Optimal Rates of Adopting Water Conservation Measures in the Aral Sea Basin

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Objectives/Research questions:

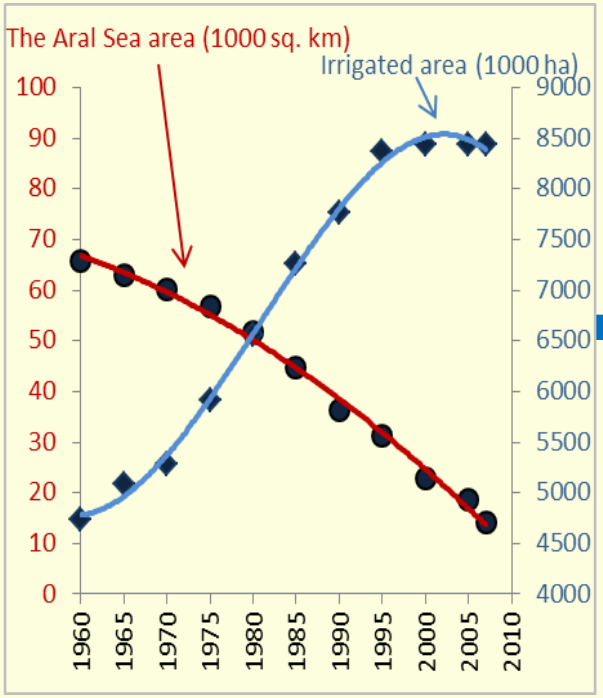
Assess efficient allocation of irrigation technology resources across the regions of the Aral Sea Basin

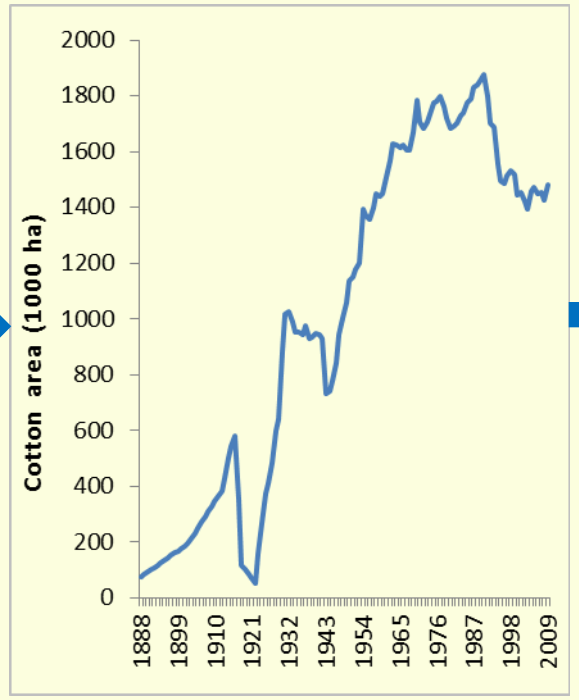
- Location and magnitude of implementing water application technologies?
- Place and magnitude of improving conveyance efficiency?
- Investment costs to improve field application and conveyance efficiency?
- The role of public (government) and private (farms) sector?

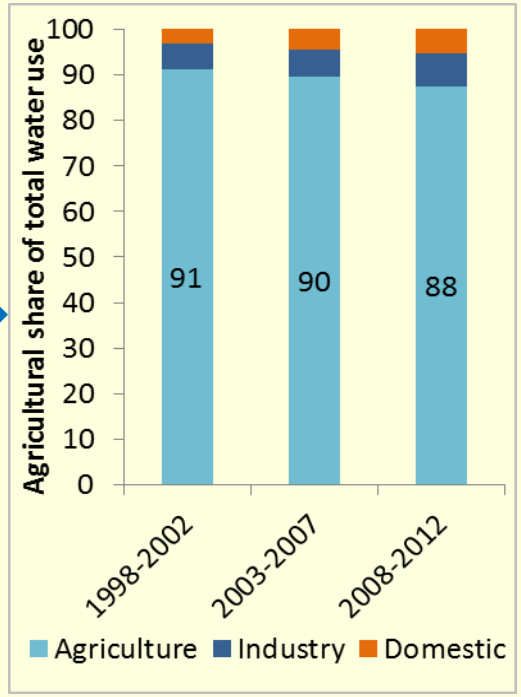
The Aral Sea Basin is One of the Largest Irrigation Zones in the World (over 8 million ha)

Source: Modified after Royal Haskoning (2010)

The Tremendous Expansion of Irrigation and Particularly Cotton Production Occurred Since 1960s

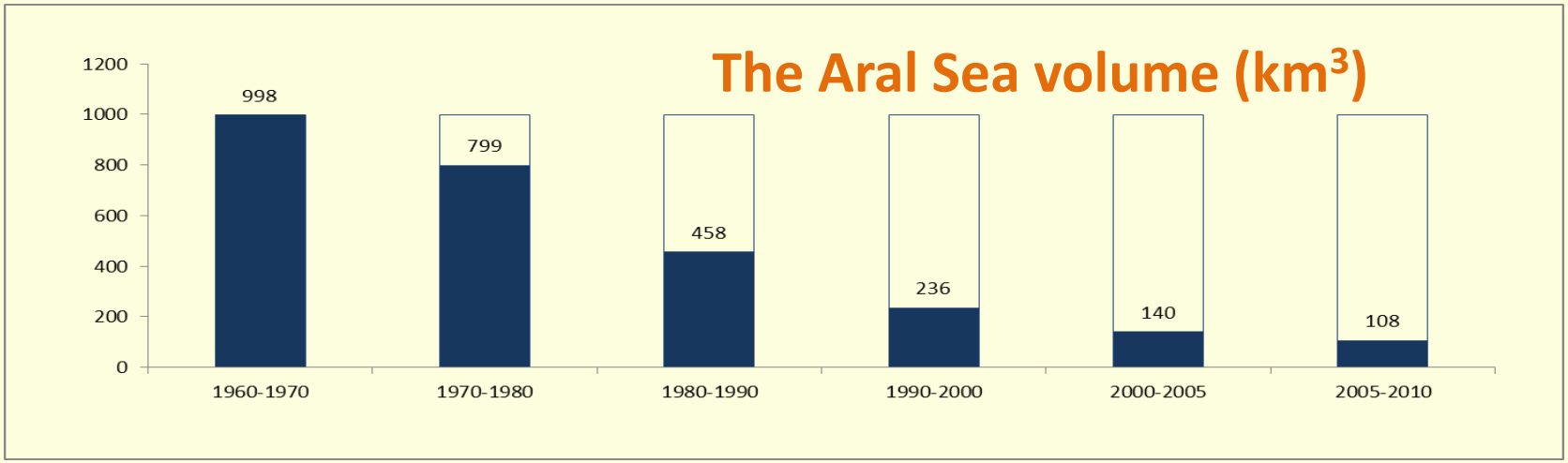






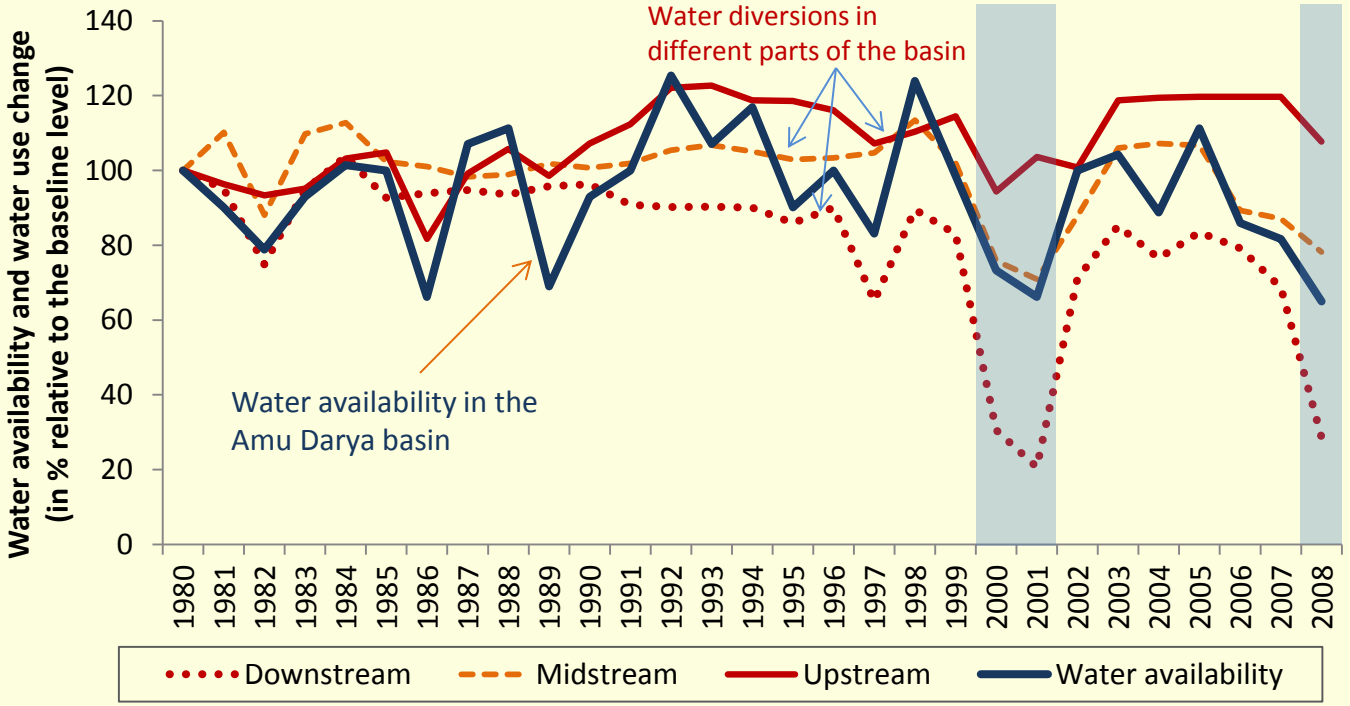
Source: Based on Micklin (2010), MAWR (2010), FAO (2013)

The Aral Sea Desiccation (1960-2009) is One of the Worst Manmade Disasters in the World



Source: Based on Micklin (2010)
Note: Initial area of the Aral Sea in 1960s was more than 60.000 km^2 (equivalent of the area of the Netherlands and Belgium together)

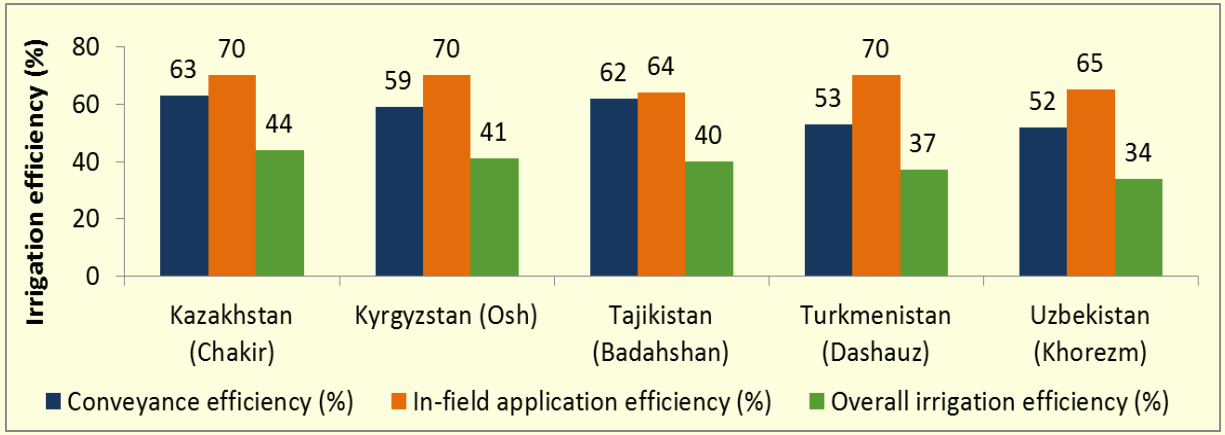
Changing the water release modes of the upstream reservoirs to increase hydro-power production during winter decreased water availability to downstream irrigation in summer



Source: Based on Dukhovny et al. (2008), UzHydromet (2009), and SIC-ICWC (2011)

Irrigation Efficiency is Low and Water Overuse (Water Wastage Ended up at the Tail-end Salt Lakes/Ponds) is Considerable

1



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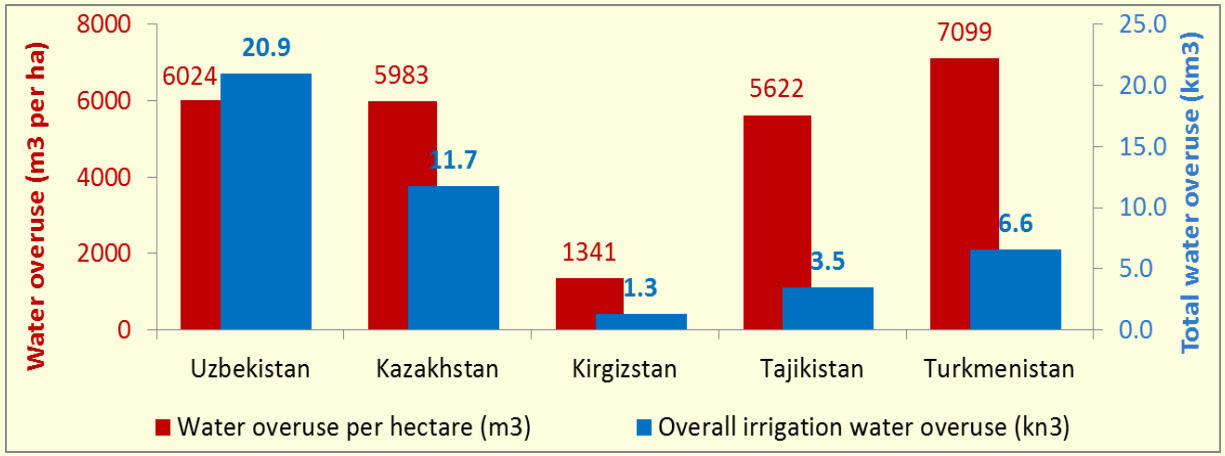
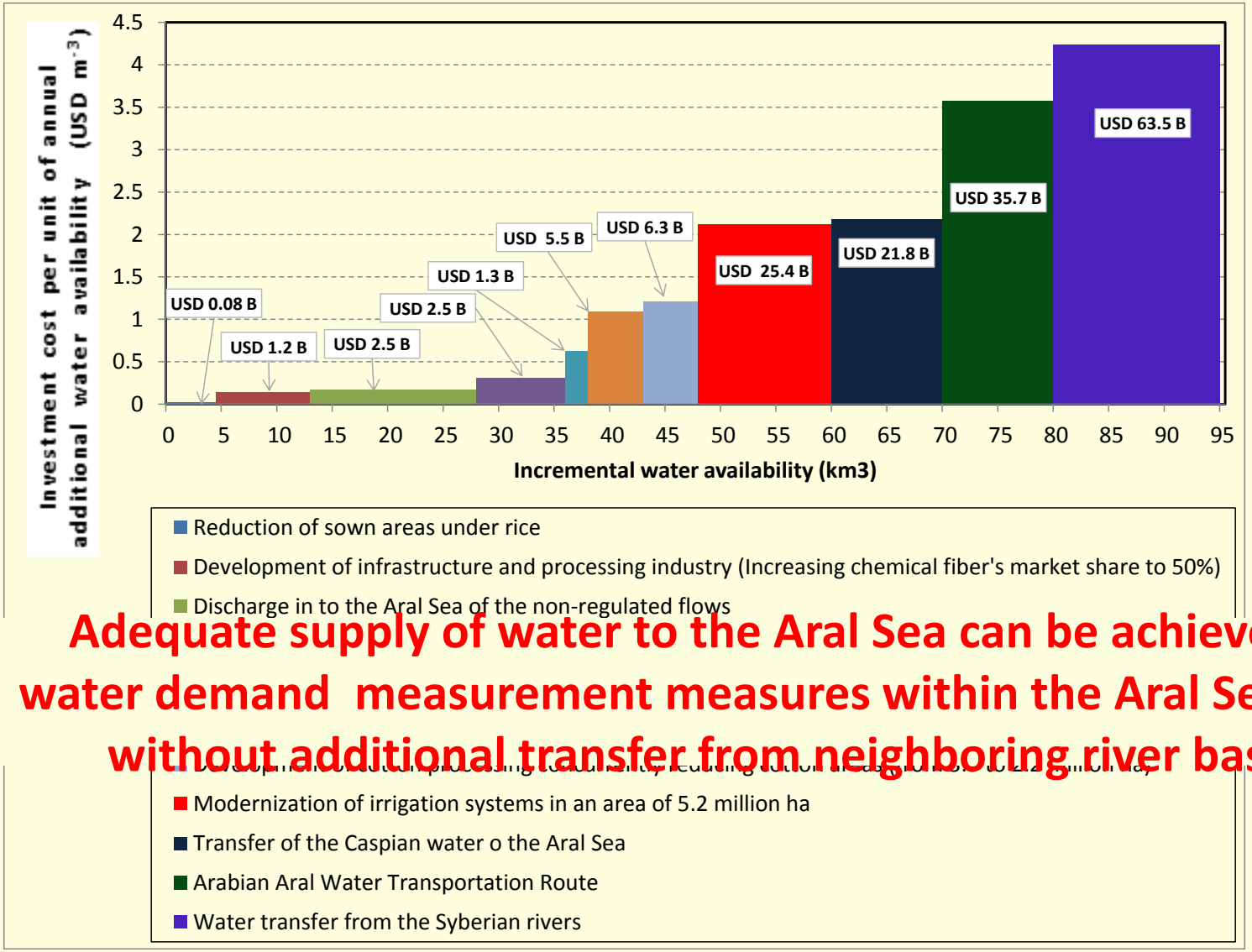


Source: Based on WARMAP (1998), Glazovsky (1990)

Investment costs of different water supply enhancing options



Adequate supply of water to the Aral Sea can be achieved by water demand measurement measures within the Aral Sea Basin without additional transfer from neighboring river basins

Note: Numbers in the white text boxes represent the total required capital investment costs, B = billions. The costs at the price level of 1990 were inflated by factor of 1.58 to evaluate the costs in prices of 2006.
Source: Based on Levintanus (1992), Khamraev (1996a), Micklin (2010), and Badescu and Cathcart (2011)

State of the Art/Contribution:

-**Cost-benefit analysis of adopting water saving technologies** such as drip irrigation, laser guided land leveling, or alternate dry furrow irrigation in particular regions or specific crop fields (Bekchanov et al 2010, Khorst et al 2008)

-National water development plans: technical assessment of drip irrigation in different regions of Uzbekistan (Nerozin et al 1995)

-Modeling adoption of irrigation technologies in the western Uzbekistan (Bekchanov et al. 2014, Bobojonov et al. 2009)

-Hydro-economic-agronomic model relying on old database and considering the regions and river nodes at very aggregated level (Cai et al 2003)

THE MODEL IN THIS STUDY: integrated approach to model water conservation across the regions and crops in the entire ASB, based on updated database, regions/crops disaggregated

Method

A static hydro-economic model of IFPRI (Ringler et al 2004) modified and adapted to the case of the Aral Sea Basin

Crop-specific
Inter-regional
Seasonal

Objective function:

Irrigation benefit

$$\sum_c \sum_r \sum_t \left(Revenue_{c,r,t} - Costs_{c,r,t}\right) +$$

c-crop, r-region, t-technology

Hydropower production benefit

$$\sum_h \sum_s energy\_price_{h,s} hydropower\_prod_{h,s} +$$

h-hydropower station, s-season (month)

Environmental flow benefit

$$environ\_ben\_per\_water \sum_s environ\_flow_s \rightarrow \max$$

17985 equations and 18405 variables

[For more details, see Bekchanov M. (2014): Efficient water allocation and water conservation policy modeling in the Aral Sea Basin (PhD Thesis)]

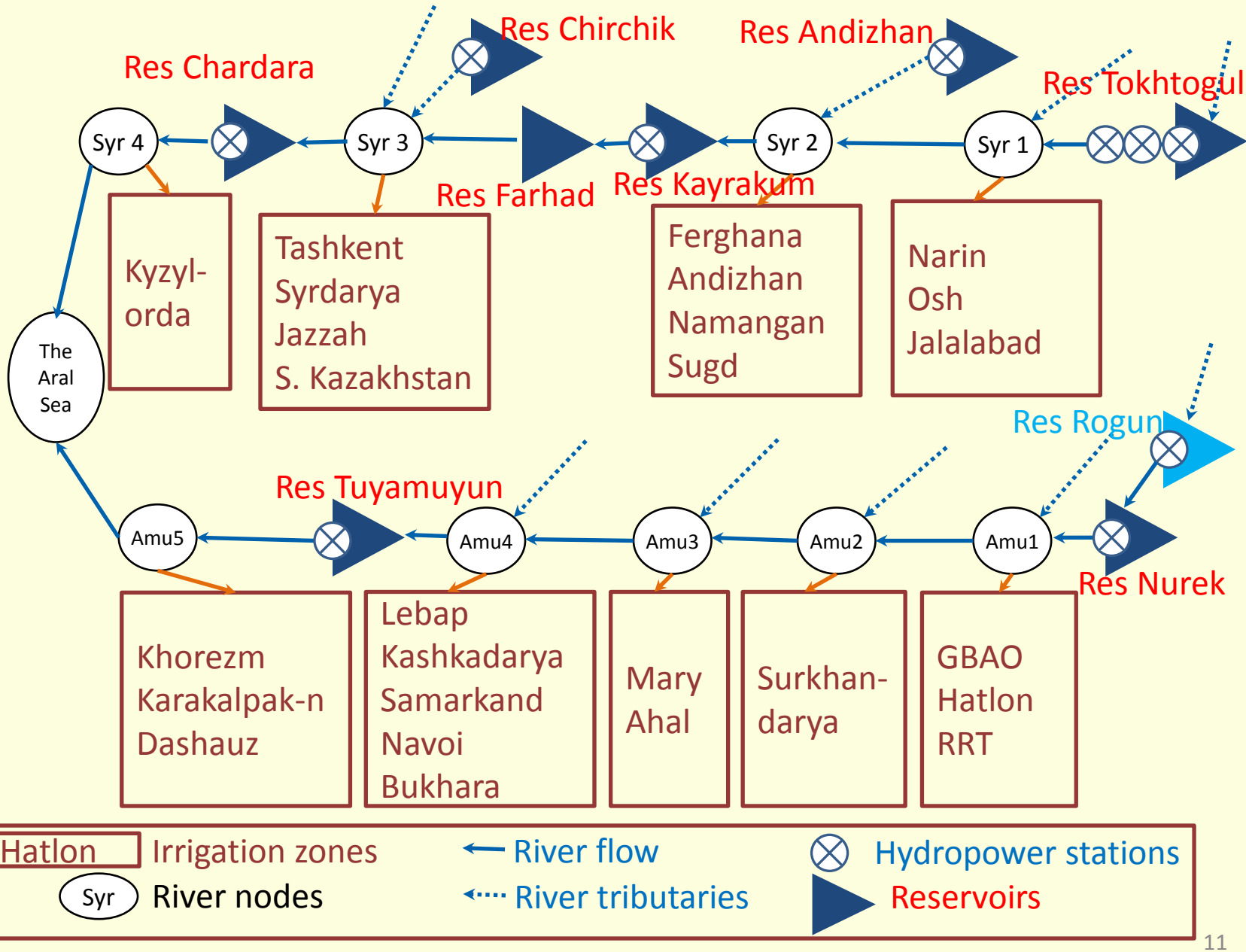
River node scheme of the Aral Sea Basin

9 river nodes

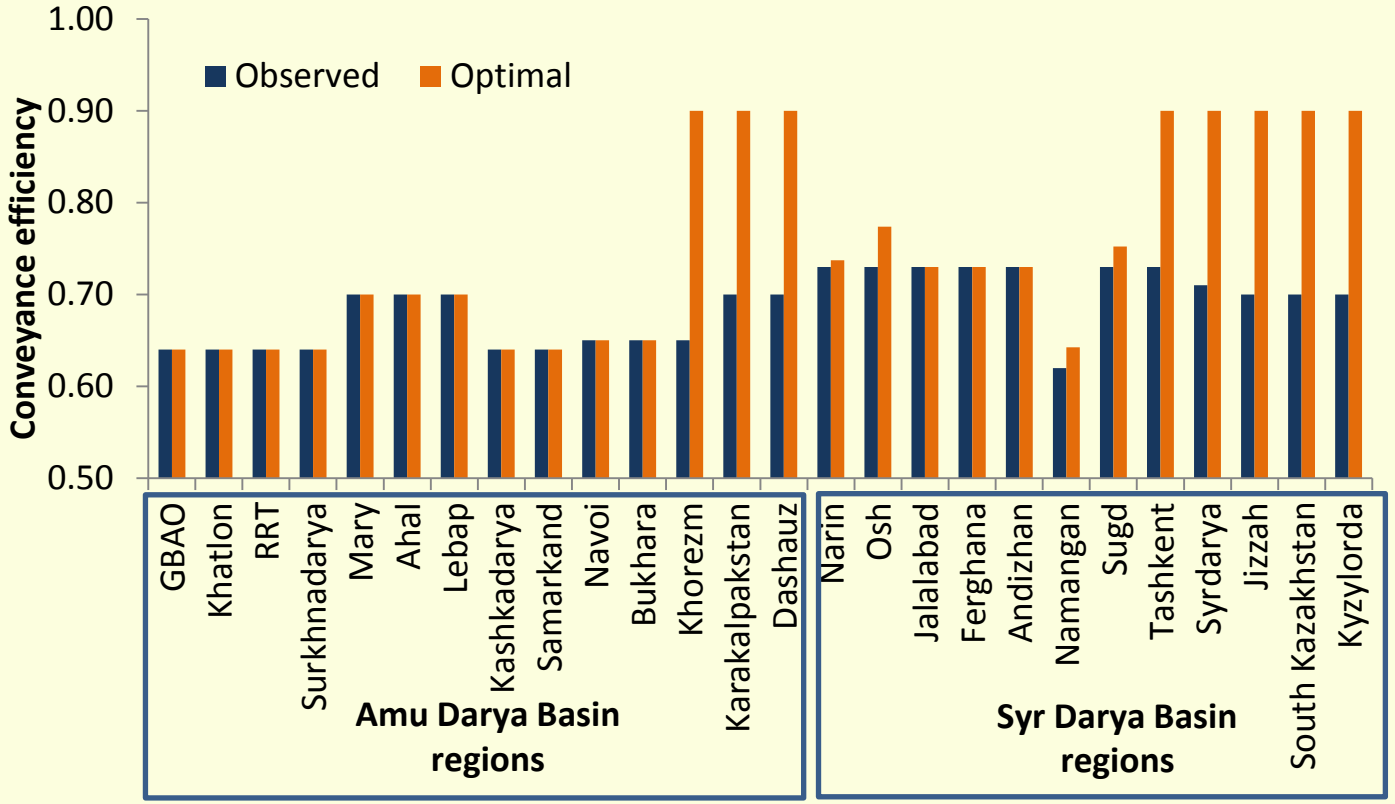
32 main river tributaries

26 irrigation zones

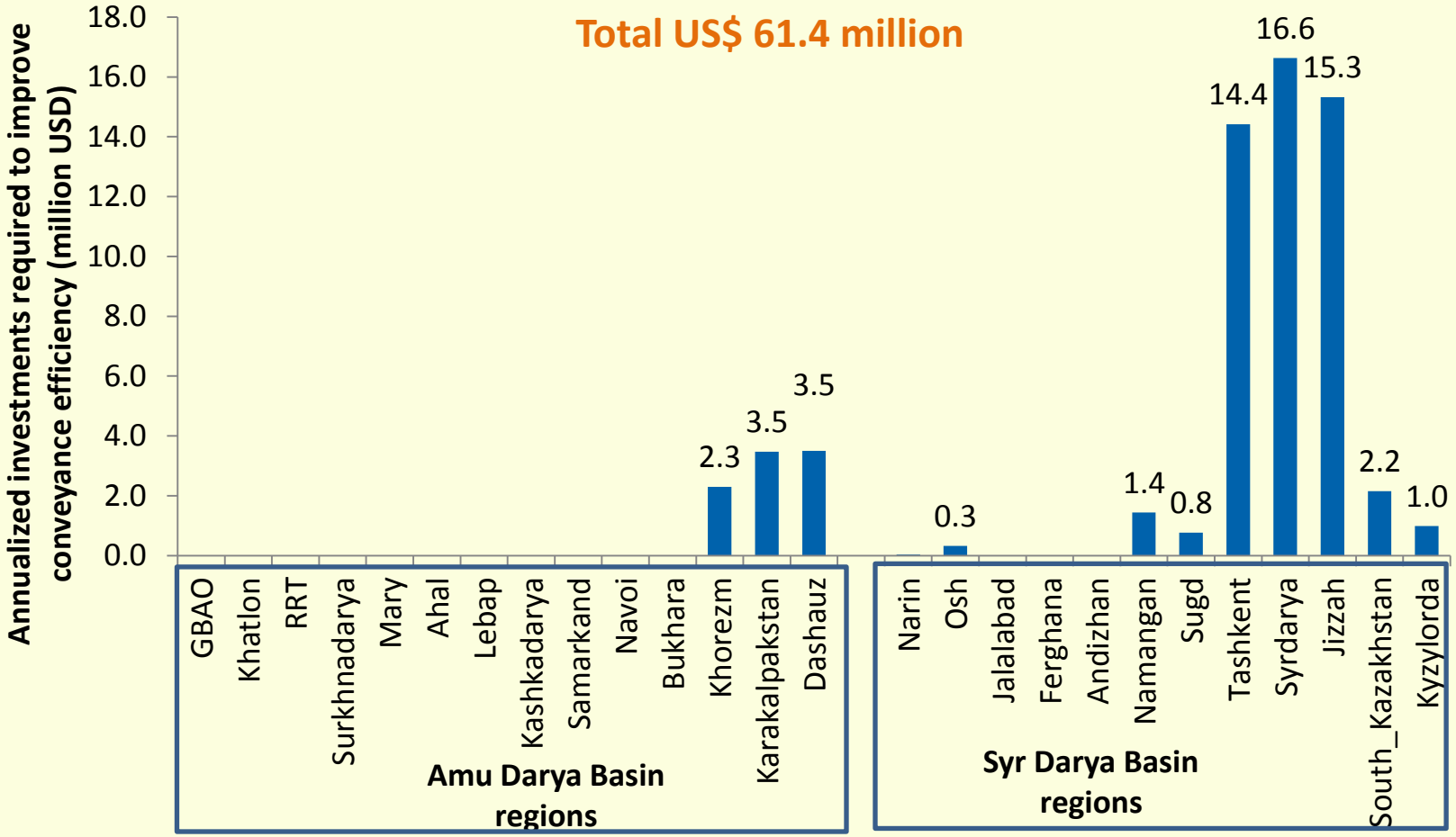
11 crops



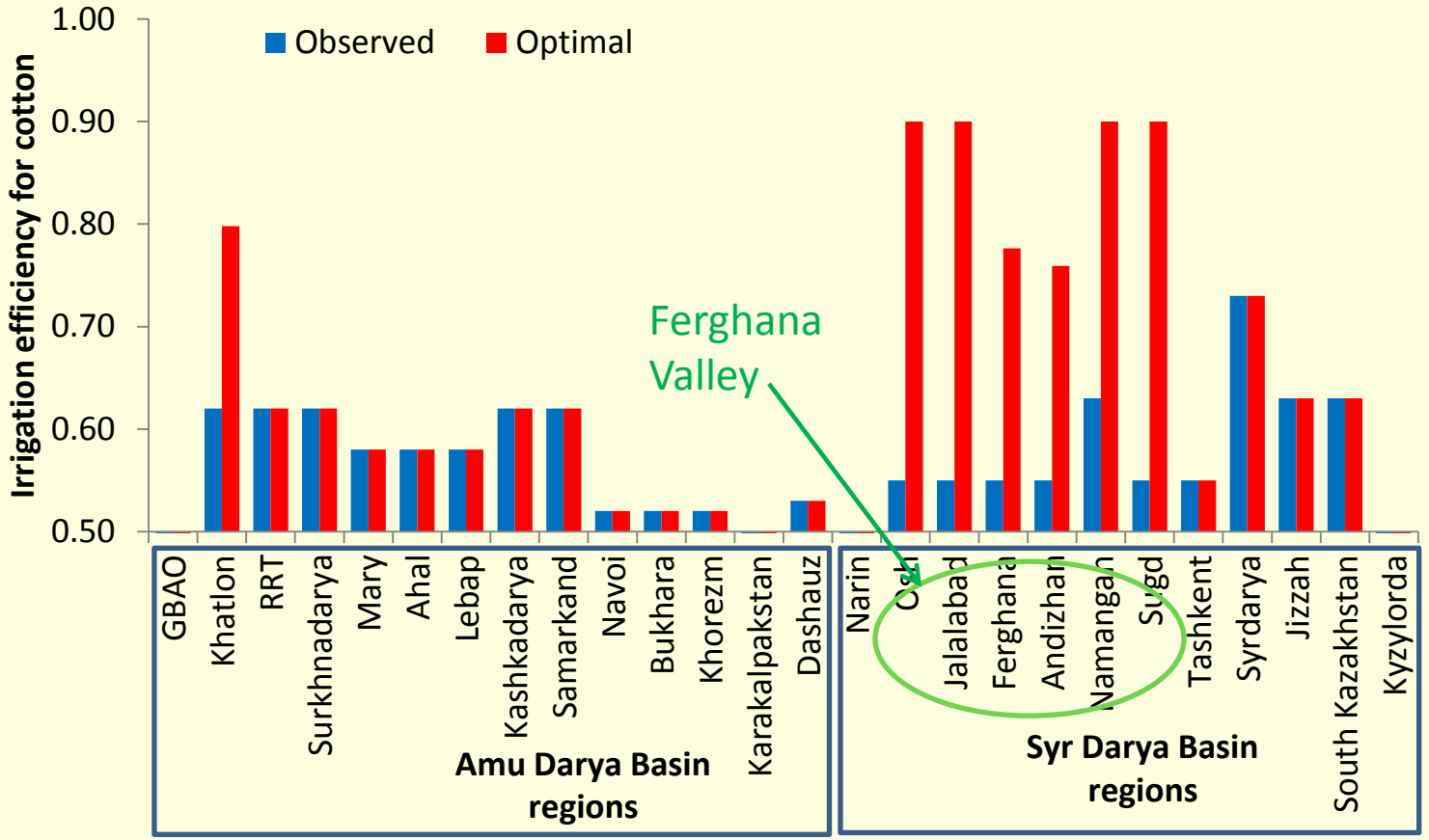
The importance of conveyance efficiency improvements increases in downstream areas of both river basins and midstream regions of the Syr Darya Basin



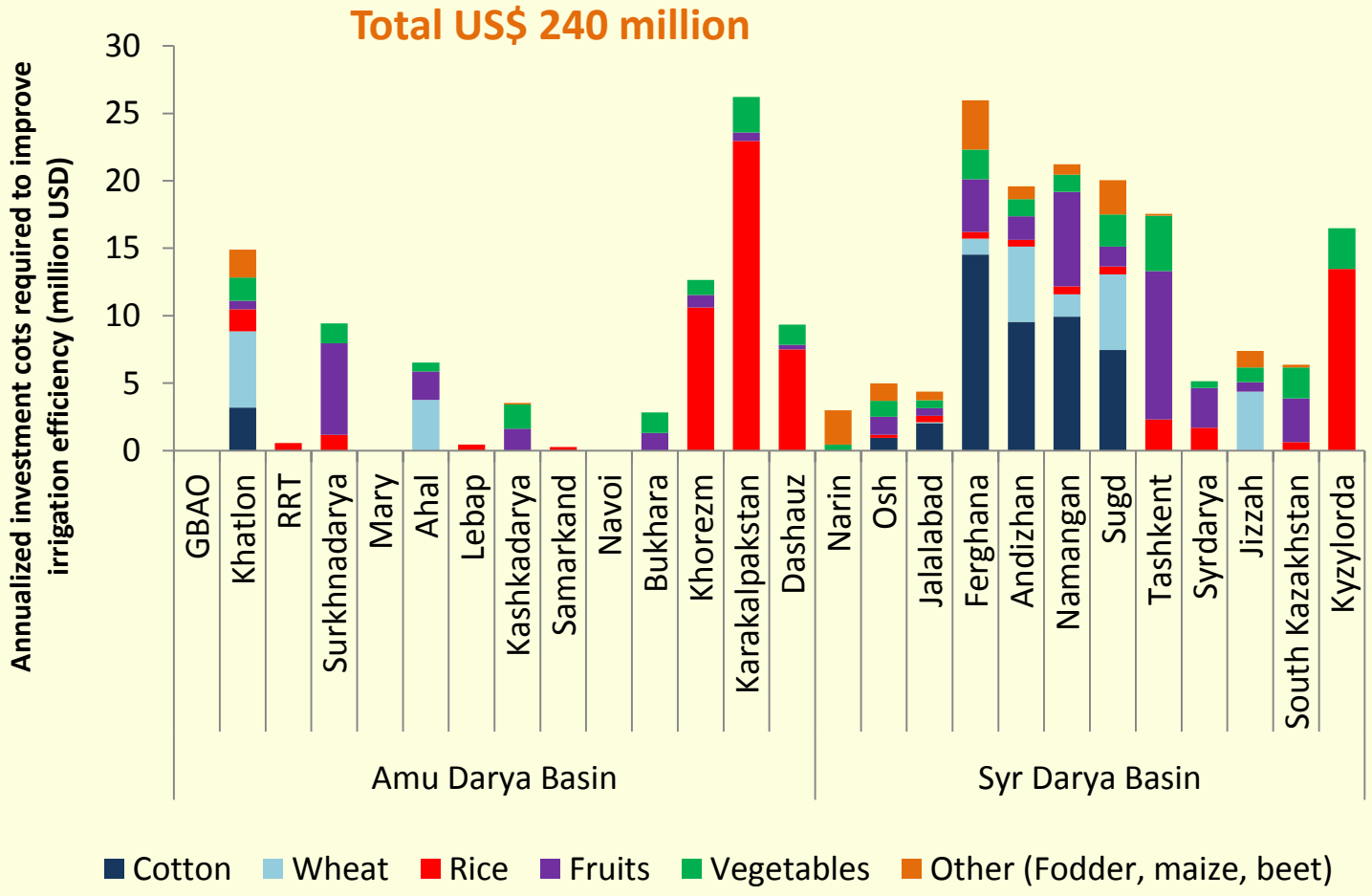
Substantial investments needed to improve conveyance efficiency in Tashkent, Syrdarya, and Jizzakh regions



Substantial irrigation efficiency improvements in the cotton sector are needed especially in the regions of the Ferghana Valley



Substantial investments needed to improve irrigation efficiency of rice production in downstream regions and cotton production in Ferghana Valley



The role of public (government) and private (farms) sector to implement the water use efficiency measures:

Public sector (government):

- Invest in improving the efficiency of main irrigation canals
- Make the improved irrigation technologies such as drip irrigation and laser guided land leveling available at the national market at reasonable price
- Introduce laws that increase the value of water and create incentives to save water
- Eliminate government intervention in agriculture through cotton production quotas and thus help to increase the benefits to agricultural producers
- Empower farmers in decision making processes over water and land allocation and crop production choice
- Improve the system of training of personnel in water and agricultural sectors
- Use the results of modeling and planning tools to prioritize the regions in implementing the technological investments

Private farms:

- Invest in improving field application efficiency and efficiency of on-farm canals
- Continuous search for updating their knowledge and improve the production technologies
- Environmental consciousness and responsibility over their water overuse
- Active participation in decision making processes over land and water allocation

Conclusions:

- **Improving conveyance efficiency** in **downstream regions of both river basins** and **midstream (Tashkent) regions of the Syr Darya Basin** is required for achieving the highest basin-wide benefit

- Substantial investments are required to enhance **field water application efficiency** in **rice production in downstream regions** and **cotton sector in Ferghana Valley regions**

- **Total annualized investment costs** required to improving **conveyance efficiency** are **US$ 61.4 million**
  irrigation efficiencies of the crops are **US$ 240 million USD**

- **Active participation of both government and private farms** is essential for the success of the technological reforms

Next Steps:

- More spatial disaggregation and more attention to water quality and uncertainties
- Analyzing efficient water allocation within dynamic modeling framework
- Including inter-regional trading component
- Combine different modeling approaches (hydro-economic model with computable general equilibrium models)
- Improvements by integrating GIS and HEMs