Session 1B: Policies for Improved Groundwater and Conjunctive Use
Rapporteur: Stephen Mink

"Managing Groundwater in India: Problems and Policy Options"
Siwa Msangi (International Food Policy Research Institute, IFPRI, Washington, DC, United States) and Sarah Cline (US Department of the Interior, Washington, D.C. United States)

- Growing demand for surface and groundwater. Megacity demand is growing
- Supply enhancement options are running out
- Maharashtra State case study; hard rock aquifer
- Model pairing: farmer and social planner decision makers (myopic and dynamic-management optimal)
- Policy context
  - Legislation exists, but not enough
  - CBGWM tried with varied success – requires multiple farmers' cooperation and coordination; is harder the larger the aquifer and number of users.
  - Electricity subsidies – politically hard to take away or reduce
  - Water pricing – tax on volumetric withdrawals equally hard
  - Info/monitoring – very limited
- Tackle demand – full electricity pricing, with rebate for farmers who accept crop choice change
  - Implementation faces trust and acceptance vis implementation of rebates.
- Markets role? Difficult with many farmers; welfare implications a concern
- Scale-up? Need to go beyond charismatic leader successes
- Summary: manage demand; internalize pumping costs; incentivize farmers on crop choice (less water consuming).

"Can Marginal (Opportunity) Pricing of Electricity Reduce Groundwater Use in Indian Agriculture? Evidence from a Field Pilot in Gujarat"
Ram Fishman (George Washington University, Washington, D.C., United States), Upmanu Lall (Columbia University, New York, United States), and Vijay Modi (Columbia University, New York, United States)

- Results challenge the thinking that proper pricing (electricity, water) would solve the overdrafting.
- No metering of irrigation pumps! Billing at flat (based on pump HP; often 60 HP, 1000 feet lift, in Gujarat), subsidized rates, and even these declining; administratively simple.
- Adoption of water saving irrigation technology is very low.

- Electricity Act of 2003 mandated metering; States not implementing; the few, fiscally stressed States, that have tried to, have failed.
- New approach/pilot
    - Provide electricity entitlements reflecting current usage, and compensate voluntary electricity reduction; participant farmers must accept metering. Introduces marginal cost structure, an incentive to reduce water/electricity use, and revenue neutral for State.
    - Results: 65% of candidate consumers participated (higher than prior); only 3% tampered with meters (lower); only 3% of meters malfunctioned; no change in behavior/water use (!!).
    - Compensation applied by State was below cost of generation, but above median price in local water markets. Compensation was deduction in electricity bill, which meant a cap of 15% of baseline electricity cost/bill.
    - Method: 85 of 113 farmers consent; control group separate (but not metered…)
    - Result: high rainfall season, so low pumping, so that participating farmers benefitted from electric bill reduction without having to make crop adjustment.
- Why did farmers not respond much? Price incentive was pretty low. Lack of familiarity with tech options. Tech options likely not taken in short term. [Credit constraints?]. But acceptability of the pilot approach was surprisingly high.

"An Agent-Based Modeling Approach to Integrated Groundwater Management in Oman"
Akbar Karimi and Slim Zekri (Sultan Qaboos University, Muscat, Oman)

- Coastal groundwater over-pumping resulting in salinization is seriously damaging crops (perennials and horticulture) in the coastal strip of 2->3.5 km from shore.
- Many Government interventions since 1990s
    - Freeze on new wells
    - Recharge efforts
    - Crop substitutions
    - Subsidies on irrigation effectiveness tech
- 1995 regulation on framework for groundwater quotas; but not implemented (expensive metering; easy cheating)
- Farmers open to quotas, if groundwater remains free, quotas cover crops requirements, fair implementation
- Trial: 40 farms equipped 2013 with smart electricity-water meters (cheaper, maintenance free, modem-based monitoring that minimizes cheating)
- Aim: monitor so able to design appropriate quotas; introduce protocol for moisture sensors, temperature sensors -> better informed irrigation decisions (to reduce loss, over-irrigation), introduced in 15 farms.
- Scenarios: business as usual, central planner model, agent-based model.

- Results: lots of current inefficiency, higher profits now possible; profiles of water use differ across the three scenarios, over time. LT cropped area best with CPM
- Conclusions: smart groundwater meters good; low cost smart irrigation

"Measuring Efficiency of Village Tanks in Purulia and Bankura Districts of West Bengal, India" (via videoconference from Dhaka)
Samrat Goswami (Tripura University, India)

- Tanks are dammed reservoirs; differ in scale but usually community-based management
- Act as flood and drought moderators
- West Bengal prevalence not as high as elsewhere in India. Why? Performance?
- Tank performance – various measures/indicators. In study zones, area irrigated by tanks max around 3 ha.
- West Bengal area irrigation: highest and growing for groundwater; irrigation with tanks relatively low at 7% now, and declining.
- Study: two districts, 12 villages in total; decision making units for common property tanks. Outputs are crops and fish, inputs are water, working costs for crops/fish, and tank maintenance.
- Conclusions:
    - There is variance over the 12 villages/tanks in tank efficiency.
    - Factors determining this variance have not yet been quantitatively assessed.
    - "Better management" (including rejuvenation/maintenance) appears to affect efficiency. Existence of a village level tank management committee varied across the villages. Not all communities charged for use of tank for fish cultivation, nor applied the revenue for tank maintenance.

"Climate Change in Conjunctive-Use Basins: Water Quantity, Variability, and Salinity"
Keith Knapp and Kurt Schwabe (University of California, Riverside, United States)

- Interaction of conjunctive use, aquifer dynamics, and water quality
- Kern County, CA; 0.9 million acres
- 6 major crops, 6 irrigation system types
- Programming model – regional irrigation agricultural production, maximization of regional net benefits subject to constraints.
- Crop-water production function. Non-linear evapotranspiration (ET)-Water (salinity); Yield-ET; deep percolation (to aquifer). Functions differ by crop and by irrigation type
- Greater irrigation efficiency means lower deep percolation/recharge
- Equations of motion: water table, and salt mass
- Choice variables and state variables (water table height and salt mass); solved with GAMS/FORTRAN
- Examine common property and efficiency optimality paths vis water table, salinity, net benefits

- Climate change impact pathways: season length, temperature, crop ET, older and more variable surface water supplies. Climate change means lower mean and higher variability.
- Climate change -> uncertainty -> more groundwater extractions, faster salinization.
- Two qualities of initial aquifer quality; 20 or 40% uncertainty. Net present value of benefits drop up to 14% due to climate change. Groundwater salinization is likely to increase. Groundwater as a good buffer to lower and more variable surface allocations.