2nd Asian Irrigation Forum
Securing Water and Food for the Future
20–22 January 2016 · Asian Development Bank, Manila, Philippines

Thematic Paper
Session 2: *Innovations to Meet Future Needs for Water, Energy and Food*

I. Background

1. Competing demands for finite water resources in Asia are compounded by climate change. These increasing challenges threaten the livelihoods of billions of people – especially the urban population. For example, energy price volatility contributes to food crises and access to unreasonably cheap supplies of energy can lead to the depletion of water resources, further intensifying the impacts of droughts.

2. Agriculture uses the bulk of global water resources, about 70% on average. Aging infrastructure, weak institutions and poor water management result in low productivity and inefficient use of water for food production. As economies develop, increasing demands are placed on water for food and energy. Prosperity results in more water-intensive meat based diets. Urban and peri-urban agriculture is expanding to meet the growing demands for food in cities, but the sector must compete with industry and municipalities for water and land resources as well as facing increased impacts on water pollution.

3. Agriculture will need to produce 60% more food globally by 2050, and 100% more in developing countries using the same finite water resources.[1] Estimates for Asia predict a 65% increase in industrial water use, 30% increase in domestic use, and a 5% increase in agriculture use by 2030.[2] This illustrates the growing and acute competition among the principal water consumers. The 2030 Water Resources Group has estimated the gap between demand and supply will be 40% by 2030.

4. Superimposed on all these challenges are the impacts from climate variability. Asia is on the frontline of climate change impacts both in terms of exposure and vulnerability. In parallel, climate impacts are most keenly felt on water resources. The latest Intergovernmental Panel for Climate Change report indicates that water scarcity is expected to be a major challenge for most of Asia due to increased water demand and poor management practices.[3] The Asian Development Bank is to double its annual climate change financing to $6bn by 2020. Of this, $2 billion is to be utilized for more resilient infrastructure, climate-smart agriculture, and better preparation for climate-related disasters. This provides ample opportunity within the irrigation sub-sector to increase financing for climate adaptation.

5. ADB is uniquely positioned within the global hot spot for water insecurity and has much to gain from the detailed knowledge of partners and networks within the region. This paper presents efforts to quantify the links between energy and agriculture and implement suitable innovative technologies and approaches for improved water and energy productivity. It will also

[1] Alexandratos and Bruinsma, 2012.
[2] Charting Our Water Future 2030, Water Resources Group.
[3] Climate Change 2014 Synthesis Report Summary for Policymakers, Intergovernmental Panel for Climate Change.

discuss in more detail, the impediments and opportunities for scaling-up and mainstreaming approaches.

6. The paper aims to: (i) consider irrigation in the context of water-energy links; (ii) look at the use of solar pumping and its cost effectiveness, buying back power to avoid over-exploitation and demand management of water and energy; (iii) opportunities for improved technologies and knowledge in irrigation – like reintroducing laser land levelling and use of remote sensing for improved water productivity; (iv) generate cross sectoral dialogue to exchange views, bring experiences from other projects or regions learning; and (v) translate these into actions to contribute to development of more responsive investments.

II. Finding Solutions to a Complex Equation

7. Supply crunches, inefficiencies, and sector dysfunction are powerful forces restraining sustainable development within the climate change scenario. The facts are evident and well documented yet the region is grappling to respond particularly within the confines of weak governance and institutions. Finding solutions within this labyrinth of complexities and "doing more with less" require more innovative and cross-sector approaches which recognize water as being intrinsically linked across all users.

8. The ADB Water Operational Plan 2011-2020 highlights expanded knowledge and capacity development that use technology and innovation more directly to address water challenges. Core areas of investment and providing more cutting edge solutions are: (i) expanded wastewater management and reuse, including sanitation; (ii) increased efficiencies in water use across the range of users; and (iii) embedded integrated water resources management. The paper showcases ADB and other innovations to respond to a more challenging environment where water is cross-cutting across a range of users. The main aspects of innovations highlighted are: (i) advanced technologies and alternate approaches for improved water productivity; and (ii) options for more integrated solutions across the water-energy-food interfaces.

A. Energy and Water

9. Energy use in irrigation is mainly associated with water abstraction and conveyance. As global demand for food and biofuels increases, there will be more intensive irrigation and associated increased consumption of energy. Climate change impacts will further exacerbate the pressures on finite water resources to meet the demands for food, power generation and domestic supplies.

10. According to estimates by the Food and Agriculture Organization, more than one-third of the world's 303 million hectares irrigated area is served by groundwater. Of this over 70 percent is in Asia. The countries with the largest extent of areas equipped for irrigation with groundwater, in absolute terms, are India (39 million ha) and the People's Republic of China (PRC, 19 million ha). Bangladesh, India, Nepal and Pakistan annually pump about 210-250 km^3 of groundwater using about 21-23 million pumps. The total energy used in these countries for lifting groundwater is estimated to be 68.6 billion kilowatt hours per annum, costing $3.78 billion.[4]

[4] Groundwater Governance and Irrigated Agriculture. Tushaar Shah, Global Water Partnership Technical Committee (TEC), 2014.

11. Continued expansion in groundwater use, its impact on declining water tables, demand for energy and the cost to the power sector are highly relevant for the Asian region where energy does not reflect true cost of supply. Recent studies on greenhouse gas emissions from the water sector highlight that in countries like India, lifting water for irrigation can contribute up to 6% of total national greenhouse gas emissions.[5]

12. A recent study on energy use on large scale irrigation projects in Punjab, Pakistan provides a first estimate of energy, irrigation and agricultural production inter-dependencies for a key agricultural region.[6] It demonstrates that whilst total crop production in the province increased by 31% over the past 15 years, direct energy intensity for agriculture has increased by 80%. Direct energy use is driven mainly by groundwater pumping (61% of energy used in agriculture) and that about 20% of the province's energy (electricity and petroleum products) is used in the agricultural sector. The study reinforces an Asia-wide message that energy-use in conjunctive water management remains unmeasured and poorly monitored. Despite decades of recognition, conjunctive use of water for irrigation remains a neglected area, one that has not been reflected in policy and development interventions and an aspect over-looked in designing solutions.

13. At the project level, consumption of energy and water productivity in irrigation is largely unquantified. As competing demands for water for cities and industry increase, we can no longer neglect the requirement to start considering a more rigorous approach to these links, finding integrated solutions and defining how much energy and water are used to produce a unit of crop. Energy availability, access and cost volatility are a growing fraction of farm production costs.

a. Case Study 1: Solar Energy - Power Buy-Back

14. Many countries can benefit from solar energy as an alternative to electric and diesel pumps. Coupled with options for groundwater and intelligent power supply management, this can lead to a responsive solution to the water-energy nexus in the context of agriculture.

15. The new option for solar pumping may exacerbate already fragile groundwater resources. In India, state governments and solar companies are attempting to manage the situation by limiting subsidies to only 1.5 to 2.5 kilowatt peak pumps and/or coupling solar irrigation pump (SIP) subsidy with adoption of micro-irrigation. Enforcement is challenging. An alternate option is the public financed Surya Raitha scheme in Karnataka state, India. This offers a guaranteed buy-back of surplus solar power from (off-grid) SIP owners at an attractive feed-in-tariff.[7] The guarantee of buy-back combined with metering will also increase the incentives for farmers to raise energy and groundwater productivity by investing in micro-irrigation. In this way the scheme will avoid over-pumping and wasteful use of water and energy as is observed in regions with free or heavily subsidized power for agriculture tubewells. It will counter this situation by paying farmers to conserve energy and water. This scheme is promising and with fine tuning during implementation can provide a suitable model for replication.

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[5] Shah, T. Climate change and groundwater: India's opportunities for mitigation and adaptation. Environment. Res. Lett. 4, 035005 (2009).

[6] Energy use in large-scale irrigated agriculture in the Punjab province of Pakistan, Afreen Siddiqi and James L. Wescoat Jr, Water Journal (2013).

[7] http://www.epw.in/commentary/karnatakas-smart-new-solar-pump-policy-irrigation.html. The tariff is Rs 7.5/ unit for farmers who avail the capital cost subsidy and Rs 9.45 for those who do not. There is no time limit for the buyback – it is perpetual.

16. The main challenges in replication of such models are: (i) lack of knowledge sharing and dissemination of the details of such initiatives; (ii) need for champions to drive the way; (iii) cross regional experiences need to be showcased; and (iv) cross-sector working between energy, water and finance specialists. This is perhaps one of the most major impediments, that an irrigation specialist may take the lead role for project design but will be less familiar with energy sector aspects and financing mechanisms. We can no longer have a tunnel vision approach and exclude energy from irrigation project design.

b. Case Study 2: Solar Energy - Scaling up with Financial Intermediaries

17. ADB is assisting the Government of Bangladesh by supporting the Infrastructure Development Company Limited (IDCOL) to install solar irrigation pumps (SIPs). This is on the basis of successful installation (by IDCOL) of 3 million solar home systems in the off-grid rural areas. As a result, 13 million beneficiaries (around 9% of the total population) are getting solar electricity. IDCOL has set a target of installing 1,500 SIPs by 2016. So far, ADB has supported the financing of 7 SIPs on a trial basis.

18. Under the SIP sub-projects, potential sponsors request for financing from IDCOL for SIPs in selected sites. IDCOL verifies the suitability of the project site for project implementation and collects relevant water and energy information.[8] The sponsor enlists suppliers for the submission of quotations to provide a turnkey solution for the project which IDCOL approves. SIP sub-projects are then approved by the Credit Risk Management Committee of IDCOL.

19. Under the ADB interventions, IDCOL extends a mix of loans and grants in order to reduce the investment cost and to ensure the financial feasibility of SIP sub-projects, as per the following structure: debt: 40%, equity: 20%, grant: 40%. Equity which is 20% of the total project cost is injected by the sponsor, a one-time subsidy (grant of 40% funded by various donors) is provided by IDCOL while the remaining 40% is financed by IDCOL as an 8-year loan with an interest rate of 6% and a grace period of 9 months. The loan amount is fully secured by collateral provided by the corporate entity of the sponsor and/ or individuals that own and operate these SIPs.

20. The sponsor is the primary borrower responsible for: (i) selection of locations and target customers; (ii) operation and maintenance (O&M) of the SIP, (iii) supply of water to farmers at affordable rates; (iv) collection of fees from farmers; (v) repayment of IDCOL loan; and (vi) monitoring of pump performance and effects on surrounding environment.

21. The main impediments to date in this model are: (i) relatively high cost of the technology when compared with conventional (diesel or gasoline based) technology - SIPs competing with conventional and cheaper technologies;[9] (ii) lack of awareness amongst customers about the technology and its benefits; (iii) sparse distribution network of the participating organizations - especially when compared with the solar home system program; and (iv) high levels of subsidies of diesel and gasoline which makes the conventional technology cheap in comparison with the high up-front cost of SIPs.

22. ADB is considering support for the establishment of a guarantee fund to offer partial credit guarantees (PCG) scale of investment cost required from the farmer. This will secure up

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[8] Like minimum irrigation charges, cropping pattern, groundwater level, level of arsenic in groundwater, availability of grid electricity, etc.

[9] SIP with an average output of 900,000 liters per day costs about $33,000 of which IDCOL extends $13,200 as a loan to the sponsor.

to 50% of the amount of sub-loans extended by IDCOL to individual borrowers for the installation of individual SIPs. The PCG would provide an additional layer of security to IDCOL for its loan. This concept requires further detailing and may not resolve fundamental issues like competition with conventional technologies.

23. This example again highlights the potential gains that could be made by cross sector links and regional experience sharing for a more incentivized design (like introduction of drip irrigation associated with SIP) and use of mini-grids or introducing a buy-back scheme. Likewise, such models are not building traction on main stream irrigation projects which may aim to introduce SIPs but do not have the detailed insight that other sectors may have for financing mechanisms and energy solutions.

c. Case Study 3: Demand Management of Energy and Water

24. Power subsidies including free power to farmers have led to unsustainable development without matching growth in food-grain yields. In India, this has led to groundwater depletion, necessitating the use of higher capacity pump sets, which in turn consume more power and result in higher power subsidies. In Punjab state, India, provision of free power to farmers to promote agriculture has led to major ramifications on the state's fiscal condition. Committed expenditures of the state government have almost exhausted the total revenue receipts in recent years. Punjab is caught in two vicious cycles of power subsidies and debt–deficit dynamics, reinforcing each other, and undermining fiscal and environmental sustainability. The ADB is financing the Punjab Development Finance Program, India. This seeks to facilitate implementation of a comprehensive fiscal consolidation program in the state of Punjab.

25. Rationalization of agriculture power subsidies is highly politically sensitive. It requires changing behavior by introducing demand management incentives supported by a public awareness campaign. The program will adopt a phased approach with continued free power to farmers but capped based on standardized power supply requirements. Regional, crop-specific thresholds for power consumption in agriculture will be assessed by a technical assistance team.

26. A three-tranche policy framework, consistent with the timings of various reforms, is envisaged.[10] Measures to encourage reducing power consumption to below the normative requirements include: (i) introducing standardized free power requirements for agriculture and incentivizing efficient uses of power; (ii) segregating agriculture feeder lines and using the agriculture feeder data for subsidy calculation; (iii) introducing 100% feeder metering; (iv) introducing electricity distribution meters; (v) introducing a system of power demand forecasting and management; and (vi) implementing a debt restructuring plan for Punjab State Power Corporation Limited.

27. The project targets the root causes of fiscal instability yet makes powerful impacts on demand management of water and energy to increase productivity. It provides an alternate to tackling groundwater management with financial and policy instruments, rather than solely relying on technical solutions at the farm level. Water management through power and an overall fiscal strengthening program provides an innovative approach to the water-energy nexus. Coupled with other initiatives like infrastructure investments, farmers' capacity building and introducing water-saving technologies could provide an attractive incentive package.

[10] The distribution of the tranches will be $50 million, $50 million, and $100 million providing sufficient incentive for policy actions.

28. The visibility, dissemination and uptake of such initiatives again remain constrained more due to fragmented approaches. Energy, water and finance sector work in isolation of each other rather than leveraging knowledge and experiences from each other. A more comprehensive package of interventions could make a greater impact on tackling the cross sector links, reinforcing the imperative to move away from piecemeal and silo efforts.

d. Case Study 4: Greener Pastures from the Sun - Solar Photovoltaic–Driven Irrigation

29. ADB supported the Gangcha County of Qinghai Province through innovative use of solar photovoltaic (PV) to develop and demonstrate improved pasture conservation and water management. In 2009, a solar PV demonstration system was installed. The Qinghai Institute of Water Resources and Hydropower Research led the installation and data collection. Activities included the design and installation of the solar PV system, assessment of irrigation technologies and impacts on productivity, as well as economic analyses.

30. The pilot test in Gangcha County, Qinghai Province was successful. Compared with the controlled land, the treated land provided drinking water for 2,000 goats and sheep and increased fresh grass by 300 kg/mu and forage grass by 1,500 kg/mu. Grass production in PV-irrigated areas in the Qinghai Demonstration Site increased by over 300 kg/mu and has the potential for further improvement through better management.

31. In this project solar lift irrigation appeared to be most economically feasible when precipitation levels are between 300 mm and 600 mm. The highest economic benefit of solar lift irrigation is found in areas with precipitation between 350 mm and 400 mm.

32. The Qinghai Province pilot demonstration shows that the solar PV irrigation system is a cost-effective way to supply small-scale irrigation and drinking water from both surface and groundwater sources. In addition, solar PV irrigation of the grassland around the Qinghai Lake is helping prevent land desertification and degradation; increased production in irrigated areas is reducing overgrazing and degradation leading to desertification in other areas.

B. Technologies to Improve Water Productivity

33. Food production consumes significant amounts of water, ranging between 5,000 and 10,000 cubic meters per hectare per season – or more. The challenge to grow more food with less water requires an increase in water productivity – the amount of production from a given amount of water. This end goal has been largely overshadowed by the drive to increase water use efficiency for increased productivity. The drive for efficiency gains have focused mainly on infrastructure solutions and channel lining which has detracted from the fundamentals such as sound land and water management practices at the field level to improve water use efficiency and productivity.

34. The reality is more challenging, given that there is very little flow measurement on irrigation systems, especially at field level. Farmers do not know how much they receive in terms of volume of water and attributing agricultural production against a volume of water is difficult. It is most usual that agricultural productivity is set as the target as yield is easily measured. To date there is little or no quantification of crop water productivity, its regional variations and benefits derived through development interventions.

35. Reducing losses in the food supply chain could also have a significant impact on improved water productivity. Wastage is occurring at all stages of the supply chain, from field to fork. Improvements in post-harvest practices, in food-processing industries, and by households must be promoted to reduce the loss of food and the waste of water used in production through food not consumed.

36. There are a number of areas where irrigation technologies can be improved, with a key focus area being at the field level. Much is currently being made about drip irrigation, but this technology is suited to specific conditions and crops, and even in countries such as the United States of America (USA) and Australia drip irrigation is only used on 6% and 13% of irrigated land, respectively (see Tables 1 and 2). As can be seen from the data the area under drip (0.7%) and sprinkler (2.4%) irrigation in South and South East Asia is significantly lower than that under gravity-fed surface irrigation (94.9%). This indicates: (i) there is room for expansion of drip and sprinkler irrigation; and (ii) that when compared with the figures in Table 2 for the USA and Australia, surface irrigation will continue to play a central role for many years to come.

37. The following sections provide case studies of a range of technologies which are likely to have application in the Asian irrigation context for improving water use efficiency and productivity.

Table 1 Asia Region summary of irrigation technology use

Region	**Total**	**Gravity**	**Sprinkler**	**Drip**	**Undefined**
	Ha	**Ha**	**Ha**	**Ha**	**Ha**
Central Asia	12,360,331	12,161,394	183,714	15,223	-
South and East Asia	180,480,311	171,229,276	4,335,757	1,348,729	3,566,549
		Gravity	**Sprinkler**	**Drip**	**Undefined**
As % of irrigated area		%	**%**	**%**	**%**
Central Asia		98.4%	1.5%	0.1%	0.0%
South and East Asia		94.9%	2.4%	0.7%	2.0%

Source: FAO Aquastat - http://www.fao.org/nr/water/aquastat/tables/index.stm

Table 2 Summary of irrigation technology use in USA and Australia

Country	**Irrigation Method (%)**			**Irrigated Area (ha)**
	Surface	**Sprinkler**	**Micro**	
USA in 2003	43.4	50.5	6.1	21,591,000
Australia, 2008-09	44.0	42.7	13.3	1,826,000

Sources: Hoffman et al 2007 and Government of Australia NWC. 2011.

38. It is important to also look at the numbers of farmers involved in agriculture (Table 3). These large numbers, the landholding sizes and resultant incomes have a significant bearing on the type of innovation that farmers are both willing and able to adopt.

Table 3 Potential and actual irrigated area, estimate of number of farmers, and contribution to GDP in South Asia

Country	Potential Irrigated area (M ha)	Area Irrigated (M Ha)	Economically Active in Agriculture (million)	Estimated contribution to GDP (%)
Bangladesh	6.93	2.74	32.15	17.2
India	139.50	62.29	273.66	18.2
Nepal	2.17	1.17	11.54	35.1
Pakistan	21.30	19.27	25.90	25.3
Sri Lanka	0.57	0.46	4.01	10.8

Notes: GDP – gross domestic product, M ha – million hectare.
Source: FAO. 2015. AQUASTAT database - Food and Agriculture Organization of the United Nations (FAO).

a. Case Study 1: Remote Sensing to Improve Monitoring

39. Several international organizations (like ADB and FAO) have mutually agreed that crop water productivity should be defined as crop yield (kilogram per hectare) per unit of water consumed (cubic meters per hectare). Under practical conditions, crop evapotranspiration can be considered as the major component of water consumption. Whilst there are no in-situ sensors to measure crop yield and crop evapotranspiration directly, satellite measurements can be converted into yield and evapotranspiration.

40. Organizations such as UNESCO-IHE and the Remote Sensing Technology Center of Japan have developed suitable software to compute daily and weekly dry matter production of crops, in association with crop transpiration, crop interception and soil evaporation. Using high resolution satellite imagery and ground truthing provides much opportunity to ascertain crop water productivity and undertake comparative analysis of why certain areas may perform better than others.

41. Despite such software being available for a number of years, its field implementation has been slow to take off. ADB has recently initiated the use of remote sensing for assessing regional crop water productivity. This aligns with ADB Water Operational Plan and also provides a more robust and relevant parameter against which to monitor the benefits of irrigation investments. The activity will be initiated in India, Indonesia, Pakistan, Sri Lanka and Uzbekistan to provide regional comparison and with a view to scaling up across the entire region. It is envisaged that data collected will contribute to the FAO database on water productivity and provide suitable monitoring data.

b. Case Study 2: Laser Land Levelling

42. Traditional land levelling systems (using animal traction etc.) are commonly used in land preparation in Asia but generally result in uneven field levels and slopes and low yields.

43. Since early 2000 laser levelling has been piloted in selected developing member countries. As a result adoption of the technology in South Asia increased. In India, the acceleration was partly driven by water scarcity, high cost of pumping water in some districts and government policy to encourage adoption through subsidies for purchase of hardware and

subsidizing private contractor land levelling services (Box 1). The World Bank has included investment in laser-levelling in selected projects in India and Pakistan.

44. Trials in farmers' fields have demonstrated that they can achieve higher yields with reduced energy and labor inputs, compared to control plots under their management. The International Water Management Institute (IWMI) through a 3 year (2004-2006) pilot demonstration of laser levelling for cotton, showed average annual net income from the laser levelled field increased by 22% and gross margins were on average 92% higher than a control field.[11] More recent IWMI research in Punjab, Pakistan for cotton (2014 summer season) achieved a 12% increase in water productivity (kilograms per cubic meter) and an 11% increase in land productivity (kilograms per hectare).

Box 1: Viability of providing laser levelling services in Punjab, India

> The Government of Punjab, India has been providing a subsidy of about $1,100 (INR 70,000) for laser levelers costing $4,700-5,500 (INR 300–350 thousands). Where a cooperative society exists, agricultural machinery, including laser leveler, are provided on-hire to farmers. Elsewhere, wealthier farmers, middlemen, and contractors provide rental services.
>
> At current rental rates, $7.8-12.5 (Rs.500 – 800) per hour including a 50+ horse power tractor, diesel and labor cost and a conservative assumption of an annual use of 45 days at 15 hours per day during the months of May and June, owners are able to recover the capital cost of $5,500 (INR 350, 000) within three years.

45. In central and west Asia, despite more than 5 million ha of irrigated land, extensive problems of salinized soils, limited water availability and low water productivity, adoption of laser land levelling has been extremely slow. In Uzbekistan the techniques has been demonstrated for more than 20 years, through at least 8 projects, with similar results as obtained in other developing member countries yet adoption remains effectively zero despite costs having fallen substantially in recent years.

46. Widespread adoption of land levelling in central Asia remains a challenge. ADB will undertake a study to identify potential strategies to overcome binding constraints that are limiting adoption of laser land levelling technologies in Central Asia. Outcomes may guide more appropriate strategies and tailored interventions for improved land and water management.

c. Case Study 3: Beyond Drip Irrigation

47. Drip and sprinkler irrigation technologies are more widely used in the USA and Australia. In Asia the uptake of these technologies has been relatively slow, but is anticipated to increase in coming years. Though the technology is relatively simple, it does require capital investment and maintenance and it is not suited to all crops. Under the right conditions drip and sprinkler irrigation can prove to be both economic and beneficial in terms of improving water use efficiency and productivity.

48. Over the past decade there has been much progress in price reduction for drip and sprinkler sets, increased number of local manufacturers and the provision of a more comprehensive package of support services for farmers to enable them to manage the O&M of these systems. In India, the central and state governments are providing subsidies to farmers to incentivize micro irrigation uptake. Farmers working on less than five hectares of land receive a 50% to 60% subsidy on equipment. The subsidy is routed through banks in some states and

[11] Abdullaev, I., M. Ul Hassan, K. Jumaboev 2007. Water saving and economic impacts of land levelling: the case study of cotton production in Tajikistan. Irrigation and Drainage Systems (2007).

administered through special purpose vehicles set up by the government in other states. Farmers raise the balance of the funding from their own sources or from the banks responsible for routing the subsidy.[12]

49. Despite these incentives the uptake remains slow. In Maharashtra (India) the state government is providing 50% to 60% subsidies to smallholders and marginal farmers for drip irrigation. Of the 3.2 million hectares (ha) of irrigated farmland in the state, drip irrigation is confined to only 600,000 ha (about 18% of total irrigable area).[13] The main challenge is maintaining systems; farmers with land holding less than 2 ha make a one-time investment and use it for three to four years. When it requires repairs or replacement it is discarded. In 2014, the state government made drip irrigation mandatory for sugar cane cultivation, for which the average cost for drip irrigation is about $1400 per hectare. The state government had indicated that if it were to provide full subsidy to cane growers for drip irrigation it would incur expenditure of about $600 million covering 900,000 ha. Thus the initial investment cost and importantly, O&M financing is a key impediment to more widespread uptake of high efficiency systems.

50. In PRC the government has promoted irrigation technology as a priority in its water conservancy reforms.[14] The twelfth Five-Year Plan, issued in March 2011, highlights efficiency and innovations. The government also announced expenditures of over USD 600 billion on water conservation over 10 years starting in 2011, and investment of USD 6.03 billion to support the adoption of modern irrigation technology over 2.53 million ha.[15] This highlights the policy level commitment to improve agricultural water productivity. Of those households adopting modern irrigation technology, there are very few adopters that use it in all their crop sown areas; this observation especially applies to high efficiency systems. Studies confirm the relevance of subsidies in encouraging adoption of agricultural innovations. These appear to be the most influential and comprehensive policy for encouraging the adoption of technological improvements. However, only 10 % of villages are currently eligible for such support which does impede the potential for expansion.

III. Summary

51. Examples of the adoption of improved technologies in irrigation and attempts to tackle the water-energy-food interlinks remain: (i) sporadic and linked to state or project-specific interventions; (ii) de-linked from an overall strategic vision where for example, all relevant irrigation projects will build in high efficiency irrigation systems (where appropriate) and undertake more water and energy accounting;[16] and (iii) isolated actions with water and/or energy projects being developed by sector specialists rather than multi-sector teams which include finance specialists who can advise on appropriate and affordable financing models.

52. Together with these challenges, improving the efficiency of irrigation systems can often lead to an increase in water consumption and reductions in aquifer recharge and return flows. There is a need to couple technological improvements with more comprehensive water accounting to ascertain impacts on the overall water balance. Remote sensing and hydrological models provide opportunities to include in irrigation modernization and/or improvements.

[12] An average loan for purchasing a drip irrigation system is about $817 per farming household.
[13] http://indianexpress.com/article/india/maharashtra/drip-irrigation-losing-steam-over-rising-costs/
[14] CPC: Communist Party of China, Central Committee; State Council of China, Number 1 document for 2011, Decision from the CPC Central Committee and the State Council on accelerating water conservancy reform and development, from: http://www.gov.cn/gongbao/content/2011/content1803158.htm 2010.
[15] Xinhua: Xinhua news agency. Water-saving irrigation techniques to boost crops, from: http://www.globaltimes.cn/NEWS/tabid/99/ID/695165/Water-saving-irrigation-techniques-to-boost-crops. aspx, last access: 20 March 2012.
[16] Especially in the case of groundwater and conjunctive irrigation and where biofuels are a main crop.

53. **New approaches.** Water being intrinsically linked and cross-cutting across almost all sectors (and themes) of investments requires broadened approaches in project design, including looking at it from the non-water project perspective. The impacts of one user on the other cannot be tackled with sector-specific solutions. Opening new horizons is essential to consider how one user can benefit another or, to highlight trade-offs between users.

54. **Governance.** The water crisis is not only due to physical scarcity of water, but also inadequate or inappropriate water governance.[17] Conventional, sector-specific projects focus predominantly on infrastructure development with lower emphasis on governance aspects. Operational and financial inefficiencies can be more powerfully tackled through direct targeting of weak governance in the sector. Demand management can be more rigorously approached and may strike deeper.

55. **Financing mechanisms.** Appropriate use of relevant financing instruments can bring innovations to project design and implementation. The case study from Bangladesh highlights that solutions to energy and water nexus do not have to be overly focused on technology. Rather that sound financing models may be the key to more sustainable and out-of the-box solutions.

56. **Operations champions.** Cross-sector working is essential for driving a more holistic project design. It enables a team to be enriched with a range of specialists, and to not rely solely on engineering or technology based solutions. Projects that require broadened thinking especially for suitable business or financing models would benefit from close working with the finance sector.

57. **Working through the farmers.** In all the discussion it is essential to be aware of the huge number of farmers that are engaged in irrigated agriculture in Asia. The adoption by a large number of farmers of even a small innovation or change in behavior which conserves or makes more efficient use of irrigation water will have a dramatic impact on the total water use efficiency and productivity in an irrigation scheme or river basin.

[17] Asian Water Development Outlook (ADB, 2007).