rogun, without shifting additional water from summer to winter.

While the FSL 1220 alternative has lower resettlement and a lower capacity from summer to winter, it has a reduced energy output, a relatively short life span and it does not mitigate the Vakhsh cascade’s inability of handling PMF. Overall, it offers no comparable advantages to the two higher dam alternatives.

FSL 1290 and FSL 1255 alternatives differ considerably in the main environmental and social impacts and risks. In addition to the best economic results, the longer life span and the better flood and drought mitigation potential are strong arguments in favour of the FSL 1290 alternative. On the other hand, the lower potential for adversely influencing the downstream flow conditions, and mainly the fact that resettlement would be reduced by more than half are similarly strong arguments for the FSL 1255 alternative.

Thus from an environmental and social point of view, there are strong arguments for and against each of these two alternatives, and important trade-offs have to be considered.

Given the considerably longer life span of the FSL 1290 alternative, the higher electricity production and that the incremental environmental and social impacts can be appropriately mitigated, the ESIA consultant recommends to take the FSL 1290 alternative forward for detailed consideration.

23 PUBLIC PARTICIPATION

23.1 Principles of Public Participation

Participation is *“a process through which stakeholders influence and share control over development initiatives, decisions and resources which affect them.”* (Participation and Social Assessment, Tools and Techniques, World Bank, 1998).

Programme development must be participatory. It is essential to involve all stakeholders effectively in the development of the mitigation programmes. Key stakeholders are the affected population and representatives of the local administrations and social services (especially educational and health). The best results in terms of social acceptance and programme effectiveness are often obtained by involving experienced NGOs in this process.

For the Rogun project the stakeholders are at local, national, regional and international levels. All these have to be involved and kept up-to-date on what is happening with the project, get feedback from them in terms of their opinions and reactions, and generally exchange and share information on the project with them.

A public participation or consultation plan for Rogun HPP up to the present stage has not been obtained. But from discussions with RU, villagers, local administrators and individuals reveal that consultations have taken place, or rather the population at large is aware of Rogun HPP through various channels of information dissemination.

During 2009 the GOT used media (newspapers, radio and television), posters, etc. at public institutions, places of work, schools, all over the country to encourage the public to buy shares in Rogun HPP. Foreigners also bought shares. This campaign lasted a year, and with the participation of the population and foreigners, everyone has a stake and say on the planning and implementation of Rogun HPP.

23.2 Public Participation Carried Out

23.2.1 Public Participation done for ESIA TOR

Public participation was carried out by WB and GOT in the process of preparation of the TOR for the ESIA.

For this purpose, public meetings were held in Rogun, i.e. in the project area, and in Dushanbe. The meetings were announced publicly. The purpose of these meetings was (i) to present the project, (ii) to present the TORs for the ESIA, and (iii) to answer questions and obtain comments on the TOR. This was documented in a report (CAREC 2010).

The World Bank also carried out consultations with the riparian countries.

The comments received in these meetings were considered in the process of finalisation of the TOR.

23.2.2 Consultations with Riparian Countries

In parallel with the development of the TEAS and ESIA studies, WB hosted and facilitated a program of consultation and information sharing with six riparian states:

Afghanistan, Kazakhstan, the Kyrgyz Republic, Tajikistan, Turkmenistan, and Uzbekistan,. The meetings provided an opportunity for riparian governments, civil society representatives, and member of the diplomatic and development communities to review the building blocks, interim findings and draft reports of the Assessment Studies. The program consisted of a series of correspondence, comment periods and consultation meetings.

The purposes of the Riparian engagement were:

- To ensure credible, transparent assessments that benefit from international scrutiny
- To encourage dialogue among riparians
- To respond to the request of riparian governments with the support of international financial and donor communities
- To ensure the highest quality of the assessment studies and a process that considers stakeholder concerns.

The riparian consultation and information sharing program was structured as a series of activities, beginning with correspondence from President Rahmon of Tajikistan to other Heads of States, in-country consultations on the ESIA draft Terms of Reference and five comment and consultation sessions at key points in the study process. The activities are listed in Table 23-1.

- Each of sessions 1-5 was structured as follows:
- Disclosure of documents in advance of the consultation meeting by email and on the World Bank website6
- Comment period of 4-6 weeks during which time an email address to the World Bank received input
- Within the 4-6 week period a set of consultation meetings hosted by the World Bank for: (i) riparian governments; (ii) civil society organizations; and (iii) diplomats and development community. Sessions 1-3 and 5 were hosted in Almaty, with the 4th consultation meeting hosted in Dushanbe. Each of the six riparian countries (and other sites as needed) were connected via video and audio conferencing.

At the consultation meetings, presentations were made by both the TEAS and ESIA consultants on components of the studies, results obtained and ongoing work. The WB-funded Panels of Experts for the studies presented their views on the consultants work and the study process. Participants interacted directly with the consultants, members of the Panels of Experts, and World Bank staff, providing feedback and sharing their concerns. Riparian comments were recorded and responses provided. The Panel of Experts incorporated riparian input in recommendations to the Government of Tajikistan to be taken into account in the ongoing work of the Consultants.

[6] Draft report documents were also disclosed on the Government of Tajikistan website.

Table 23-1: Activities included in riparian consultations

Date	Activity	Purpose/Format	Documentation
2007	Letters	Letter from President Rakhmon of Tajikistan to Heads of riparian states announcing the initiation of the Assessment Studies	
2008/9	Rogun studies Terms of Reference	To share and receive comments on the draft Terms of Reference for TEAS and ESIA, and to modify accordingly (In-country meetings)	Annex VI ESIA Terms of Reference (summary) http://siteresources.worldbank.org/INTECA/Resources/VakhshConsultations.pdf
May 2011	1st Session	Outline of study and consultation process, Introduction of Panels of Experts (Comment period and consultation meeting)	Materials and background papers: http://web.worldbank.org/WBSITE/EXTERNAL/COUNTRIES/ECAEXT/0,,contentMDK:22908545~pagePK:146736~piPK:226340~theSitePK:258599,00.html
Nov 2012	2nd Session	ESIA Screening Report; TEAS design criteria (Comment period and consultation meeting)	Consultation report, materials and background papers: http://web.worldbank.org/WBSITE/EXTERNAL/COUNTRIES/ECAEXT/0,,contentMDK:23291624~pagePK:146736~piPK:146830~theSitePK:258599,00.html
Feb 2013	3rd session	Technical inputs to TEAS: results and methodologies for hydrology, geological investigations, Vakhsh Cascade simulations, seismic hazard assessment, social cost components, site layouts (Comment period and consultation meeting)	Consultation report and materials and background papers: http://web.worldbank.org/WBSITE/EXTERNAL/COUNTRIES/ECAEXT/0,,contentMDK:23343293~pagePK:146736~piPK:146830~theSitePK:258599,00.html
Oct 2013	4th Session	TEAS Phases 0 and 1 Draft Reports: Geological and Geotechnical Investigation of the Salt Wedge in the Dam Foundation and Reservoir (Phase 0 of the TEAS Terms of Reference) Assessment of the Existing Rogun HPP Works, including caverns and tunnels (Phase I of the TEAS Terms of Reference) (Comment period and consultation meeting)	Consultation report and material and background papers: http://www.worldbank.org/en/events/2013/09/30/Fourth-Information-Sharing-Meeting-on-the-Assessment-Studies-of-the-Proposed-Rogun-Hydropower-Project-HPP
TBD	5th Session	TEAS Phase 2 Draft Summary Report and Draft ESIA Report (Comment period and consultation meeting)	Documentation will be placed on: http://www.worldbank.org/en/region/eca/brief/rogun-assessment-studies

Consultations on the Terms of Reference are documented in a stand-alone report and summarized in Annex VI of the ESIA Terms of Reference showing where the comments has been addressed on the Terms of Reference. The websites are noted above.

Consultation reports for the 2nd -5th Riparian Consultation and Information Sharing Sessions summarize the topics discussed, document riparian questions and comments and provide responses as well as the Panel of Experts recommendations. The reports, along with all materials shared in the consultation meetings, are posted on the noted website. The main issues raised in the meetings were:

- Dam safety related to: seismicity; salt wedge at the base of the dam
- Floods, slope stability and mudslides

- Status of existing works
- Application of modern standards for engineering design and environmental assessment
- Impact on flows downstream of Nurek Dam and on consequences for communities in riparian countries
- Monitoring of various aspects of the proposed project (e.g., dam stability, flows)

Comments were taken into consideration by the consultants through direct involvement in the consultation and information sharing sessions, preparation of the consultation reports, as well as the recommendations of the Panels of Experts.

23.2.3 Consultations During ESIA Preparation

During the entire process of preparing the ESIA reports, the Consultant engaged in a number of consultations with various stakeholders (see also Section 23.3.2).

These consultations and meetings were mainly the following:

- Meetings with various agencies and ministries at the national level.
- Meetings with local authorities (district and community level) in the project area and in the resettlement sites, as far as already established.
- Meetings with PAPs in the project area and in resettlement sites (Focus Group Discussions, village meetings, discussions on an individual level during site visits, etc.).
- Meetings with representatives of national and international NGOs; these meetings were held mainly in relation with two issues, namely (i) resettlement and related aspects like human rights, gender issues etc., and (ii) biodiversity conservation, mainly on efforts to save Tugai ecosystems along the Amu Darya.

On a number of occasions, local TV stations informed about the project. There was, however, no proactive efforts made by the Consultant in this respect.

A very close cooperation during the entire process of ESIA preparation was established with the Resettlement Unit (officially called Directorate of the Flooding Area of Rogun HPP). The Consultant also participated in a seminar on resettlement organised by RU in Toichi, Tursunzade, one of the resettlement sites, on August 27, 2013

The bulk of these meetings and consultations were carried out during the phase of intensive information gathering and field work for the studies, which was done mainly in the period between April and November 2011. The process continued since then, albeit on a lower level of intensity. A list of meetings is provided in Vol. II, Annex 1.2, of the ESIA, and also in the RAP Vol. II, Annex 1.2.

23.3 Approach to Ongoing Public Participation

Involvement of affected persons of villages in the planning process is important to achieve a successful relocation in which the concerns and needs of the community are met to the extent possible. Participation of host communities is also necessary to avoid disputes and potential conflicts that could arise. For both resettled persons and the host community, open communication and discussion regarding the relocation plans and progress are essential to avoid misunderstandings that could occur and lead to conflicts.

23.3.1 Objective of the Public Participation Plan

The objective of the Public Participation Plan is to ensure that participation occurs at all levels including the involvement of PAPs, local, regional and national government institutions and other government agencies and organs. For Rogun HPP this also includes the participation or consultation of riparian countries and international donors.

23.3.2 Public Participation Stages

Initial Participation, Stage 1: This has so far been carried out during the preparation of ESIA and RAP and the earlier stages. The consultations were carried out with RU, affected villagers and their leaders, local administration (Jamoat Heads) in project area and new relocation sites, host community HHs, new settlers at new sites, and government and non-government institutions. The processes used included meetings, FGDs and HH surveys, which are still ongoing. The aim was to solicit information but also to get the stakeholders involved and share and exchange information on project. In addition, the process was used to obtain socio-economic information of villagers in the project area, their opinions on the project and these have been used in the identification of some social impacts. In addition, affected villages have pinpointed the economic activities they would like to engage in to generate an income and thus restore their livelihoods once they relocate. This point is very crucial for the designing of RAP.

At the local level, the baseline surveys have involved use of FGDs and having meetings with local authorities, village leaders and villagers, HH questionnaires have also been used to have the directly affected HHs involved.

At the national level, meetings have been held with the RU and other government organs that may have a say in the project (various ministries) and monthly meetings with the Deputy Prime Minister in charge of the project, until his passing. Also the state has held meetings with the World Bank and, via satellite the riparian countries' governments have also participated in discussions. NGOs with a strong interest in resettlement and whose expertise could be used were also met.

At the international level, the media has been active in reporting on the status of the project and the meetings and workshops held. The internet websites are also accessible to catch up on the status of the project.

Public participation for Rogun HPP has so far taken place at international, national and local level, mainly carried out by state organs and local administration. The RU has played a significant role in informing the affected and host community of the changes in settlement, with participation from both groups (PAPs and HCs) giving their opinions. This should continue as detailed planning for resettlement starts. RU should continue to be the lead and coordinate information given or received, as it has been so far, with support from other state organs assigned to deal with resettlement issues.

Participation during detailed planning, Stage 2: The methods to be used will include discussions, workshops, meetings and what has not been included so far, participatory rural appraisals (PRA), as construction of the dam started years ago. But use of the above mentioned methods on all stakeholders would have incorporated concerns into project design and initiated a feedback process; but this can still be achieved as implementation will continue.

Participation during implementation and monitoring, Stage 3: this entails participatory implementation arrangements.

23.3.3 Vulnerable Groups, Gender and Language Issues

The public participation process should involve all groups and it is therefore necessary to introduce additional measures to ensure that women and other vulnerable group members participate in project planning and implementation on the same level with men or dominant group members.

In some cultures women have less experience in dealing with outsiders and occupy very few positions of formal authority in traditional village society. Although many women share agricultural tasks and are active in running small business, men tend to dominate decision-making. This has been found to be apparent in the project area where women have left the decision of where to relocate to their husbands.

For women to participate in the consultation process it is necessary to:

- Involve NGOs dealing with gender (or if there is a women's union) in the consultation process as village facilitators. This might involve mobilising the village-level, district and national NGO members and training/orientation in relation to the project. The present ongoing surveys have used female facilitators for the women's FGDs.
- Additional effort is required to ensure participation of women due to their possible lack of familiarity in participation in such processes, e.g. general inexperience in dealing with outsiders. Again female facilitators will need to go house to house in advance of meetings to encourage women to participate.
- Segregate groups of men and women for FGDs, as has been done during the surveys, in order to ensure that women's views are heard. These groups must be led by female facilitators.
- For mixed discussions, the views of women should be presented to all members of the village and debated; such meetings should not only confirm the views of men in the villages regarding mitigation of project impacts.

The official language is Tajik but a lot of people speak and understand Russian. The diverse ethnic groups also make it necessary to use a common language, understood by all when carrying out public consultations. Where language is a barrier then efforts must be made use a facilitator that speaks the language, which is understood by majority of participants. In the project area, the people speak and understandd Tajik as they are 100% Tajik.

Under the resettlement process, specific measures will be taken to address issues related to specific groups, like e.g. youth about to enter the work force, elderly or disabled people. Opportunities for participation in the design of specific programs will be provided to these groups.

23.3.4 Identification of Stakeholders

Stakeholders can roughly be separated in three groups as illustrated in the following Figure.

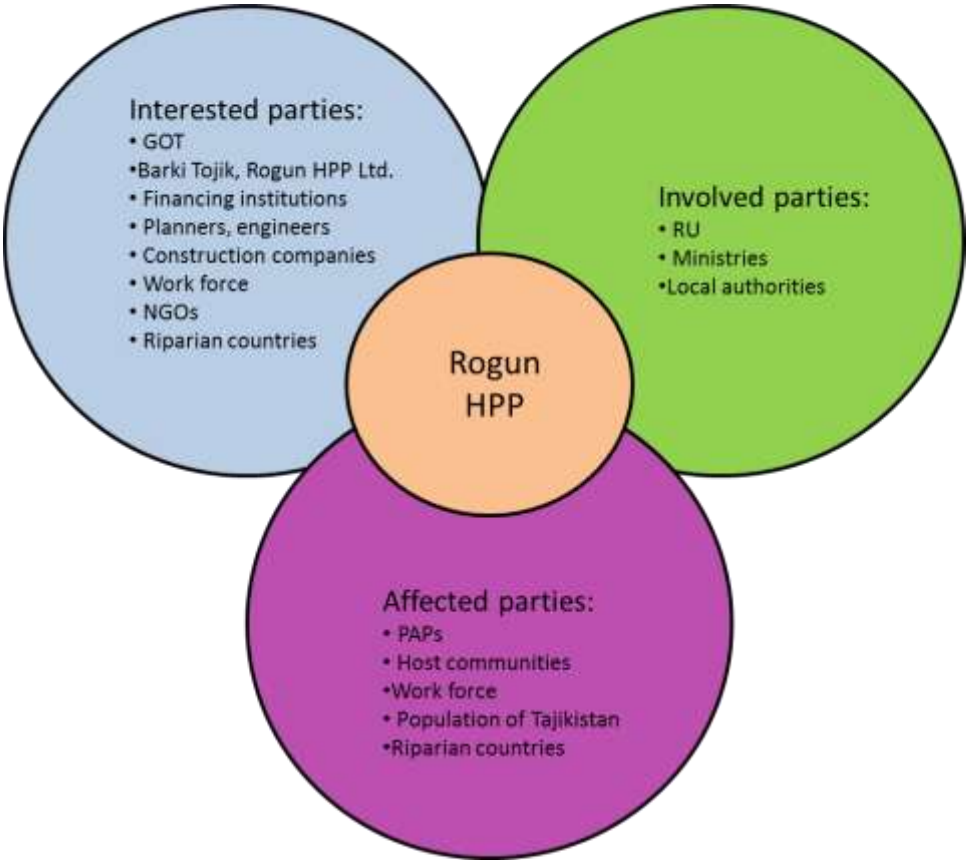

Figure 23-1: Main stakeholders

These three groups are characterised as follows:

- **Interested parties:** all the stakeholders who have a direct interest in the project (which can be in terms of a professional interest for going ahead with the project, or opposing it), and who have, at least to some degree, the possibility of influencing the outcome (i.e. the decision of whether or not to implement the project, selection of alternatives, etc.).
- **Involved parties:** these are institutions which according to their function have to participate in the project (e.g. Committee on Environmental Protection for guiding, evaluating and approving environmental assessments), without necessarily having a direct interest; this group also has the possibility of influencing the project.
- **Affected parties:** these are mainly and most directly the PAPs, i.e. the people directly affected by the project, and then the population at large, which will be affected by the outcome of the project (in terms of energy supply and general economic development). These are groups which generally do not have the power to directly influence the project in any way.

Obviously, there is no clear boundary between these three groups. So e.g. one person can be affected since he will have to be resettled, and at the same time have an interest in the project since he is working on the construction site. One example for this could be the work force: while workers have an direct interest in the project in terms of getting jobs, they have little if any direct influence on decisions related to the project, and they are affected parties in the sense that decisions on how to proceed (alternative selected, schedule) affects directly the possibility of getting or losing jobs.

As in other respects, like resettlement, Rogun HPP is a special case due to the fact that most citizens of Tajikistan are not only stakeholders in a general way, but actually shareholders of the project. In this way, everybody's interest in the project is twofold: they hope for an improvement in electricity supply, and for a payback on their direct investment in the project.

Stakeholders for Rogun HPP comprise different groups. These include:

- People directly affected by the project
- Government organisations and officials at local, district and national levels
- Local and international NGOs
- Vulnerable groups in the project area
- Construction firms and the workforce dealing with Rogun HPP
- The population of Tajikistan
- International donors
- The riparian countries.
- The Media

The above stakeholders can be divided into groups based on location:

<u>Local stakeholders</u>:

- All HHs that are impacted by loss of land, agricultural production, structures or income in the reservoir and environ area (there are approx. 300 HH in stage 1 that are physically impacted by submersion and project construction activities).
- All HHs impacted by loss of economic activities and access to resources for the activities in the dam area.
- Village and local leaders in the affected villages.
- Local government authorities

<u>Regional Stakeholders</u>:

- Government agencies at district level involved in resettlement and those delivering services e.g. energy, transport, water, health, education, etc.
- District organs responsible for planning, implementing and monitoring of hydropower (energy) project.
- Construction firms, contractors and the workforce that could be project beneficiaries during construction and after when economic regional growth comes about due to the project.

National Stakeholders:

- Relevant GOT ministries and agencies, especially Ministry of Energy and Barki Tojik
- The Resettlement Unit
- National NGOs
- National Media
- The Tajikistan population

International Stakeholders:

- Donors and international banks with safeguard policies and rules for monitoring the implementation and operation of hydropower projects.
- International NGOs as likely implementers and as “watchdogs” and external monitoring organisations.
- Hydropower developers, particularly those planning to bid for future hydropower projects in the region.
- International media

As the project continues, identification of stakeholders should continue as this project is of national importance to the country and the whole population has a stake in it. In addition, the need for the public to participate helps to manage public expectations concerning the impacts and benefits of the project.

23.3.5 Public Participation Methodologies

The construction of Rogun HPP started early and so far certain methods have been used to engage the public in the project. The methods used have largely been:

Information dissemination, meetings, discussions with donors, riparian countries, directly affected people, and other groups. This has largely been done by the GOT, relevant government ministries and agencies, and the RU. The media has also been used to convey the status of the project and also to interest the public in buying Rogun shares. Posters and placards were means of conveying messages.

The Participatory Rural Appraisal (PRA) methods that have been used and should continue to be used include:

- Review of secondary sources,
- Direct observation
- Key indicators
- Semi-structured interviews (key individuals, Focus groups, homogeneous or mixed groups)
- Case studies
- Continuous analysis and reporting
- Participatory planning, monitoring and evaluation.

Methods already used and to be used in engaging stakeholders as the project continues are presented in the following Table. The different methods may need to be adjusted, modified and refined as the project moves forward.

Note: Initial public participation stage has the aim of identifying and analysing the local criteria, perceptions, priorities, problems and opportunities, while the next stage for detailed planning presents the impacts found and mitigation measures, which are then debated and with input from all stakeholders these can be streamlined. That is why it is crucial that a feedback loop should be created as early as possible.

Table 23-2: Public Participation Methodologies

Stakeholder	Key Information	Timing	Responsible	Methods and Approaches
Villages impacted in one way or another with loss of land, assets, infrastructure, etc.	Relocation sites, village plan, livelihood restoration plans, compensation and training.	Initial consultations done during baseline surveys. Detailed consultations before relocation. Note that some PAPs had already moved before the ESIA started. These are to be captured during meetings with HCs.	Study team and RU staff for Environ & Social Protection,	PRA methods. Information dissemination, meetings, FGDs with leaders, local admin., villagers, individuals. Carry out site visits, answer questions and retrieve info on impacts. Carry out baseline surveys: HH survey and FGD with segregated groups.
Impacted villages in submersion area (reservoir)	Relocation sites, village plan, livelihood restoration plans, compensation and training	Initial consultations during baseline surveys. Detailed consultation before relocation.	RU and Study team	PRA methods. Information dissemination, meetings, FDG with segregated & mixed groups, local (Jamoats) leaders and individuals. Visit site and solicit information, “do it yourself”, observe and carry out survey,
Host communities at new sites	Relocation sites, additional infrastructure, compensation and inclusion in training for LR, possible impacts	Initial consultations prior to arrival of new settlers. Continued consultation as settlers arrive and after resettling.	RU, local administration (jamoat). Village leaders.	Individual meetings, group meetings, dissemination of information. Visit district and solicit information of HC’s views on site chosen, possible impacts (benefits for them e.g. boosted infrastructure, involvement in training for LR). Establish feedback loop via regular meetings, open channel for complaints, etc.
Local authorities at new sites	Relocation sites, possible impacts.	All planning and implementation stages of project. Consultations ongoing	RU and project implementers (contractors & diff. Government Organs),	Discussions, meetings, to update and retrieve information on impacts. Flyers, posters, media. Get feedback on HC’s reactions and find ways to solve problems if any.
District organisations	Present impacts and mitigation and role of district organisations	Initial discussions not started, only LA discussions & are ongoing	Study team	Meetings and workshops at district level. Also participation at national workshops
Construction firms & workforce	Impacts on workforce, PAPs, and firms	Initial discussions had. Next stages to continue	Study team	Semi-structured interviews, observations, National workshop participation
Rogun HPP at Rogun HQs	History, project purpose, aim, and development. Presentation of impacts &	Initial discussions with Rogun HPP. Further discussions to follow	Study team	Meetings and workshops at national and international workshops for all stakeholders

	mitigation.			
Relevant National Government Ministries	Presentation of all impacts & mitigation and their roles.	Monthly meetings started since inception of ESIA	Deputy Prime Minister & RU, all relevant ministries	Meetings, discussions, National and international workshop participation
OSHPC "Barki Tojik"	All aspects of project	Ongoing discussions at all times	Ministry of Energy, Study team	Meetings, information gathering, all Reports, National and international workshops
Resettlement Unit	Complete presentation of study results. Role of RU	All project stages regarding resettlement. Consultations ongoing	Ministry of Energy, Study team	Meetings, information & data dissemination (case studies), discussion with PAPs, HCs. Flyers, posters and media use. Established website with updated project information. National workshops
National NGOs and International NGOs based in Tajikistan	Overview of impacts and development , specific info on roles for NGOs	Initial discussions held with 2 national NGOs	Min of Energy, RU, Study team	National and international workshops for all stakeholders. Establish information centres for dissemination of project documents. Establish website for access & distribution of project information
General Tajikistan Population	Overview of impacts and development of region – specific information on labour opportunities and other advantages	Detailed design and mitigation options as start for discussions.	RU and all concerned ministries. GOT	National media – radio, TV and newspapers in Tajik and Russian. National and international workshops should be open for the general public. Use established Information centre at RU, and establish other info centres for dissemination of project documents. Establish website for electronic document distribution and access. Website at RU exists but include access to general public, or create a new website linked to other government organs or agencies involved in the project.
International Donors and Groups, Riparian Countries	Overview of impacts and development of the regions – information on safeguards or donor requirements	Detailed design and mitigation options are outlined as required for discussions prerequisite	World Bank & TL Study Team	National media, TV and newspapers, Project website. National and international workshops Establish website for dissemination of project documents. Establish website for electronic document distribution and access for all.

"Study team" refers to the ESIA Consultant; in the future, its functions will be taken up by other parties.

23.4 Local Community Participation

Participation of the local community in planning, implementation and monitoring is a crucial element in hydropower projects. The involvement of stakeholders at the local level tries to ensure that benefits reach these populations and that construction and operation of the project go on smoothly without delays or resentment from the affected communities. For local participation to function, a "feedback loop" must be established to ensure that the opinions, concerns and expectations of people have been genuinely considered and when feasible are incorporated into the design of the project. The important steps are described below:

- Information dissemination to the affected communities (Stage 1) – this has begun and will continue in the following stages as mitigation measures are developed and later refined.
- Interactive planning (Stage 2) – this has partly begun as site selection has already taken place and identification of livelihood restoration activities is ongoing as data is being collected. The technical specifications and feedback from discussions at the village and regional levels should be in the next stage; the process will continue during the whole implementation stage of the project.
- Participatory implementation and monitoring (Stage 3) – this has not started but implies that the communities affected will have a central role in carrying out mitigation measures, including relocation and rehabilitation of livelihoods with assistance from identified NGOs or local government actors. For earlier settlers who are now engaged in a livelihood restoration activity or are undergoing training at the Jamoats, this stage seems to have started as concerns implementation. Monitoring is being carried out by RU, Head of Jamoat and the mahala.

The Rogun HPP whose construction had already begun makes it complex to clearly split the public participation process into distinct stages. The 3 stages are intertwined in this project. "Consultation fatigue" among affected people has not fully crept in but anxiety is felt.

For the ESIA, meetings and FGDs have been held and sample HH surveys carried out. The consultations carried out so far have involved soliciting information from the stakeholders and for the affected who already know that they have to relocate, drawing out what they want to improve their livelihood at the new sites. The already existing impacts have been confirmed by the affected.

23.4.1 Interactive planning (Stage 2)

This stage is an important stage at the local level for ensuring that the local community participate in determining acceptable and feasible mitigation of all project impacts and become project beneficiaries. Initial discussions with leaders and some villagers indicate that villagers are aware of potential impacts and concerns that need to be properly addressed by the project. For the PAPs who wait to relocate, new sites have been chosen and accepted.

Aim: To disseminate information on project impacts to local stakeholders in project area and host communities outside project area and to fine-tune mitigation measures, especially livelihood restoration activities.

Team Composition

The Consultant has used a team of local interviewers to carry out FGDs and sampled HH surveys. The local team leader has been responsible for planning, report writing and QA of the consultation process.

Follow up on consultations in the affected project area by the same team members is recommended, as they now have a rapport with the affected and know the methodology.

Methodology

1. Refinement of methodologies of PRA, should this be required.
2. Prioritise FGDs for men and women and other groups as needed, separately.
3. Use of diagrams to illustrate estimated impacts is foreseen.
4. Discussions will concentrate on **livelihood options** as relocation sites are already chosen and people are familiar with relocation procedures. Should further consultation be required on relocation procedures, the same group will impart this in detail to the affected. District organisations and jamoat staff already dealing with resettlement and a communications officer representing RU will be met and explained the methodologies, prior to further consultations. The jamoat staff and communications officer will later take on the exercise, once methodology has been ingrained in them.
5. At village level establish Local Consultation Representatives (LCR), one must be female and the other male – in order to carry out follow-up work and to act as liaison persons for continuing consultations at the local level. At present, at village level the mahala and Jamoat Chair have partly played the role of problem solving with regard to the project, but a more defined consultation group like LCR would wholly concentrate on project matters.
6. Write up results of consultations which will be part of annex to ESIA and RAP report. Proper documentation of consultations (photos, materials used and analysis of consultations). The report must show how comments have been addressed and link relevant comments and concerns with social, environmental and technical planning in terms of modification of existing plans to address needs. Already reports on each RU stage 1 villages are being produced and this should give an indication on what needs to be refined, if any.

23.4.2 Participatory Implementation and Monitoring (Stage 3)

The planning stages (1 and 2) should lead to local stakeholders’ participation in actual implementation of relocation, compensation/mitigation and rehabilitation aspects. The earlier stages should establish a relationship between the developer and government agencies and organs responsible for resettlement and this should culminate in permanent institutional arrangements at the village level to facilitate interaction and ensure participation. For Rogun HPP, this relationship now exists, but could be refined as regards institutional set-up, especially at village level.

It is proposed that local consultation representatives – a man and a woman - be trained so that they can enlarge their role and responsibility in relation to consultations and reporting regularly.

For villages requiring full relocation and rehabilitation a Resettlement Committee will be formed and the LCRs should be included in such committees. As part of implementation had started (relocation), the remaining tasks that should be carried out by the villagers should form the basis of the final RAP, at least for RU Stage 1 villages. The RAP will outline all supporting agencies and organisations that will assist villagers and outline the required training and monitoring activities.

23.4.3 Host Community Consultations

Consultations with HCs have occurred and are ongoing at the local level as portrayed in the semester meetings at the Jamoats. Due to relocation of PAPs, impacts were already foreseen by RU that has been responsible for ensuring that the new sites have ample agricultural land, social and economic infrastructure is in place or is being constructed to avoid stretching host communities’ infrastructure and services.

The host communities should have an established baseline data that can be compared with data collected from RU Stage 1 affected villages. The local administrations (Jamoats) have general data on social and economic infrastructure, land use patterns, economic activities, etc. There is need to include a PRA for the host communities and new settlers (sample HHs) for comparisons to be made and follow up on whether new arrivals are affecting the host communities (employment, land use pattern & availability, livelihood activities, etc.).

23.5 Regional Participation

Regional participation in detailed planning, implementation and monitoring is crucial at the subnational level, as GOT agencies and organs play key roles in the resettlement and compensation processes and staff from these organisations will have key positions when it comes to rehabilitation and improvement of services and infrastructure, training PAPs in livelihood activities, agriculture improvement techniques, etc. When time comes for finalisation of the environmental and social mitigation for the project, meetings should be held with these actors and feedback be sought, as the final plans will specify the roles and responsibilities of the GOT organisations in the project.

District and regional (Inter-oblast) organisations to be involved in the consultation process include:

- Electricity suppliers (Barki Tajik)
- Local government (Hukumat & Jamoats)
- Women’s council representatives
- District and regional state agencies of energy, transport & communication, social security, employment and migration, irrigation and water resources, environment, property valuation and land allocation.

23.6 National Participation

A number of meetings have been carried out at the national level as part of this study in order to solicit information and also to present findings. Monthly meetings have been convened by the Prime Minister for all the Consultant teams dealing with Rogun HPP and GOT ministries and agencies. This included the following agencies:

- Barki Tojik
- Ministry of Energy and Industry
- Resettlement Unit, Rogun HPP
- Rogun HPP
- Ministry of Land Reclamation and Water Resources
- Committee on Environmental Protection.

National participation will continue in terms of planning and implementation meetings with responsible ministries and GOT organisations. Also a national workshop should be held to finalise the ESIA and RAP.

23.7 International Participation

Rogun HPP is a large-scale infrastructure project for the development of Tajikistan that will affect neighbouring countries too. International organisations, NGOs and funding agencies all have potential roles as implementing agents, sources of funding or as “watch-dogs” in terms of GOT and investor conformity to international standards regarding social and environmental issues. To ensure involvement by these groups and constructive engagement in further planning and implementation of the project, information will be made available through national and international workshops. These will be open to all stakeholders and the general public, at Information Centres and on the web.

23.8 Disclosure of Information

23.8.1 Principles of Disclosure

Disclosure of information to project stakeholders and the general public is necessary. This means that reliable and up to date information on the project as it develops should be available through various media. The main aspects include:

- Use of Tajik TV and radio to reach the general public – updates about progress on the project and public meeting announcements.
- Information bulletins to national and international newspapers and information to visiting journalists and international NGOs, outside and in the country.
- Summaries and explanations of the project in all affected communities.
- Information Centres where reports are available.
- Translation of all report summaries into Russian/Tajik to facilitate GOT involvement and understanding.
- National workshops open to all interested parties and the general public.

- Website information to be posted regularly.

23.8.2 Project Information Centres

During planning project information is made available to the affected villages and host communities; this has been done by mainly the local RU offices and local administrations (Jamoats). Meetings and discussions with the affected and host communities have been held; use posters, the media and flyers (as of September being made) are some of the methods used to inform the general public. The RU is a project information centre but not accessible to all. Rogun must also have an information centre but again not accessible to all.

In continuing the planning the following steps should be taken to ensure that present project information is made available to the affected, host communities and the general public:

- Posters, diagrams and short easy to read explanations of the project features, impacts and proposed mitigation are to be set up in all affected villages.
- Information centres should be established in Sicharog and Hakimi Jamoats in the Districts of Rogun and Nurobod with posters, diagrams and explanations of the project, its impacts and proposed mitigation. In addition, copies of the approved versions of reports in Russian/Tajik should be made available to the general public.
- Information centres should also be established at the new sites’ Jamoats of Rudaki, Tursunzade, Danghara, Durband and Rogun (to cover Chormagzak). These centres must have posters, diagrams and explanations of the project, its impacts and proposed mitigation. Copies of the approved versions of reports in both Russian/Tajik and English must be available to the general public.
- The RU should have an open Information Centre established with the same information and reports as mentioned in the other centres. This centre should be part of the project office where additional information could be made available to journalists and specialists.

23.8.3 Website Information

In order to reach an extensive international audience, the website at RU should be made accessible or the creation of a new one should be considered. The website could contain the following:

- Description of the project
- Latest approved report summaries
- Links to project coverage by various media
- Discussions by various interested parties or links to other websites (including GOT websites) following the development of the project.

23.9 Upcoming Public Consultation

Two specific consultations will be held in the near future:

- 5th riparian meeting, presenting the results of the TEAS and ESIA studies to the neighbouring countries.
- Public consultations within the country (Rogun and Dushanbe), where the ESIA is going to be presented and discussed in public (dates to be confirmed).

24 ENVIRONMENTAL AND SOCIAL MONITORING

This Chapter provides a summary of the major monitoring programs that have been called for in the various sections of the ESIA.

24.1 Risk Assessment

24.1.1 Risk Analysis by TEAS

TEAS has prepared a Risk Analysis (TEAS Phase II, Vol. 6, RP 53, July 2013). In this report, risks pertaining to three main groups, namely, natural, technical and economico-financial, were identified. The report also identified socio-political risks, without however addressing them any further.

Risks which were identified as important, i.e. which could have a significant impact on the project, were identified and analysed in detail. The following Table provides a list of these impacts, 26 in total.

Detailed risk assessment consisted in defining the risks in the absence of measures, in the formulation of mitigating measures aimed at reducing the risk to an acceptable level, and in determining the residual risk when taking measures into account. In this way the report shows that all the risks can be reduced to an acceptable level; however, some are still considered as moderate, indicating that special attention must be given to these topics in the future steps of project development.

24.1.2 Environmental Risks

The TEAS studies identified a number of risks to the project that could result from environmental conditions that have been characterised in the ESIA (like e.g. floods, landsides, seismicity, etc.). TEAS and ESIA studies have identified a number of measures that are intended to avoid or reduce these risks to acceptable level. Risks identified by TEAS and mitigation measures are summarised in Table 24-1.

Other environmental risks which could arise in relation to hydropower project are not of relevance in the case of Rogun (see e.g. the question of deteriorating water quality with the risk of developing anoxic conditions and the highly toxic and aggressive hydrogen sulphide (H_2S) due to the submersion of biomass at reservoir filling, described in Section 8.11). One main environmental as well as socio-economic risk, the availability of water downstream of the dam, is addressed in detail in Chapter 21.

As mentioned, the TEAS report identified the engineering and technical measures to be taken for reducing the risks. In Table 24-1, some comments are made on environmental risks which could contribute to optimise or improve risk management. Only those risks are listed to which a contribution is being made; the others, and especially those for which only engineering measures can be use, were omitted. The technical mitigation measures for these risks are described in the TEAS report. So e.g. the risk of GLOFs (glacier lake outbreak floods) was taken into account by dimensioning the freeboard of the dam accordingly.

Table 24-1: Environmental risks: additional comments on mitigation

No.[1]	Cause	Impact on	Cause/effect	TEAS measures[1]	Observations
1	Rare floods	Dam	Flash flood overtopping dam, dam collapse	Emergency plan	Emergency plan will have to be prepared (see Section 24.4)
2	Construction floods				
3	GLOFs				
4A	Sediments	Flood management system	Abrasive effects in tunnels.	Proper design, repair, closure of tunnels	Watershed management: comprehensive plan, implementation and control (see Section 24.5). Cannot stop erosion,. but can considerably reduce it, and thus lead to a reduction in sediment inflow and a prolongation of the useful life of the structures.
4B	Sediments	Power & energy system	Silting up of power intake tunnel, loss of efficiency	Additional structure at higher level; repair	
5	Water availability	Power & energy system	Wrong evaluation of water inflow.	Inflow analysis according to international best practice	Main risk: effects of climate change (first increase in water availability due to glacier melting, then reduction due to lack of glaciers (see Section 20.2); cannot be mitigated at the local or regional level.
6	Earthquakes	Dam and flood management system	Natural and reservoir triggered seismicity.	Dam design .	Micro-seismic monitoring network proposed (see Section 24.3)
8A	Reservoir rim slope instability	Dam, access	Major landslides into the reservoir leading to overtopping of the dam	Monitoring of unstable reservoir slopes. Reservoir operation (reduce level in case of danger, slow movement).	Zone with highest risk for creating a landslide identified (see Section 6.5.1). Monitoring system proposed.
11	Long-term creeping of faults	Dam, flood management and power & energy systems	Long-term creeping movements of faults near dam site.	Dam design, monitoring.	Microseismic monitoring network (see risk No. 6 above)
14	Dam excavation slopes instabilities	Dam	Localised small rockfall or landslides at the dam site; risk for workers and construction activities.	Securing slopes above dam site, protection measures for workers.	Construction site audit revealed a large number of erosion prone areas; local landslides (not restricted to dam site as such) are a hazard for workers and construction activities. Measures proposed (see ESIA Vol. III, Chapter 6).

[1] Numbering taken over form TEAS, RP 53, Table in Section 7.2
[2] Not necessarily all measures proposed by TEAS are listed here; see TEAS Report for details

24.2 Hydrological Monitoring

The following important issues were discussed in Chapter 21, namely:

- Given its size and storage capacity, Rogun HPP would have the potential for influencing in a decisive way the downstream flow pattern, which in turn could have serious consequences for downstream riparians.
- Tajikistan is well aware of its obligations under a number of agreements with its neighbouring countries (most importantly the Nukus Declaration and Protocol No. 566), and it respects water allocations as defined by ICWC, to which it is party.
- For this reason, an operation scheme for the Vakhsh cascade with Rogun HPP was developed, which will guarantee that Rogun (and the entire cascade) can be operated without changing downstream river flow patterns, and especially without changing the seasonal distribution of river flows.
- Tajikistan intends to operate the cascade according to this operating pattern.

It is therefore recommended to install a hydrological monitoring system for the entire cascade, which would continuously register inflows to the reservoirs, outflows from the reservoirs (via turbines, spillways or any other outlets) and water volume stored in the reservoirs, and make these data in real time available on an internet site. Some indications on the requirements for such a system, as far as possible in this stage of project development, are provided in Vol. III, ESMP, Section 7.1.

Such a system would add credibility to the proposed operation regime.

24.3 Seismic Monitoring

Like any large reservoir, Rogun HPP could lead to reservoir triggered seismicity, which would mean an increase in the frequency of local small tremors.

It is therefore recommended to install a micro-seismic network in the area, for monitoring Nurek as well as Rogun. Specifications for such a system are provided in Vol. III, ESMP, Section 7.2.

In the same Section some observations are made concerning a strong movement monitoring system as part of the instrumentation of the dam. However, this is part of the technical study of the project and is therefore not developed in any detail.

24.4 Emergency Preparedness

Emergency preparedness plans, in the case of high dams, are usually made for situations of extreme floods, but mainly for the case of a dam break, which would cause a major disaster in the downstream area.

It is recommended to prepare such a plan for Rogun HPP; some indications for this are given in Vol. III, ESMP, Section 7.3. Since Rogun HPP will be part of a cascade, with one other major dam (Nurek) downstream of it, it would not be possible to prepare such a plan only for Rogun, it would have to be done for the entire cascade. Since the area at risk is not limited to Vakhsh valley, but would extend along the entire course of the Amu Darya, it is recommended to coordinate such a plan with the one already prepared for the large natural dam which formed Lake Sarez as well. Lake Sarez is not directly connected to the Vakhsh cascade, but shares the lower part of the potentially affected river basin, the Amu Darya, with it.

24.5 Watershed Management and Monitoring

A hydropower plant, i.e. the construction of a dam and appurtenant structures and creation of a reservoir, does not have any direct impact on the catchment area or the watershed of the reservoir. Potential indirect impacts can be the following:

- Destabilisation of parts of the reservoir shoreline, especially of alluvions along the reservoir, which can lead to landslides. This was addressed in Section 6.5.1. The effect, if any, is limited to the immediate surroundings of the reservoir.
- Change in land use in the catchment area due to relocation of the affected population. This effect can basically go in two directions, namely:
    - reducing pressure on land resources as a consequence of moving people out of the reservoir area; and
    - increasing pressure on land resources as a consequence of moving people to higher elevations within the area surrounding the reservoir or upstream parts of the catchment area.

Concerning this latter effect, in the case of Rogun HPP both phenomena will happen, in the following sense:

- From the lower parts of the reservoir area, and certainly for Stage 1 resettlement, most PAPs are being or will be relocated outside of the project area (mainly to places like Dangara, Rudaki and Tursunzade, which are far from the project area; these are agricultural areas with a high and not yet fully used capacity, no negative effects on the new sites are expected. As a general effect, moving people out of the surroundings of the reservoir will help to reduce pressure on land resources there.
- On the other hand, villages located above the FSL of the reservoir will in general not be moved, and some settlements will be moving only over short distances, to places just above FSL. This latter development will be the case mainly in the upper part of the reservoir. In fact, Darband, the newly created Hukumat Centre of Nurobod District, is located on the left bank of the central part of the reservoir. Another example is Novi Saidon, a new village in the process of being created near the dam site. Inhabitants of these villages will continue to use the land resources around the reservoir, for agricultural purposes, but mainly as pasture. Since land will be lost due to the reservoir, this development could increase pressure on remaining land.

Except for that, the project as such will not trigger any changes in the catchment area, and it will not influence it in any other way.

However, the situation of, and developments within, the catchment area can have considerable effects on the reservoir, and therefore on the project.

One issue to be considered is water quality. Since the reservoir will be a large body of water similar to a lake, any input from the catchment area can influence water quality in the reservoir. This issue was addressed in Section 8.11. Since in the catchment of Rogun HPP there are no major urban settlements, no major industries or mining activities, and no large areas of intensive agriculture, there is no risk of elevated input of contaminants or nutrients into the reservoir, and therefore no risk of an emerging water quality problem.

Another issue, and a very relevant one, is erosion and sedimentation. This is a serious problem in the project area, and it was addressed in detail in the TEAS studies. Just to mention a few relevant points:

- Nurek, built somewhat over 30 years ago, already has sedimentation problems (see e.g. Figure 8-39).
- As early TEAS analyses have demonstrated, Stage 1 of Rogun HPP, with an FSL of 1100 m asl, cannot be operated as a stand-alone project, since the small reservoir would be filled up with sediment in a very short time.
- Shurob HPP, a ROR project planned to be built just upstream of Nurek reservoir, can only be built once Rogun dam is in place, since its small reservoir would be filled with sediments very quickly.
- The recommended alternative of Rogun HPP has a life span of 125 years before being filled with sediments (the alternatives with lower dams would last considerably shorter).

These few indications just point out the relevance of the issue.

One of the factors contributing to erosion, and therefore to sediment transport in the river (besides geological causes which might be difficult to control) is certainly the fact that vegetation in the catchment area has greatly suffered from human use. As explained in Chapter 9, forests have almost completely disappeared from this area due to logging and overgrazing. This is a development which increases erosion very considerably.

For this reason, a thorough watershed management, which among other aspects should focus on sustainable use of pastures and on reforestation, has the potential to reduce erosion, and with this increase the life span of the entire Vakhsh hydropower cascade. Besides, it would also have a beneficial impact on the human population living in this area.

In Vol. III of the ESIA, ESMP, Section 7.4, a proposal is provided giving some indications on how such a Watershed Management Plan should be developed. It is highly recommended to envisage such a planning (and its implementation).

24.6 Construction Site EH&S Monitoring

As stated in Vol. III, ESMP, potential impacts during the construction period of the dam and appurtenant structures, which will last for a period about 16 years, will have to be managed properly, by means of an important number of so-called sub-management plans. This will have to be prepared and implemented by the Environment, Health and Safety (EH&S) teams of PIU and of the Contractors.

This process will also have to be monitored, on a continuous basis, by internal as well as external monitoring procedures. Indications on what to monitor, and how to do it, including the required reporting, are provided in Vol. III, ESMP, Chapter 4.

24.7 Resettlement Monitoring

One additional important type of monitoring is the monitoring of the resettlement (which, with about 42'000 people to be relocated over the construction period of about 16 years, is a large project in its own rights).

Resettlement requires two types of monitoring, namely:

- Progress monitoring: this will be a continuous monitoring, internal as well as external, for checking implementation of the resettlement, and its compliance with established rules and applicable standards.
- Outcome monitoring: this will be a monitoring of resettled HH and communities, in order to verify whether the main aims of the entire resettlement process (these main aims being mainly: complete and fair compensation for all lost assets, provided in a timely manner, and restoration - or, wherever feasible, improvement - of the livelihood of relocated persons) has been achieved.

RAP, RPF and Resettlement Audit prepared for this project provide details on the required monitoring processes and procedures.

25 RECOMMENDATIONS

This Chapter provides a summary of all recommendations made throughout this Report. The recommendations include policy, operational, mitigation and management measures that should be considered at different points in the life span of the project. These recommendations should be reviewed and refined in order to finalise budgets, time frame, institutional implementation responsibilities and scope of work to be included in a final project Environmental and Social Management Plan.

There are two major areas of concern related to the Rogun project impacts:

- The first is the impact on the downstream flow pattern, and with that the **effects on riparian countries**, which use the water of Amu Darya, of which Vakhsh river is an important tributary.
- The second is the effect of the project on the population of the project area, or more precisely of the dam and reservoir area, i.e. the extent of **resettlement** required for project implementation.

The other project impacts, namely those on the physical and biological environment are considered as minor.

25.1 Main Impacts to Be Mitigated

25.1.1 Effects on Riparian Countries

- As it is possible to develop and operate Rogun HPP in a way that the Vakhsh river seasonal flow pattern downstream of the cascade will remain unchanged, building and operating Rogun HPP does not require any changes in presently applied agreements and practices. Nevertheless, in order to avoid adverse impacts on downstream water availability during and after the reservoir filling period, the intended operation mode should be clearly defined and disclosed. Rogun reservoir filling will remain in full compliance with the Tajik water share allocated by ICWC. However, flow release in Rogun will be managed in agreement with downstream users’ requirements in case of exceptional conditions, as e.g. in very dry years.
- An independent technical and operational audit of the present Vakhsh basin hydrological monitoring system should improve its reliability. A comprehensive hydrological monitoring system for the Vakhsh cascade should be installed, and its output data should be made publicly available in real time on the internet. Neighbouring countries should be consulted through ICWC on this monitoring system.
- Rogun project would have considerable positive effects on flood mitigation. On the other hand, risks, and mainly the case of a dam failure, need to be addressed. This has to be done in the form of an emergency preparedness plan, as outlined in the ESMP.
- It is recommended that the ICWC member states Kyrgyzstan, Tajikistan, Uzbekistan and Turkmenistan should modify existing agreements and practices to include operation of Rogun HPP in a way as to maximise benefits for all parties, like flood protection, additional water releases during dry summers and

additional hydropower generation during exceptionally cold winters. Such an agreement would have to specify the use of the regulating capacity of the Vakhsh cascade for optimising downstream flows under extraordinary conditions.

- Efforts should be made to extend such an agreement by including Afghanistan, for being able to cope with water distribution and use issues in the Amu Darya basin in the future, for irrigation as well as for the possibility where Afghanistan would want to develop its own hydropower potential in its part of Amu Darya headwaters.
- Although not related to Rogun HPP, the Consultant recommends in regard of the forecasted climatic impacts that all parties (Tajikistan, Uzbekistan and Turkmenistan) should undertake efforts for improving the efficiency of their irrigation systems, e.g. by reducing seepage and infiltration losses, increasing efficiency of field irrigation, improving drainage for re-using drainage water, increase the use of ground water, switching to less water consuming cultures.

25.1.2 Resettlement

- Resettlement mitigation consists in carrying out the resettlement according to Resettlement Action Plans prepared in accordance with international standards (World Bank OP 4.12), which means fair and adequate compensation of all losses caused by the project, following a procedure which includes the affected population in the process, and which allows them to share in project benefits.
- There is a ban on construction of new houses and on major repair on existing ones in the reservoir area. However, given the long time required for project development and implementation, it is not acceptable to impose such a restriction on the affected population and a suitable solution will have to be found.
- A Resettlement Policy Framework was developed, with takes into account national resettlement policies as well as OP 4.12, and this forms the basis for resettlement implementation for Rogun HPP.
- The detailed resettlement procedure is presented in the Resettlement Action Plan (RAP) which was prepared for Stage 1 resettlement (comprising of 7 villages, 6 in the construction area and one that will be submerged at the first stage of reservoir filling).
- Main assets to be compensated are the house plots and the houses that will be submerged. Any other immovable assets (like e.g. fruit trees) on the affected land will also have to be compensated.
- PAPs make a choice on pasture availability when they chose the site to which they want to relocate. In cases where not enough pasture land is available, this needs to be clearly communicated to the PAPs, and a compensation needs to be agreed upon.
- Special efforts will be required for providing assistance to vulnerable groups. It is important to develop a proactive strategy in this respect.

- Livelihood restoration is important. Additional programs to the ones already being implemented will have to be developed. This, besides training in agriculture, should include other options like coking and embroidery (especially for women), intensive animal husbandry, and vocational training for improving the chances of getting jobs; youth will have to be given priority in such programs.
- A Witness NGO should be selected, as a neutral outside observer of the resettlement process, in order to ensure that compensation, and the process as a whole, will be implemented in compliance with agreed upon standards.

25.2 Monitoring and Further Investigations

A detailed description of the environmental and social monitoring is given in Chapter 24. Following sections address the main sectoral issues:

25.2.1 Geology and Soils

- According to TEAS studies, the regional tectonic stresses at the Rogun site are adjusted by deformation which is both seismic, involving sudden co-seismic rupture, and aseismic, mainly by creeping. This creeping, which is permanent, takes place principally on the main faults, where monitoring was implemented to measure the deformation rate. Special protection measures must be designed for the underground structures crossing the main discontinuities with evidence of significant shear.
- Additional investigations are requested to verify the cause of damages to support at all identified locations. If necessary the rock masses should be exposed for inspection and installation of monitoring devices. Monitoring of displacements along the main faults should be resumed and additional devices installed. In addition, monitoring should be extended to the major discontinuities showing offset. Taking into account the complex tectonic setting, these tests should also be carried out at different locations into the abutments.
- Superficial sliding and creeping processes due to the presence of halide karst are expected to develop progressively during impounding. The impact of impounding on dissolution and subsequent instabilities should be considered at a further stage.
- No large unstable slopes were found. Thus landslides as well as debris and mudflows are not considered as a major threat for the feasibility of the Rogun project, as long as accurate monitoring and mitigation measures are undertaken.
- Oscillations of the reservoir water level can trigger landslide processes in the reservoir area, but will not create a problem for dam safety. Preventive measures should be taken where such areas are in close proximity to infrastructure and settlement areas.
- A strong-motion and a microseismic network for seismic monitoring are requested to be implemented as soon as possible in order to estimate the background (baseline) seismicity prior to dam construction.
- It is requested to install a digital seismic network on the Rogun site and its reservoir area as soon as possible.

25.2.2 Water

- Darband is the closest historical hydrological station to the Rogun site. The station should be upgraded and the water velocity meter calibrated regularly.
- Mitigation measures to address the long-term sediment impacts shall be considered to demonstrate that dam safety can be assured. A comprehensive sediment management plan shall take into account the whole cascade, making use of the Nurek experiences. The ESIA supports the recommendation of TEAS to carry out the following additional studies and investigations:
    - A thorough analysis of Nurek sedimentation by means of new bathymetric and sediment surveys, including echo-sounding, core sampling, measurement of suspended sediment load as well as particle size distribution;
    - A detailed simulation of the Nurek and Rogun sedimentation patterns, including turbidity currents;
    - An analysis of potential mitigation measures within the whole cascade scheme;
    - Once Rogun would be built, a thorough sedimentation monitoring is requested to assess supply processes in the reservoir as well as the efficiency of implemented mitigation measures.
- As long as the Shurob HPP between the Rogun und Nurek schemes is not built, it is recommended to maintain a minimum flow from Rogun HPP of at least 10 m^3/s for ecological reasons.
- Independently from the development of Rogun project, it is strongly recommended to assess the flood routing capacity of the existing reservoirs, to implement a flood study for the downstream area and to prepare an early warning plan in order to keep the population and authorities informed about the flood exposure of the Vakhsh floodplains.
- The risk of deteriorating water quality, and especially the risk of anoxic conditions in the deeper layers of the reservoir, which could lead to considerable greenhouse gas emissions, is very low. Still, a monitoring of water quality should be carried out as part of a standard reservoir monitoring and an input for the measures proposed to be taken for fish monitoring and fisheries development; a program is proposed in the ESMP. Likewise, waste water from settlements should be treated in wastewater treatment plants before being reverted to the river.

25.2.3 Vegetation

- With one exception, the floodplains to be submerged, specific compensation measures are not required, since otherwise no habitats of value will be affected. Still, some measures for protecting the vegetation especially during the construction period are recommended:
    - Logging by the work force must be strictly forbidden, in order to maintain the vegetation above the FSL as intact as possible. The

contractors will have to provide heating in workers' quarters as well as fuel for cooking in order not to create a requirement for fuel wood.

  - Areas located in the vicinity of the construction site, but not directly designated for a specific use, should be fenced off, and their use - including the occasional driving on such areas with vehicles and construction machines - must be forbidden.
  - Wherever construction activities, e.g. for new roads, take place above the future water level of the reservoir, appropriate measures should be taken for preventing or limiting erosion. This can include the planting of suitable trees on slopes etc.
  - In suitable areas above the future FSL of the reservoir, trees should be planted, preferably local species like poplars, apricot, apple and mulberry, for replacing such trees that will be lost to submersion. This would also be a benefit for the population in settlements which will not be relocated.
  - Trees within the reservoir area should be felled before impoundment, mainly for making use of the wood, which can be used for construction purposes or fuel wood. Since impoundment will occur gradually over the entire construction period of 16 years, this removal of trees should be done accordingly.

- Furthermore, a watershed management and monitoring plan is recommended by the ESMP. This would include reforestation and other possible measures to minimise the erosion of the slopes, but also to increase productivity of pastures and forests. Such a plan would need to take into account the human activities (agriculture, pasture), training of the population concerning sustainable farming and husbandry (correct plantation, seed selection, irrigation, plant pests etc.). This cannot be seen as a mitigation of project impacts caused by Rogun HPP, but would rather have to be part of a regional development plan. However, such a program would have positive effects on Rogun HPP, mainly by decreasing the amount of sediment supplied to the reservoir.

25.2.4 Terrestrial Fauna

- Given the type of project the impact on fauna within the reservoir cannot be mitigated, but since the wellbeing of the fauna is strongly related to their habitats it should be forbidden to destroy additional areas due to dumping of construction material. The excavation material should be deposed whenever possible in an already degraded area and should be re-used for the construction of the dams.
- Additional measures will consist in training the workforce in both construction and operation phases to prevent hunting in the entire project area.
- The floodplain areas (a smaller one near Komsomolobod, a larger near Nurobod) have been identified as important habitats for wildlife. In case of Tajikistan, this habitat type can be found along all major rivers. Thus there are sufficient habitats of this type around to ensure the survival of the species living there.
- These floodplain areas are not critical natural habitats in the sense of OP 4.04. However, both of them, which will both be completely submerged with the FSL

1290 alternative, have to be considered as natural habitats for which OP 4.04 requires an offset if avoidance of the impact is not possible, in spite of the fact that they have been degraded to some extent by human interference. For this reason, a pre-impoundment survey of both floodplain areas (covering vegetation and fauna) and, based on its results, a formulation of an offset plan are recommended.

- Presently, the Consultant recommends measures to be taken in the Tigrovaya Balka area as offset for this impact.

25.2.5 Aquatic Fauna

- The analysis has shown that the project area is not very suitable for fish and fisheries. Still, with Rogun dam in place, there might be a certain potential for managing fish stocks. It is recommended to investigate the feasibility of fish stock management, possibly including the introduction of fish to suitable sites. If this should be envisaged, it is strongly recommended to use primarily local species, and not, or only after careful identification of potential risks, to introduce exotic species. Before this is implemented, a monitoring of conditions and fish stocks should be carried out for providing the necessary data base.

25.2.6 Protected Areas

- There are no protected areas in the reservoir area of Rogun. Under the intended operation scheme for Rogun HPP, Rogun will neither have any impact on downstream located protected areas, since the seasonal flow pattern will remain unchanged. Still, should Tajikistan and the downstream countries agree on complementary releases from Rogun in exceptionally dry years this would positively impact downstream reserves.

25.2.7 Local Population and Socio-economy

- The situation of villages around the reservoir, but above FSL, which will not have to be relocated, will have to be investigated, and measures (in addition to those already planned, like new access roads) may have to be taken.
- The population of Rogun town is expected to increase considerably. Therefore, a development plan will have to be prepared for Rogun town, which will have to be based on a more detailed assessment of the expected development, and the possibilities to deal with it. The assessment should identify specific infrastructure, systems and resources that would need to be put in place to mitigate potential negative impacts and enhance potential benefits. This will mainly be a task for the local authorities, who will certainly require input and support from Rogun OSC for this purpose. A similar plan may be required for Obi Garm, also given the fact that the new road will no longer lead through this village.
- Measures will be required for coping with the situation of a large influx of population (labour force directly hired for work on the Rogun HPP construction site and others looking for or having indirectly generated jobs in the area). Handling the development of the population and the work force will be a challenge for both the local authorities and the management of Rogun HPP,

since it presents a number of risks, which will have to be addressed with appropriate measures:

  - Given the very high number of workers required, it is quite clear that hiring them exclusively locally will not be possible; a considerable number will have to come from outside. However, it is important, for the economy of the region and also to minimise the risk of tensions between "locals" and "outsiders", that the company develops and clearly communicates its recruitment strategy (priority to locals, when providing the same qualification; no loss of job due to resettlement; job trainings for locals; local recruitment offices for locals and regional ones for outside workers etc.).
  - A large construction site invariably attracts people who come to the site, not necessarily for finding a job, but looking for some opportunity of getting an income indirectly related to the project. Such an influx can cause considerably problems in the project area. It is important that the local authorities as well as Rogun HPP are aware of this and cooperate for solving the issue (recruitment outside of the area; strict regulations for any informal establishments etc.).
  - Conflict between work force and local population: Such conflicts can arise - or are almost inevitable - in the case of the presence of a very large work force, which might ultimately be larger than the resident local population (priority to locals; suitably located, staffed and equipped community liaison office etc.).
  - It is important that contractors will be obliged to provide adequate lodging quarters for their workers.
  - Access control is required, not in the least, for keeping unauthorised persons away from the site, and with this also away from accident risks. This measure will have to be maintained. It also has the side effect of preventing workers to haphazardly use, for any purpose whatsoever, land outside of the constriction area as such, which would not only increase the impact of the construction activities, but could also lead to a conflict with local residents.
  - Bringing workers from outside also presents a number of health risks, like e.g. bringing diseases from outside to the project area. Thus an entrance health check, health instructions to workers and adequate health services have to be provided on site.

- Existing livelihood mechanisms should be assessed and additional programs developed. Such programs should take into account contributions of both men and women to household income, the potential for youth employment, sustainability of endeavours and the potential for tapping into the economic opportunity resulting from Rogun HPP construction.
- These and further measures are also addressed in the ESMP.

25.2.8 Cultural Resources

- The investigation so far, including analysis of previous work carried out in the area of the project, did not give any indication that any sites or objects of archaeological or historical importance would have to be expected at and around the dam site. For these reasons, it is not necessary to develop a chance find procedure for the construction site. However, for any project related construction activities outside the dam and powerhouse construction site, e.g. for the local access roads to be built, or for new sites for relocation villages, such a chance find procedure according to OP 4.11 will still be necessary.
- Graveyards are sites of socio-cultural importance for the local population. In cases where such graveyards would be affected by the project - and these will usually be cases where a graveyard will be submerged during reservoir filling - it has to be relocated.
- One site of historical or archaeological interest is located within the reservoir area and will be submerged. It is recommended to carry out an archaeological investigation of this site prior to impoundment.
- An ethnographic study should be carried out for documenting the oral tradition of the local population, and this will have to be done before they are relocated to the new sites.

25.2.9 Construction Site

- In the ESMP, comments are made and recommendations provided on requirements for construction site management aiming to achieve general good housekeeping and acceptable environment, health and safety conditions on site. In addition, recommendations are made for construction site rehabilitation.
- The Health and Safety Management Plan (HSMP) that will have to be prepared by the main contractor shall be carefully followed by Rogun OSC and the other construction companies. An outline of and elements for such a plan are provided in the ESMP. Sub-plans shall be prepared by the Rogun Construction Company in cooperation with the others. The procedures and the introductions to prevent work related accidents, injuries and mortalities including related training programs shall be formulated in compliance with primarily national and international standards. The language of the sub-plans and the related documents shall be simplified for the workers.
- Health and safety management including the site implementation team shall be formed in participation with all the construction companies. Moreover a Health and Safety committee shall be formed and committee meetings shall be performed on a monthly basis.
- The budget shall include expenses of health and safety measurers’ implementation such as proper PPE, safety and rescue equipment procurement. Moreover, budget is needed to improve the conditions of the worker camps. Furthermore a full equipped ambulance is needed for patient transfers from site to Medical Headquarter Center and also from there to the hospitals. A comprehensive Medical Waste Management Plan shall be prepared and implemented.

- It is essential for someone to care for the children while their mothers are at work, prepare their meals and feed them regularly. It may be possible for mothers themselves to take turns to look after the children. Mothers, especially nursing mothers, should be able to visit their children during recognized breaks from work.
- A clean and well-ventilated room, preferably with access to an enclosed space, is the main facility needed. A few items of simple furniture are necessary for the children to sit or lie down, and some toys help. There should be provision for feeding the children with nutritious meals at regular times and, for this, there should also be access to cooking facilities or a canteen.
- In order to carry out all work on site in an optimal way, and especially for reducing the risk of accidents, specific training will be required; detailed plans will have to be developed for this purpose by the project owner and/or by the contractors. These requirements for training are mentioned throughout the different Sections of the ESMP.
- Training may also be required for skills development; this is of special importance for improving the potential of inhabitants of the project area for getting jobs on the construction site.

25.2.10 Public Participation

- Public participation for a project of the dimension of Rogun requires highest standards to inform and interact adequately with the affected parties on an international, national, regional as well as local level. Mechanisms for public participation should be maintained throughout the project implementation period. A detailed outline of such a procedure is given in Chapter 23.

25.3 Recommended Alternative

The FSL 1220 alternative has a reduced energy output, a relatively short life span and it does not mitigate the Vakhsh cascade’s inability of handling PMF. Thus it offers no comparable advantages to the two higher dam alternatives.

FSL 1290 and FSL 1255 alternatives differ considerably in the main environmental and social impacts and risks. In addition to the best economic results, the longer life span and the better flood and drought mitigation potential are strong arguments in favour of the FSL 1290 alternative. On the other hand, the lower potential for adversely influencing the downstream flow conditions, and mainly the fact that resettlement would be reduced by more than half are similarly strong arguments for the FSL 1255 alternative. Thus from an environmental and social point of view, there are strong arguments for and against each of these two alternatives, and important trade-offs have to be considered.

Given the considerably longer life span of the FSL 1290 alternative, the higher electricity production and the fact that the incremental environmental and social impacts can be appropriately mitigated, the ESIA consultant recommends to take the FSL 1290 alternative forward for detailed consideration.

ANNEXES

Annexes are provided in Volume II of this Report