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Irrigation and Water Use Efficiency in South Asia

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ABSTRACT

South Asia is one of the world's most densely populated and poorest regions, but also the region with the highest rates of irrigated agriculture. Increasingly, the region's water resources are becoming stressed through population growth coupled with poor management. This paper reviews the water policy experiences of India, Pakistan, Bangladesh, Sri Lanka, Nepal, Bhutan and the Maldives, and documents important differences and many commonalities in these practices. It then discusses the theory of water pricing in centrally managed as well as market irrigation systems. Often, the proposed solution to the lack of water use efficiency is to prescribe the adoption of better technical solutions. We review some of these in an appendix. The paper also summarizes the problems of water use, discusses obstacles to solving these issues, elaborates on policy options that are realistic in the given context, and the obstacles to the implementation of even these more realistic policy options. We conclude that water does not exist in a vacuum: while better policies can make a difference, more efficient management of water ultimately requires the state to play a strong supporting role to farmers, and any public service delivery improvement is in South Asia, as elsewhere, contingent on deep and sustained political reforms.

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1 INTRODUCTION

1.1 South Asia & Irrigation

South Asia, comprising of Bangladesh, Bhutan, India, Nepal, Maldives, Pakistan, and Sri Lanka, is one of the most densely populated and poorest regions of the world. Endemic poverty affects one-third of the population and the region faces significant spatial and periodic water shortages due to the uneven temporal and geographic distribution of rainfall1. Water shortages are set to intensify as the region's population is projected to increase significantly over the next 50 years and climate change adds further uncertainty.

Meanwhile, the region boasts one of the highest rates of irrigated agriculture in the world, estimated at around 40% of total cultivated area. The region hosts some of the oldest and largest irrigation systems on earth (Grand Anicut and Cauvery, Indus Basin and Bhakra Nangal canal), however, the area irrigated by these schemes has been stagnant over the last decade and is even on decline since 1990 due to poor operation and maintenance. Water tanks2 in India, Kareze3 in Pakistan and Kuhls4 in the Himalayas have been decreasing in both size and numbers.The exception to the trend is Sri Lanka, where smaller systems and a humid environment help canal irrigation function productively (IWMI and FAO 2009).

Increasingly, farmers are opting for private tubewells, which are easier to maintain and operate, and more flexible than canal irrigation schemes. This has translated into a groundwater boom in much of South Asia, most notably in India. Groundwater use for irrigation has become so extensive that experts and governments are now worried about overexploitation and a resulting reduction in future water resources, as extraction rates are exceeding recharge rates. (GWP and IWMI 2011)

1.2 Fresh Water Resources

The endowment of freshwater resources in the South Asian region is very varied: the annual precipitation, estimated to be about 1083 mm in India, 2666 mm in Bangladesh, 280 mm in Pakistan, 1500 mm in Nepal, 1712 mm in Sri Lanka and 2091 mm in Myanmar, is accompanied by high temporal and spatial variability resulting in an excess of surface water during the summer months and water shortfalls during the winters, due to which groundwater and surface storage and irrigation systems are of utmost importance for agriculture in South Asian countries.

South Asia's primary freshwater resources are presented in Table 1. All the major river basins cross over national boundaries. The Ganges-Brahmaputra-Meghna basin is the largest (and is in fact, the second

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[1] Three quarters of total annual precipitation occurs during the monsoons (GWP-SAS 2010, FAO 2003).
[2] A water tank is a water storage pond or reservoir used to store floodwater. This term is commonly used in India and Sri-Lanka.
[3] Kareze or Qanat is a system of providing groundwater from the mother well through underground galleries to the surface day-light point for domestic and agricultural purposes. Commonly used in Pakistan, Iran and Afghanistan.
[4] Kuhl is a system of conveyance of snow and glacier melt for irrigation or domestic use. It is commonly used in the Himalaya, Karakorum and Hindu Kush ranges.

largest fresh water basin in the world after the Amazon basin). Water from this basin supports 40% of the region's population. It is followed by the Indus basin which, with less than 1,700 m^3 per capita water availability, is classified as a water stressed basin and will likely be reclassified as water scarce (below 1000 m^3 per capita) by 2015. The Helmand basin and the much smaller Karnaphuli basin are next.

Table 1
Freshwater resources of South Asia

River Basins	Basin Area (km^2)	Per Capita Water Availability (m^3)	Country's Coverage (km^2)	Annual Available Water (billion m^3)
Ganges Brahmaputra[a] Meghna	1,745,000	3,473	Nepal (140,000) India (1,105,000) Bangladesh (129,000) Bhutan (45,000) China (326,000)	2,025
Indus[a]	1,170,838	1,329	Pakistan (632,954) India (374,887) China (86,432) Afghanistan (76,542) Nepal (23)	287
Helmand[b]	306,493	2,589	Afghanistan (262,341) Iran (33,111) Pakistan (11,041)	18
Karnaphuli[b]	12,510	-	Bangladesh (7,400) India (5,100) Myanmar (10)	-

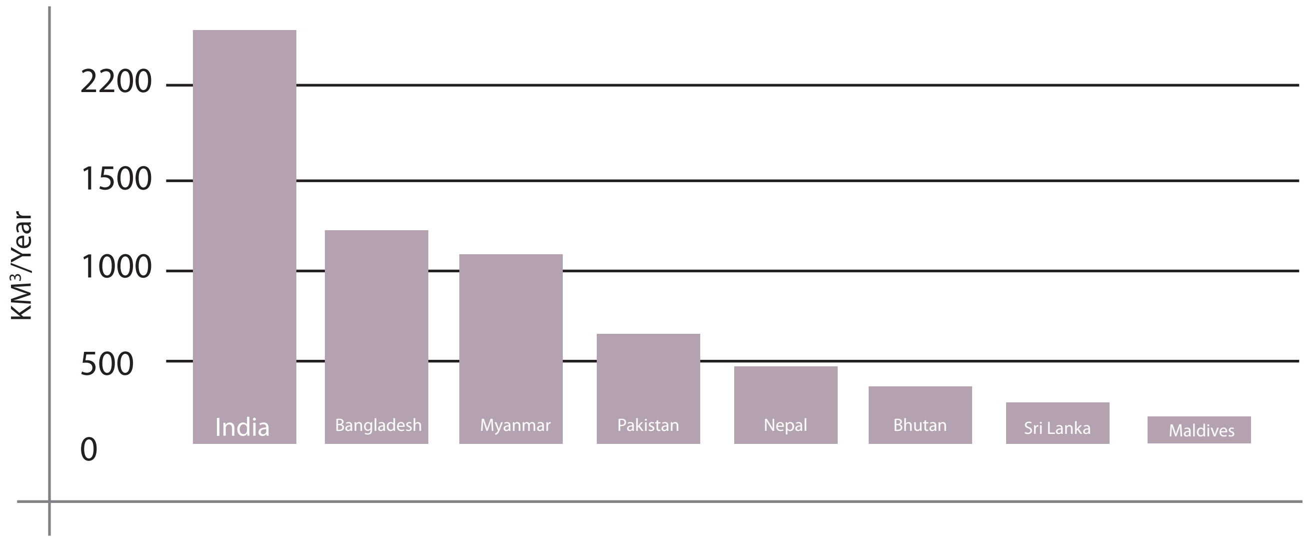
Source: Aquastat 2007[a] and UNEP 2008[b]

Irrigation systems differ across country and region: there are large contiguous centrally controlled irrigation systems in India and Pakistan, and medium-sized ones in Sri Lanka, Bangladesh & Nepal; there are also isolated scale farmers' managed systems in Pakistan, India, Nepal and Bangladesh.

In terms of total renewable water resources[5], India comes first with an availability of 1911 Km^3, and Bhutan, Sri Lanka and Maldives last with 78.0, 52.8 and 0.03 km^3; (FAO 2011). However, renewable water per capita exhibits quite a different pattern, with Pakistan and the Maldives falling in the water-stressed category and Bhutan coming out on top with 109244m^3/capita, falling in the water-surplus category. With populations set to increase, per capita availability of renewable water is expected to further decrease across the region (FAO 2011).

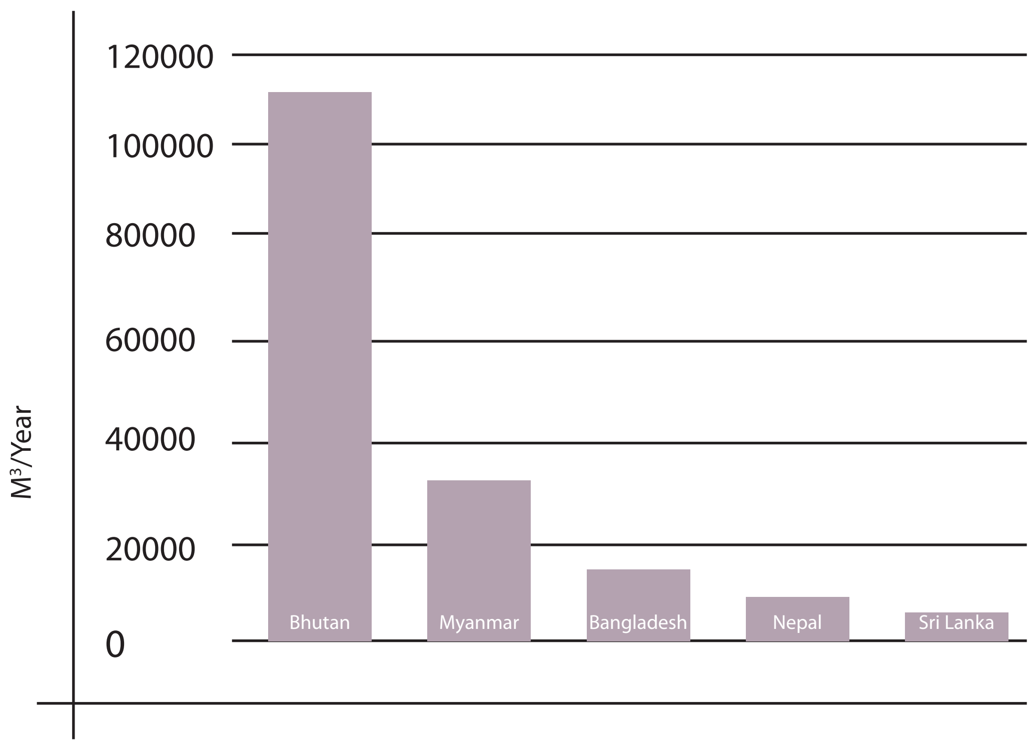
[5]Renewable water resources represent the long-term average annual flow of rivers (surface water) and recharge of aquifers (groundwater) generated from precipitation. They are computed on the basis of the water cycle (FAO 2005).

Figure 1
Total Renewable Water Resources of South Asian Countries (2009)



Source: FAO2011

Figure 2
Per capita Renewable Water Resources of South Asian Countries (2009)



Source: FAO2011

1.3. Challenges of Managing Water in South Asia

With a share of 95% of total consumption against a world average of 70% (UNEP 2008), agriculture is by far the highest water-consuming sector in South Asia. Therefore this report focuses predominantly on water use in the agricultural sector. Any policy on water will not be complete until it caters for efficiency calculations across sectors and takes into account allocation decisions on the margin. However, it was felt that agriculture's share in water consumption in the region is so overwhelmingly dominant that focusing our attention sharply on irrigation and water use on farms is more appropriate than providing a cursory overview of water use in non-farm sectors, such as in industries and in settlements. As South Asia industrializes and continues to urbanize, and this share falls, the current choice of focus will need to be reconsidered, but agriculture will continue to be at center stage in any foreseeable water strategy in the region.

The challenges of managing water in South Asia are largely due to increasing development pressures, resource stress, ecological insecurity (climate change), management and policy failures (IWMI 2004; 2011; David 2005). Among the problems faced are the facts that: irrigation efficiency[6] is <40 % against an achievable potential irrigation efficiency of 60%, resulting in low cropping intensity[7] and productivity[8]; farmers over-rely on subsidies; there is inefficient conjunctive use of surface and groundwater; trans-boundary issues exist both within and across countries; limited choices of technologies for efficient and cost-effective irrigation exist and support for R&D is inadequate; water markets are underdeveloped; water pricing is seldom observed; and even where attempts are made to charge for water, collection mechanisms are weak.

The remainder of the paper is structured as follows: Section 2 discusses how water use policies have been developed in South Asia in the past. Section 3 discusses pricing in centrally managed systems, while Section 4 discusses pricing resulting from water markets. Section 5 summarizes the problems of water use, discusses the obstacles to the adoption of policy options and how these obstacles can be responded to. Section 6 concludes. Finally, the appendices are an integral part of this paper: Appendix A provides evidence of the South Asian experience in adopting newer technologies for irrigation and discusses why despite their demonstrated efficiency, some of these technologies are not being taken up by farmers. Appendix B lays the foundations of our analysis by discussing economic theory relevant to surface and groundwater provision.

2 SOUTH ASIAN FORMULATION OF WATER POLICIES

South Asia is host to some of the world's largest river systems, and many other, minor rivers. The types of irrigation systems and policies countries have pursued vary considerably: India and Pakistan have developed large contiguous centrally controlled surface irrigation systems; India specifically has an enormous storage

[6] Irrigation efficiency is a multiple of water conveyance efficiency in canal network (main canals, distributaries and minor canals and watercourses) and application efficiency at the field level. Water use efficiency is a ratio of marketable product in kg per unit of water, normally taken in m^3.
[7] Cropping intensity is the ratio of cropped area to the command area at the farm level covering all the crop seasons. In South Asia two cropping seasons are used (winter and summer) and thus potential cropping intensity is 200% by having all the command area at farm level cropped fully in both the seasons. This is a land and time based ratio of using different crops and cropping patterns. It does not consider productivity of land or efficiency of irrigation or water use.
[8] Productivity is a marketable product of a particular crop in kg per unit area normally taken as hectare. Water productivity is same as water use efficiency and these are synonymous terms.

capacity with approximately 4000 dams and barrages (Briscoe, 2007). Bangladeshi water policy has concentrated investments in large scale multi-purpose flood control and drainage projects (FAO 2010), while Sri Lankan policy makers have focused on alleviating seasonal water scarcity in the dry zone through large scale storage tanks and inter-basin transfers (Ariyabandu, 2008).

2.1 Trends of Investment in Irrigation

Major investments in irrigation in the region started during early 19th century and continued for over a century. More recently, government promotion of irrigation in South Asia started extensively with the Green Revolution in the mid-1960s, when it was fuelled by the introduction of high-yielding varieties of cereal grains and other agricultural productivity enhancing technologies and by soaring food grain prices which promised a high rate of return to irrigation investment. South Asian governments were further supported by Western donors who worried about food insecurity in the world's leading area for cereal production. From 1962 to 1985, irrigated area in South Asia grew at an average of 2.7% - 3% a year, which meant that it nearly doubled during that time frame. Many large dams, reservoirs, and canal distribution networks were constructed and significant investments were also made into head works, pumps, drainage roads and land leveling, all strongly supported by the World Bank and other lenders. Public spending on irrigation was at an all-time high, with many countries in the region as well as the Word Bank allocating 50% or more of their agricultural budget to irrigation development (World Bank 1991 as cited in Barker and Molle 2004).

However, starting in the 1980s, public investment in irrigation started to decline, taking up less priority in budgets and slowly disappearing from the agenda of international development organizations. By the late 1980s, lending for irrigation by the World Bank and the Asian Development Bank had fallen to less than half its level a decade earlier (World Bank 1995; Rosegrant and Svendsen 1993 as cited in Barker and Molle 2004) and although irrigation is now coming back into focus as part of national food security strategies as well as climate change concerns, investment remains relatively low. (Barker and Molle 2004).

What explains these developments? First of all, grain prices declined. The expansion of irrigation combined with the spread of green revolution technology had led to a massive increase in supply, prompting developed country governments to increase subsidies to their grain producers, further boosting world supply & reducing prices. Between 1975 and 1985, cereal prices dropped more than 50% and have declined even further since then, thereby greatly reducing the rate of return to irrigation investments. At the same time, rising incomes around the globe shifted consumer preference away from cereal staples. As a result of these successes, irrigation slipped down in both domestic and donor priorities[9].

Second, construction costs increased, particularly because new project sites were less suitable to irrigation, further reducing the cost-benefit ratio of irrigation projects (Kikuchi et al. 2001; Svendson and Rosegrant 1994 as cited in Barker and Molle 2004). Next, operation and maintenance was gravely underfunded, shrinking the achieved returns from irrigation by as much as 44% over time (Kikuchi et al. 2003). Lastly, environmental opposition to dams grew prominent and dampened enthusiasm for irrigation. (Barker and Molle, 2004).

In general, many irrigation projects initiated during the green revolution performed poorer than expected,

[9] We are not suggesting that declining food prices should have been treated as failures of irrigation investments (and are not aware that anyone has suggested this in the literature either). Clearly, lower food prices are in and off themselves good and should be counted as a positive in any social returns calculations. There are however at least two important ways in which lower prices can dissuade investments into irrigation. First, if the crops grown through irrigation are exported, lower prices suggest less revenue and in turn, lower returns from further investment. Domestic policy makers will treat lower domestic prices as a benefit and lower international prices as unfavorable. Second, underdeveloped countries have serious funding constraints and weak cost recovery/collection systems. If food prices are lower, it makes cost recovery harder, and governments may drop such programs in favors of ones where financial break-even is more likely.

which played a role in discouraging further investment (Inocencio and McCornick 2008). Yet, it cannot be said that investments into irrigation did not pay off. Many studies have documented the contribution that irrigation has made to alleviating both temporary and chronic poverty (Hussain and Hanra, 2004) and generally, economic returns to irrigation projects were positive (Inocencio and McCornick 2008). With the rising importance of alternative uses of water such as for hydropower and industry, the payoff from investments in multi-purpose dams or even from adoption of high-efficiency technologies by farmers may even be larger today than in the past. The main question facing South Asian governments today is thus not whether irrigation pays, but how its profitability can be maximized in the long run and how both politicians & farmers may be motivated to make the necessary investments.

2.2 Surface Irrigation Policies

Different countries in the region have had varying degrees of success in pursuing larger scale surface irrigation systems, such as increasing storage capacity and transferring water from water-abundant to water-scarce areas, both of which are becoming increasingly necessary with greater climatic variability.

In 2002, the Government of India decided to launch the National River Linking Program, which seeks to transfer water from the water abundant regions to the water scarce regions of the country. The proposed benefits include the formation of a gigantic South Asian water grid which will annually handle 178×109 m3/yr of inter-basin water transfer; construction of 12,500 km of canals; generation of 34 Gigawatts of hydro-power; addition of 35 million ha to India's irrigated areas and generation of inland navigation benefits. (Verma, 2008) However this project has been criticized widely due to its negative environmental impacts and alternatives such as virtual water trade have been suggested (transferring virtual water in the form of food grains instead of physically transferring large quantities of water). In Pakistan, the Water and Power Development Authority and the Indus River System Authority (IRSA) are continuously working but with little success to date to get the provinces to agree on the construction of further dams and reservoirs[10]. Inter basin diversions are cited as future prospects to deal with the increasing costs of irrigation in Nepal.

Perhaps the biggest proof that irrigation continues to pay for the end user is the sustained expansion of the groundwater economy, which we will return to in a later section. Despite some grand plans for future development of larger-scale irrigation systems, many policies are turning to increasing the productivity of existing schemes, through a) water-saving technologies and practices, b) restoration and maintenance and c) improved management.

a) Restoration and maintenance

IFI lending of earlier decades presumed that the debtor countries would maintain facilities once built up, and so did not provide funds for maintenance. Due to poor maintenance, many of the large scale irrigation sites developed since the 1960s have deteriorated significantly, and lenders are now more amenable to financing maintenance and rehabilitation. These changes have had the effect that rehabilitation projects are now a common sight and are often found to have higher returns than new project construction (Inocencio and McCornick, 2008).

[10] Personal communication with Mr. Rao Irshad Ali Khan, Chairman of IRSA (Indus River System Authority) in Islamabad on October 18, 2011

India, in particular, has been struggling with the "build-neglect-rebuild" phenomenon, which sees the rapid decay of existing irrigation structures due to weak maintenance, and is therefore focusing new investments on enhancing the productivity of the existing system through reforming management practices (Briscoe, 2006).

One of the pioneering projects started in Pakistan in this regard was the Irrigation System Rehabilitation Project in Sindh started in the 1980s with strong donor support. The World bank, ADB and JBIC financed National Drainage Project in 1997 which completed in 2005 (Musharraf unveils plan, 2002) and large investment and institutional reforms components were included. The total cost of the project was US$ 760 million. Considerable funds have also been diverted towards solving the problem of water logging & salinity through lining the canals and installation of tube wells. (FAO 2010) However, insufficient attention was paid to management issues during the process. This is a topic we now turn our attention to.

b) Improved management – The role of WUAs and FOs

Till recent times, investments by governments were predicated on the fact that much of the problems with the large-scale structure were technical and hence there was a need for technical solutions. This limited approach did not work since much of the problems were organizational and political in nature. Failure to identify the cause of these problems has led to a major portion of the governments' investments to be directed towards the rehabilitation of the system (e.g. in the preceding case).

However, reform of irrigation management has begun to take center-stage in discussions on how to improve irrigation in South Asia. In view of the poor performance of many irrigation systems, the Bangladeshi government has recognized the importance and need for introducing appropriate on farm water management (FAO 2010) and Sri Lanka has announced that a focus of investment in the future will be on integrated water resource planning and management (Interim National Water Resources Authority of Sri Lanka 2011).

One major policy change with regards to improving irrigation management in the last two decades has been the devolution of power in irrigation management from the government to the water users associations (WUAs) and farmers' organizations (FOs). This transfer of power has initiated greater participation from farmers in irrigation management. However, the policies followed by governments differ across as well as sometimes within countries (notably in India's case), and differences in state capabilities and political will to implement and run WUAs and FOs also makes a general determination of their efficacy moot.

For instance, in Sri Lanka and Nepal the management of small schemes has been transferred to the WUA but the larger schemes are under joint management of the state and the WUA. In Sri Lanka, the main function of FOs is to deal with irrigation matters but they can also formulate and implement agricultural programs for their areas. The ownership of the water resources, however, remains with the government, both in Sri Lanka and Nepal. (Ariyabandu, 2008; Bhattarai, 2002) In Pakistan, the government initiated the National Drainage Program that entailed a shift in the strategic decision making policies away from the state to the FOs. This policy facilitates greater use of market mechanisms, on-farm capital investment, water allocation and O&M (Dinar et al., 1998).

In most South Asian countries irrigation is a state matter and the efforts to implement WUAs and FOs vary from state to state. In India, for example they range from cosmetic changes in Haryana to more comprehen sive arrangements in Gujarat and Andhra Pradesh. The main responsibilities of the WUAs and FOs include operation and maintenance of the irrigation system, water distribution as well as the collection of water fees. Moreover, the Andhra Pradesh Farmers Management of Irrigation System Act of 1997 stipulates that officials of the irrigation department are accountable to the WUAs.

The impact of WUAs and FOs has been analyzed in various empirical studies. For instance, studies conducted in Sri Lanka (Samad, 1998) and India (Cornish, 2003) reveal that the participatory approach did not lead to a reduction in government expenditure for O&M. However, results for Nepal proved otherwise. A study conducted by Cornish and Perry (2003) found that in Nepal the rate of recovery of O&M costs was only 1.3% under schemes managed by the department of irrigation (DOI) and fee collection rate was 30%, whereas under schemes managed jointly by WUAs and the DOI the collection rate was almost 58%. In India, there is also evidence that FOs improved the quality of irrigation service provision: a study was conducted by Naik and Kulro (2000) in Maharashtra, in which farmer surveys were carried out to assess the impact of FOs under the Mula and Bhima canal schemes and results showed that 82% and 74% of the farmers, respectively, ranked WUAs as their first choice water supplier. On the other hand, in Sri Lanka, where the government formally transferred the operation and management of the irrigation system to the FOs in 1998/1999, a study in Nachchaduwa found that nearly 60% of all farmers interviewed felt that the condition of the canal system was worse after management transfer (Samad and Vermillion, 1998). Infrastructure inspections also revealed a serious under-investment in maintenance.

Most of the available evidence regarding WUAs and FOs is at the micro or scheme specific level. As stated earlier, there are too many differences in prevailing conditions, policy design, and implementation to draw firm conclusions as to the best role of WUAs and FOs in water management. However, there is broad consensus that more participative decision-making is a desirable feature of a system. Building capacities and stronger farmer groups requires a lot of time and resources, which the governments will eventually need to invest for projects to be viable and sustainable (Briscoe, 2007). In the absence of firm evidence in favor of one set of design decisions, governments of the region would be well served by starting small, experimenting with various different ways of designing these bodies, collaborating within and across boundaries to build collective wisdom, and scaling up successful designs gradually.

2.3 Groundwater Irrigation Policies

Whereas public investments in surface irrigation has waned, South Asian countries have experienced a groundwater boom as private investments in tubewells and other groundwater technology continue, resulting in large areas in the semi-arid regions of South Asia that depend on groundwater irrigation.Today, India is estimated to draw some 60% of its irrigation water from below the surface. In the populous Punjab region of Pakistan, it is estimated that groundwater accounts for 40% of irrigation. The total area irrigated by groundwater in South Asia is on the rise.

Groundwater development is less restricted by topography and hydraulics than large surface irrigation systems and is better suited to private development as tubewells can be independently owned and water can be used on demand. Groundwater development has thus historically been seen as a core element of livelihood creation programs for the poor in the developing regions of South Asia, supported by subsidies for tubewell equipment and especially, pumping electricity (Shah, 1993; Kahnert and Levine, 1993).

BOX 1 Kareze – Sustainable Groundwater systems

Kareze is an ancient system of harvesting groundwater through a series of wells, called the mother-well, that begin at the base of mountains along the contours of the hillside, and link with underground channels to bring groundwater to the surface, or the day-light point. Kareze is prevalent in the world's highlands irrigating 15 million ha – 6% of world's irrigated lands. Half of this is in Iran and rest in Afghanistan, Pakistan, Central Asian states, Oman, Maghreb, Morocco, and Mexico (Ahmad 2007).

A survey of over 1146 Karezes conducted by the Irrigation and Power Department, in Balochistan, Pakistan indicated that the construction and maintenance is still based on traditional but participatory approaches. IUCN Balochistan is now actively involved in the modernization of Kareze system, whereas FAO with the support of USAID is involved in rehabilitation of over 250 Karezes (Ahmad 2007, IUCN 2006; FAO 2012).

Kareze provided water sustainably till the 1970s when, with the increasing take-up of tubewells, the water table started declining, adversely affecting the Kareze system. Pakistan's public and private sector institutions are now involved in modernizing the Kareze system through: a) improvement of mother well and water flow control devices; b) lining of water conveyance channels using PVC pipes between the two wells; c) lining of vertical wells; and d) storage of water at tail-end reaches. More recently, there is a concern that efficient water use in Kareze command area is essential to improve water productivity so that water demand is reduced for sustainable farming.

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There are few regions left in South Asia, in which there is still scope for further groundwater development[11]. In these areas, subsidies facilitating groundwater extraction are very effective in improving agricultural production and alleviating rural poverty. Even though such regions are declining rapidly, government policies aimed at facilitating groundwater extraction persist, leading to increased stress on groundwater resources and growing concerns of the impacts of overexploitation, meaning that the rate of water abstraction exceeds recharge possibilities and will ultimately lead to groundwater depletion and subsequent

[11] They include areas in the Nepalese Terai, Orissa, North Bihar, North Bengal, Eastern Uttar Pradesh, Central and Southern Gujarat, and Western Godavari.

decline in agricultural output (Shah 2007). This policy persistence has led to socio-economic disasters such as those currently being experienced in Southern Rajasthan, coastal Saurashtra and Tamilnadu, and Northern Gujarat, where the ecological consequences of overdraft are being fully realized, leading to abandonment of entire village clusters.

There is no disagreement about ideal policy interventions (our discussions of the economics of groundwater use in Appendix A and on implementing market trade in groundwater is particularly important in this context): they include formulation and enforcement of a groundwater law, establishing unambiguous tradable property rights for water, treating groundwater as an economic good in terms of pricing, and implementing a licensing and permit system in order to regulate groundwater extraction. However, no Asian country has been able to adopt these measures effectively on a sufficiently large scale[12].

India, for example, has been working on a groundwater bill for over three decades, but has not succeeded in legislating it due to concerns about enforcement on almost 20 million water pumps spread out across the vast countryside. Instead, not only South Asian countries but also North China are still promoting more groundwater development with little or no regard to overexploitation of the aquifers. This can be partly attributed to a lack of information regarding the actual occurrence and condition of groundwater resources in the regions and partly to political and social obstacles associated with enforcement of regulatory interventions. To give an example of the latter, Sri Lanka's recent water policy has instigated a lot of controversy, which has been fueled by the sensationalist media. The locals fear that the government has sold Sri Lanka's water resources to multinational companies, and policy reforms aimed at discouraging groundwater withdrawals by increasing the initial or/and operational cost of extraction seem to confirm their suspicions (Shah, 2007).

With strong community resistance to any reforms restricting water use and high direct monitoring costs, pricing of energy has become the only medium through which governments can indirectly regulate groundwater withdrawals in South Asia and energy remains subsidized in much of the region.

2.4 Persistence of Rainfed Agriculture in Regions of High Climatic Variability

Despite the fact that most of the world's irrigated area is found in Asia, 58% of cultivated land in South Asia remains rainfed (Wani et al. 2009). In the face of increasing climatic variability, this seems worrisome; however, in comparison with other regions in the world, including developed countries such as the USA, South Asia has a very high irrigation rate.

The reasons underlying the persistence of rainfed agriculture are manifold. Firstly, investments in irrigation are driven to an important extent by necessity such that more humid areas are less likely to develop extensive irrigation infrastructure. At the same time, public irrigation investments tend to be focused on high-potential areas, such as densely populated districts or regions located close to watercourses, major markets and roads (Kerr 1996). Given limited state resources, this has had as a consequence that semi-arid areas which remain predominantly rainfed are some of the poorest regions in South Asia, where complimentary

[12] There are important success stories that do not conform to this generalization: in Pakistan, a Groundwater Administration Ordinance 1978 was promulgated in Balochistan and farmers are compliant with it at least as far as the spacing of wells is concerned. Court cases are common for non-compliance. We do not currently have data on how well the court system functions to resolve disputes.

conditions are not always conducive to private investments in irrigation on the part of farmers (Bantilan et al. 2003). In these regions, there is a need to invest in rain water harvesting and storage technologies including natural wetlands, groundwater aquifers, ponds, small tanks, as well as micro dams to buffer against increasing climatic variability (McCartney and Smakhtin 2010).

From a policy perspective, this variation of investment across regions raises the question of how decisions are made about investments by governments: if decisions are made on a measure of efficiency, it may be useful for policy-makers to consider diverting some water to "protective irrigation" of dryland crops, since this could substantially improve yields in those crops (Kerr 1996). Some studies suggest that investments into infrastructure and technology in rainfed areas have high marginal returns that out-compete additional such investments in irrigated areas as well as expansion of irrigation and call for governments to move into this direction (de Fraturier 2007, Fan et al. 2000). However, it is rare that extended areas are completely irrigated or completely rainfed. In a study of rainfed agriculture in India, Kerr (1996) points out that irrigated and rainfed agriculture co-exist in practically every village; farmers tend to intensively irrigate crops such as paddy, sugarcane, and horticultural crops while leaving grain crops rain-dependent. When differences in irrigation are across crops, this simply suggests that more expensive irrigation processes are reserved for higher-value crops.

However, if access to irrigation services varies across closely-situated farms, this raises questions of equitability and efficiency, since it suggests that these differences are not driven by differences in the farms' suitability for irrigation. If investments in irrigation are a result of owners' characteristics, such as having the financial resources to invest in tube wells, this implies funds may not be being directed to the most efficient investments. There are two policy directions that emanate in such a situation: first, policy-makers must focus on removing barriers to investments at the individual's level – cheap access to credit, subsidized inputs, farmer education and extension services etc. can all be used to ensure that fewer farmers face the situation of being on a farm that would benefit from being irrigated but is not because of a removable constraint. Second, policy makers should ask the question why farmers cannot privately cooperate to irrigate in the most efficient physical way, and then find a way to share surplus. This question is discussed in detail in Appendix B. The short answer is that there exists a problem of trust in collaborations.

Most importantly, it must be stressed that water is a finite resource and hence irrigation potential is limited. In India, for example, the optimistic estimate for total irrigation potential of 175mha represents only about 72% of existing agricultural land (World Bank 2011b, ADB 2009). Given this, it is vital to identify how existing water resources can be used both efficiently and equitably as well as how productivity in rainfed areas can be increased to meet future food demands.

2.5 Water-Use Efficiency Policies

There has been a recent move in South Asia towards subsidizing new water efficient irrigation technologies. Much of the focus of these subsidies has been on micro irrigation technologies such as the drip and sprinkler systems. Subsidies and options for financing from organizations and government schemes increase the profitability of investing in micro-irrigation, which makes a crucial difference in adoption by poorer farmers. (IWMI, 2006) Thanks to government subsidies, drip irrigation is expanding rapidly in India. In Pakistan pilot projects have demonstrated the technical benefits of these techniques and the government is now directing subsidies in the same direction. These subsidies have concentrated at the farm rather than the surface water conveyance system level. (Faurès, 2007) Nepal has also indicated that most of the future investments as envisaged in the five year development plans are directed towards the widespread use of appropriate technologies to increase agricultural production. (FAO, 2010)

The other aspect of improving on-farm utilization of water is proper irrigation timing and planning, which is often undermined by a lack of knowledge on crop water requirements and the like on the part of the farmer. For example, in Pakistan, due to a lack of research and extension services, Pakistani farmers have little understanding of the most productive applications of water during crop-growing cycles which has led to lot of water wastage in the system. All these problems should be the focus of any future investments undertaken by the governments in this sector (Briscoe, 2007).

BOX 2 Adoption of Drip and Sprinkler Irrigation in India

In 1995, the Government of India constituted a Committee on "Private Sector Participation in Irrigation Projects" to involve the corporate sector in the adoption of drip and sprinkler irrigation systems. This effort was further endorsed by the Indian Water Policy of 2002 (ADB 2008).

Drip irrigation was introduced in India by the Tamil Nadu Agriculture University (TNAU) during the 1970s and field demonstrations were encouraged. However, adoption remained slow till the mid 1980s because of deficient promotional efforts. The area covered by drip irrigation up until 2003 was 500,000 ha. In 2004, a National Committee on the "Use of Plastics in Agriculture" was constituted by the Ministry of Petroleum which promoted technological development and encouraged farmers to use these systems. The real impact was observed when Jain Irrigation Systems Private Limited started playing an effective role in 1989 for promoting sprinkler/drip irrigation systems through local manufacturing and provision of integrated services to the farmers (Narayanamoorthy 2006). A similar impact was observed for the adoption of sprinkler irrigation in India initially for coffee and tea and later for other crops (INCID, 1998).

Maharashtra government invited tenders for irrigation projects in 2007, on a build-own operate-transfer basis and several private-sector firms have shown interest by structuring coalition with drip and sprinkler irrigation service providers in the private sector and by creating forward and backward linkages. It enhanced farmers' willingness to pay for premium use of water and high compliance from irrigation engineers and the private sector firms (ADB 2008). This was the beginning of large-scale technology adoption in India for high value horticulture using high efficiency irrigation systems.

Jain Irrigation won two prestigious Plast India Awards in 2009, which is indicative of the growth and quality of micro-irrigation system production and services. Jain, which now has a significant share in the export market, received a very promising order of Rs. 778 Million from the World Bank in 2009. The other significant development was the signing of an MOU between Jain Irrigation & the International Rice Research Institute (IRRI) for collaborative research and adaptive field trials on paddy using micro-irrigation systems. Rice is one of the most demanding crops in terms of water demand, and there is a perception that irrigation will not work with rice, so this is a significant development.

While Jain still has a long way to go, other South Asian governments would do well to study its success closely and evaluate how they can adapt this success story to their own contexts.

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3 WATER PRICING IN CENTRALLY MANAGED SYSTEMS

For reasons discussed in detail in Appendix B, surface irrigation systems such as large-scale canal irrigation systems are typically publicly provided[13]. The central authority must therefore make both decisions on allocations across users, and on whether and how much to charge for provision. It is often argued that water is a special good (Zaag and Savenije, 2006), since it has not only economic, but also social and environmental effects and its provision up to a minimum consumption level is argued to be a basic human right. Moreover, many major water resources in the world cross provincial or national boundaries and this has its own set of important issues. For the sake of brevity however, we consider here only the pricing and allocation of water that a state has available for its productive use, after allocation for any international claims and basic consumptive provision is done.

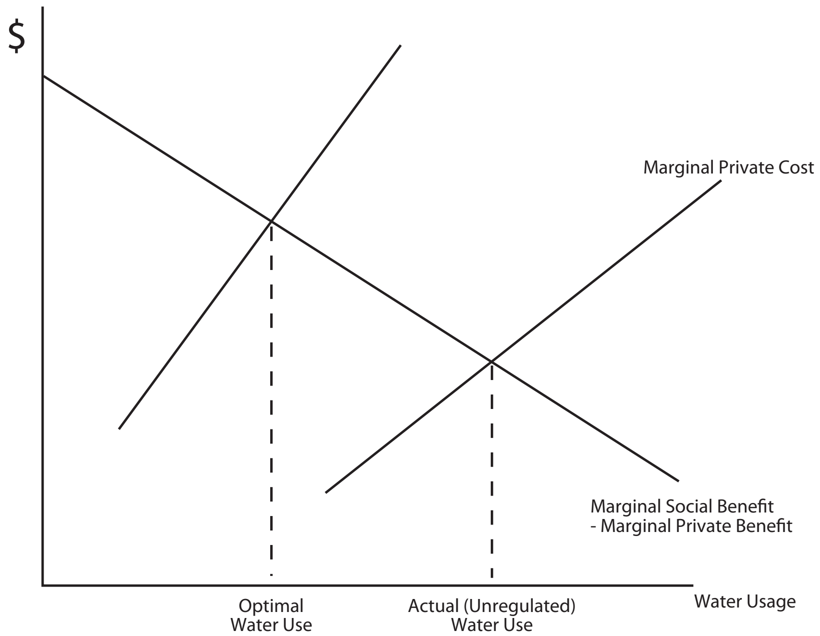
Generally, water from large-scale, centrally managed surface irrigation systems are priced for two reasons: to cover the operation and maintenance (O&M) costs so that the project is financially sustainable, and as a means to encourage farmers to use less water per unit of output[14]. While it is often argued that lower-than-efficient water prices help poor farmers raise their incomes and contribute to national food security, there is general consensus that most farmers should pay at least the O&M cost of irrigation and contribute something toward capital cost.

At the farm, the decision-maker's choice of how much water to use for producing output depends in part on the cost of the water. Specifically, a profit-maximizing firm will use more water till the cost of using an additional unit of water exceeds the benefit (in terms of additional revenue from the sale of the extra produce generated by that additional water)[15]. The implication of this is that water use increases, ceteris paribus, when: a) the unit cost of water decreases, b) when the market price of output produced increases, and c) when water use efficiency increases.

[13] Note that since it is both rival and excludable, water is not a public good.
[14] Or equivalently, to produce greater net economic returns per unit of water.
[15] Technically, the marginal revenue product (output price times marginal physical product) equals the marginal input cost.

Because centrally-set prices do not fully reflect the costs of provision[16], public allocation mechanisms often lead to waste and water misallocation. Efficiency in the economic system as a whole occurs when those who decide on consumption levels for a good have to bear all costs associated with it. Stated differently, efficiency requires that externalities, whether positive or negative, are both internalized. In situations where water prices do not fully account for costs, whether due to subsidies on inputs such as electricity or oil, or because negative externalities in the form of aquifer overuse remain unaccounted, or because the surface water supplier does not charge for fixed costs, or for any other reason, the marginal private cost of water is less than the marginal social cost, and therefore the quantity of water consumed will be greater than is socially optimal, as depicted in the figure below:

Figure 3
Overuse of water occurs if costs are not fully recovered



In addition to the reasons discussed above, this wedge between marginal social cost and marginal private cost of water may reflect conveyance costs because private water conveyers may not fully account for all social costs associated with conveyance in their decision-making process. Other causes of the wedge may be externality costs associated with diversion of water from the environment to irrigation, and the discounted future cost of reduced water availability because of extra water pumping in the present. (Schoengold and Zilberman, 2007).

[16] In theory, the price of water should reflect its marginal cost and value. The simplest way of determining this price would be to use a market allocation system. For central planners it is near impossible to determine the "right" price. However, countries such as France, have gone a long way in trying to match their water pricing with the marginal cost pricing (MCP) principles (Dinar, Rosegrant and Mienzen-Dick 1997).

Moreover, because centrally determined prices do not reflect the value to the consumer, allocation decisions cannot respond to any signals of the relative intensities with which different farmers require scarce water. In centralized systems, the state decides what water resources can be used by the system as a whole, and allocates and distributes water within different parts of the system[17].

Absent a price signal, purely centrally managed systems (i.e. ones determining both allocation amounts and charges) suffer from a lack of information about which users need water more than others at a given point in time, and thus fail to react to this (Hayek, 1945). In such systems[18], the water charge is either uniform (if differences in use cannot be feasibly assessed), area-based (if the area owned or the area cropped can be assessed) or crop-based (if the area and type of crop can be assessed). Note that these types of prices are increasing in both complexity of assessment and responsiveness to user differences. These charges may be for open access to the water supply, or for a separately determined quota allocation.

Centrally managed systems may allow the user to determine their own allocation amounts and calculate charges accordingly. In these cases a volumetric charge is used, i.e. one in which water is charged based on actual diversions to a user or group of users (bulk pricing), and metering becomes necessary (although volume may be calculated by measuring time or the number of turns allocated). The volumetric charge can be used in isolation, combined with a flat rate, or applied only to usage above quota. If metering is used, different rates can be applied to different levels of consumption. Although volumetric pricing does not solve the problem that centrally managed systems fail to respond to differences in intensity of need across users, it reduces the problem that such systems also fail to respond to differences in usage.

Countries in South Asia have typically had centrally managed irrigation systems with non-volumetric prices. There have been important differences in both design and implementation however.

In India, government policy has focused on introducing volumetric pricing where possible, as in the states of Gujarat and Haryana. Water charges are set such that they cover the O&M costs of project. Collection of water charges has, in many cases, been shifted to the Water User Associations (WUAs) who may use the revenue to finance their operations. Overall, India's record with water pricing has been relatively successful (Easter, 2005).

Water pricing in Nepal differs according to the type of management scheme. About 70% of all irrigation projects are farmer-managed schemes and no fee is levied on these systems by the government. The national treasury retains the water fee from the public irrigation schemes and the fee collection rate was reported to be less than 30%. Lastly, in systems managed jointly by the farmers and the government the collection rates are about 58%. Water pricing in Nepal covers neither O&M nor capital costs. (Easter, 2005)

In Pakistan water pricing has generally been ineffective, both in terms of cost recovery and water-use efficiency. (Ahmad, 2002) The pricing mechanisms used are area-based or crop-based flat rates; which are relatively inefficient as neither is related to actual water use. Furthermore, the revenue that is collected is not reinvested in the irrigation systems, giving farmers little incentive to pay water charges.

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[17] Although the state allocation usually applies only at the trunk and distributaries level of canal irrigation systems, in systems with pukka warabandi rotation such as in Pakistan and India, the agency even specifies the particular times and places individual farmers are entitled to water.(Dinar, Rosegrant and Mienzen-Dick 1997)

[18] The discussion of prices that follows is adapted from Molle and Berkoff (2007)

Water pricing policy in Bangladesh is somewhat similar to that in Pakistan. Under the Flood Control Drainage and Irrigation (FCDI) projects, water is not billed in proportion to the volume used; thus water pricing does not significantly affect farmers' cropping decisions. According to the Water Ministry of Bangladesh (2000) water fee collection rate is about 3-10% and the cost recovery in intensive infrastructure based irrigation projects is very poor. (Easter, 2005)

Regardless of the type of pricing, water charges need to be assessed and collected by the state, through a revenue or irrigation department or a combination of the two, as in India; by an autonomous irrigation entity at the national level, as in the case of the National Irrigation Administration (NIA) in the Philippines;
or at the scheme level, as in China and other countries where schemes are managed autonomously or quasi-autonomously; or by a communal organization (such as a Water User Organization) collecting charges directly from its members. (Molle and Berkoff 2007)

However, records show that the collection rate of water fees have generally been low throughout South Asia; in the 1980s, for example, they amounted to about 8% in Sri Lanka, 3-10% in Bangladesh and 20% in Nepal. There is no known evidence of rates having gone up since.

In some projects, fee collection rates are near zero, even when water charges are well below the cost of project operation and maintenance (O&M). For example, in Pakistan, irrigation charges are extremely low: the average gap between O&M cost and revenue was calculated to be Rs. 192 (slightly more than $2) per acre of Canal Command Area in 2008. (Sufi, 2010) These low charges and the fact that a small percentage of farmers actually pay them are increasingly being questioned. (Easter and Liu 2005) Clearly, the arguments that pricing water helps offset financial burden and that it encourages more efficient use are moot if prices exist on paper but are seldom actually paid.

However, there are instances where centrally priced systems function relatively well. Lessons for at least a second-best solution can be learned from Haryana in India where water is divided equally over thecommand area through a canal system that automatically apportions the water among farmer groups, who then share the supply in rigidly fixed turns. (Perry and Berkoff 2008) Allocation and scheduling of water among canals is the responsibility of the irrigation department but once the water reaches the outlets, farmers are fully responsible for operation and maintenance (O&M).

This system has proven to be one of the most productive in India, mainly because it provides strong peer pressure governance. A farmer who steals a turn from another farmer can cause instability over the entire canal as can a delay or shortfall in supply from the irrigation department. Water charges are set to cover the O&M costs but not capital costs and are based on area and crop type, amounting to approximately 0.5% of the average net farm income. Fees are collected by the state revenue department and collection rates are high, between 85 and 95 percent, which may be due in large part to the fact that the government can take land away from defaulters. The actual O&M costs overall are also very low, which can be attributed to highly centralized management, limited staff requirements, and substantial farmer participation. (Easter and Liu 2005).

In general however, the experience in the region is that even though water fees cover a tiny fraction of total O&M costs, they are not sufficiently collected. There are even cases where the cost of assessment and collection exceeds recovery. Despite the efficiency arguments for volumetric pricing, the basic enabling pre-requisite is improvement in collection. Governments may even find it worthwhile to consider interim policies that run counter to final prescriptions, such as one-time flat-rate fees collected at the start of the cropping season to save collection costs.

Determining the 'right' price to charge in a centrally-managed system is difficult. For reasons documented above, a popular policy prescription is the use of markets in water. The next section assesses the advantages and disadvantages of water markets in light of experiences around the globe.

4 WATER MARKETS

Economists widely advocate the use of water trade in markets as a means of efficient allocation. Prices in a well-functioning market reflect both the marginal cost of supply and the marginal value of use, a feat that is not possible for even the best central planner to match. When water can be traded, it carries an inherent opportunity cost that creates incentives to conserve water, use it efficiently, or trade it away to higher-value users.

Tradable water rights encourage investment in water saving technologies because investors benefit monetarily from the savings (Rosegrant and Gazmuri, 1995). They also allow users to engage in activities requiring large quantities of water provided the surplus created is large enough to buy the additional water needed. In the same way, changes in crop prices, demand patterns, and relative efficiency of water use can all be responded to with maximum flexibility, resulting in efficiency-enhancing water reallocations. This flexibility that the ability to trade water provides is expected to become increasingly important for cross-industry allocations too, as non-agricultural demand for water grows, e.g. through continued urbanization.

Moreover, since voluntary exchange in a well-functioning market requires that any reallocation of water only occur with the original water user's consent, the user is empowered and cannot theoretically be worse off than without trade (since any exchange that makes him worse off will be overruled). However, as the discussions below demonstrate, problems can arise in at least two ways: due to market failures, or because the prerequisites needed to support functioning markets do not exist.

4.1 Markets in surface water systems

One of the countries with the most advanced water markets globally is Australia, which offers transferable water entitlements within the Murray Darling Basin (Qureshi, Shi and Qirbi 2009). The Australian water industry was divided and decentralized in the early 1990s; Murray Irrigation, for example, is a separate licensed entity with its own board. The system also allows water trade between states. Subsequent tariff reforms have ensured that consumers now pay according to the quantity and the efficacy of their water use. The National Water Commission (NWC), as both regulator and investor, has been the system's backbone. This model pre-supposes that agriculture is a commercial sector, which is far from the reality in most of South Asia's developing countries.

Another example cited in favor of water markets, and one that is argued to be more relevant to South Asian countries, is Chile's experience with transferable water use rights, which it introduced in 1981. A study conducted on these reforms by Heame and Easter (1995) found that the transfer of water-use rights produced substantial gains from trade, and that WUAs played an important role in facilitating the market reallocation of water, especially in the Limari valley. On the other hand, Romano and Leporati (2002) argue that the reforms led to higher inequality in access to water as farmers with lower social and human capital and little access to information were in a weak bargaining position. In 2005, the Chilean government passed a reform to the Water Code, amending it to give the government more control over the social & environment effects of water trade. In the end, although Chilean water trade has been successful in allocating water from lower to higher-value uses in some instances, water markets by no means function all over the country; many farmers are not aware of the Water Code (1997), do not have the resources needed to function in a formal market or have not even registered their water rights (Bauer 1997). It is also important to note that water rights existed in Chile before the introduction of the Water Code, which makes pre-existing conditions for functioning water markets much more favorable than in South Asia, where water rights are not as established a concept.

For a water market to function certain preconditions have to be in place; well-defined water rights, measurement devices and routines, enforcement and sanctioning mechanisms as well as specifications concerning return flows. (The World Bank 1999) We will discuss these in detail in a later subsection.

4.2 Markets in Groundwater

Groundwater markets are fundamentally different from their surface water counterparts. In sophisticated surface water trade, buyer and seller may be very distant from each other and interact only through the water market, while trade of groundwater is typically localized and personal, and infrastructure requirements are correspondingly far smaller. Therefore, although South Asia may still face significant hurdles to surface water markets, groundwater trade is already commonplace in the region.

Tubewell water sales have, for example, become a profitable enterprise for small farmers in Uttar Pradesh in India (Shankar, 1992) and even for the landless under programs sponsored by several NGOs in Bangladesh. In Gujarat, India, water markets are highly advanced and farmers make substantial private investment in water pumps and underground pipeline networks. This generates a high degree of competition amongst sellers of water. (Dinar, Rosegrant and Meinzen Dick 1997).

For suppliers, the major benefit cited of groundwater trade is that by selling water to other farmers, tubewell owners can use a higher proportion of their well capacity than they would on their holdings alone and realize a higher return on their initial investment. On the demand side, groundwater markets increase access to irrigation water, especially among farmers with small or fragmented holdings and those without their own wells, thus increasing equitable access to water as an input. Shah (1991) argues that the resultant expansion of irrigation has led to increased cropping intensity and agricultural labor demand, ultimately benefitting the landless and those who rely on wage labor for household income, and lowered water tables in waterlogged areas.

As effective as their positive effects may be, unregulated markets in groundwater are subject to a fundamental flaw: trade of surface water is typically separated from production decisions and the decision is essentially of how to allocate a fixed amount of water to rival uses. On the other hand, in groundwater markets the seller is typically the owner of a pump who can sell water that he would otherwise not have pumped[19]. This adds a significant possibility of overexploitation absent in surface water markets.

The ability to trade groundwater exacerbates the Commons problem (studied in detail in Appendix B) that the non-excludable nature of groundwater exposes it to, especially with the prevalent ownership rule of First Possession. This has, predictably, already led to overexploitation of groundwater resources in some areas where groundwater markets exist, beyond the possibility of recharge. In short, groundwater markets, by increasing access to water pumping, magnify both the beneficial and harmful dynamics that pre-exist in groundwater pumping.

4.3 Preconditions and limitations of markets

As discussed earlier, for all but the most rudimentary and inefficient trade, transactions must be underpinned by clearly defined water rights, verifiable measurement and credible enforcement. This presents many difficulties.

First, since any formal market in either surface or groundwater requires clarifying initial rights[20], this entails apportioning rights according to a principle or rule. Since rights are rival, this implies that there will be winners and losers. In groundwater, for example (and as discussed in the appendix), a rule of tied ownership (rights to water linked to property rights over land) favors those who have not yet developed their water pumping capacity over those who have, when compared to a rule of first possession (whoever pumps owns the water). In surface water, allocating rights according to current or historical usage, linking rights to amount of land, or assigning flat rights to each person all impose different costs and benefits on different people. Support for a particular rights apportionment principle will depend on these expected costs and benefits that people face.

Moreover, the existing valuations of land already incorporate formal or informal expectations of water apportionment (or prevailing sense of entitlement to water rights). New laws will correctly be perceived by some existing land owners as expropriating value. An added complication arises when flows are variable: if rights must be conceptualized not as claims to an absolute amount of water, but a share of whatever water exists, this clouds expectations. Finally, the new rules and institutions may clash with preexisting informal rules of resource allocation that grew out of local traditions and culture (Griffin, 2005). Resistance is almost certain because such an allocation of rules is disruptive both economically and culturally.

By reducing wastage, incentivizing water saving, discouraging overexploitation and encouraging reallocation from low-value to high-value users through trade, water markets that meet the necessary preconditions improve economic efficiency. However, many of the benefits[21] are dispersed across a large group, and accrue to individuals with little say in the political process ex ante. These people may also be rationally ignorant of these benefits . It is therefore conceivable that those enjoying cheap access to water, effectively riding roughshod over rival (likely lower riparian) claims, will lobby to preserve the status quo.

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[19] Informal groundwater markets do not represent the sale or trade of water rights, rather, groundwater markets might be considered "spot markets", examples of spontaneous water market development. (Mienzen-Dick 2002)
[20] We also discuss this problem in the context of groundwater in Appendix B.
[21] Rational ignorance is discussed in Appendix B.

The precondition that initial assignment of property rights is completed is therefore one of the biggest hurdles to the functioning of water markets. As noted previously, Chile had existing water rights at the time water trade was introduced.

Similarly, Australia not only had water rights, but the idea of trading water like other inputs was well-established because agriculture was already viewed culturally as a commercial, not a social activity. South Asian countries would do well to set their sights on the lower but more difficult goal of establishing unambiguous property rights before water trade is promoted.

Since apportioning water rights places burdens on some users, it should be done as part of a broader package of reforms that carries other benefits that may be compensatory for those whose water rights may have been affected. The western experience with water markets was successful because it was coupled with agricultural policies that promoted less water consuming crops, and carried out subsidization of irrigation equipment to reduce the burden on farmers. (Berbel, Calatrava and Garrido, 2005) Employing such policies in developing countries of South Asia in conjunction with the market may be ambitious.

Another separate problem that needs addressing before water markets can be established in South Asia is the improvement of the infrastructure and administration of water measurement. Currently, water measurements are mostly done at the canal or distributary, not the farm level, and this complicates efforts to trade because claims of withdrawal levels are not verifiable, and the enforcement of withdrawal rules thus undermined. Improving measurement is not merely a technical problem, but is also made difficult by resistance from powerful local elements, corruption and formal political resistance, since overdrawing is prevalent.

Moreover, even if these requisite preconditions are met, while there are clear benefits from using market mechanisms, there are also important limitations that need to be addressed in practice. First, bilateral voluntary trade is efficiency-enhancing if there are no externalities, but not otherwise. If a farmer's decision to buy water implies congestion of water channels, environmental degradation or unsustainable abstraction from a common aquifer, the rules of trade must regulate and account for these effects. Unregulated, a system of tradable property rights impedes the development of effective river basin planning and environmental and ecological protection. (Dellapena 2008)

Second, while voluntary trade is considered welfare-enhancing in most environments, inequalities of social or human capital, and little access to information can weaken an agent's bargaining position. Ostensibly voluntary trade can be exploitative or even fraudulent if the market participant cannot read or interpret regulations properly. A complementary condition for market development therefore is the development of community organizations to advise, educate, and manage water allocations. (Rosegrant, 1994)

To sum, while market allocation can be clearly efficiency enhancing in some cases, the development of markets cannot proceed in an isolated fashion from the real-world institutional and technological context of developing country irrigation. We discuss this issue more broadly in the next section.

5 PRESCRIPTIONS & PROBLEMS IN SOUTH ASIAN WATER POLICIES

Over the course of this document, we have described South Asia's experience with past and current water policies. This section summarizes the preceding discussion and documents problems. As a water-stressed region, South Asia clearly needs to harvest more water, and use existing water resources more efficiently.

5.1 Problems of water use

Surface water is, for reasons discussed in Appendix B, primarily managed by the state and involves large investments because governments need to construct dams of both micro and large scale. However, both foreign and domestic investments in irrigation have declined. As already documented, donor support for irrigation projects has greatly reduced over time. Furthermore, governments are faced with ever increasing demands on their budgets, further squeezing money allocated to agriculture and specifically irrigation. For a sector as important as irrigation, South Asian countries need to look inwards for investments, and not be dependent on aid.

If the irrigation investments are truly beneficial, i.e. social returns net of costs are positive, it is not action but inaction that states can ill afford. Developing countries in general, and South Asia in particular suffers from the problem of not ranking potential investments across different sectors by favorability in a cost-benefit analysis. In making investment decisions, governments can seldom refer to evidence that money spent on the proposed project is likely to provide greater socio-economic returns in this use than in any other. As a theoretical example, it may be beneficial to reduce de-silting of canals in order to invest resources in providing protective irrigation in remote drylands, but the decision-making process for such investments will often be independent.

Another problem is the lack of farmers' involvement, both during initial planning and implementation of projects and in operation and maintenance. Irrigation projects that have some farmer contribution tend to perform better than solely government managed systems, yet most water development for irrigation in South Asia has been implemented using a top-down approach with little involvement of farmers. As a result, farmers often do not feel like they have a responsibility in maintaining the projects.

While it is recognized that farmers must more actively contribute to the operation and maintenance of irrigation infrastructure to increase its longevity and efficiency, further work is needed to understand how the state can incentive such contribution: the evidence on water user association (WUA) management varies case-to-case, and more investigation is needed to understand what does and doesn't work. While South Asian governments have begun encouraging WUA, progress is slow and effectiveness far from guaranteed. (Inocencio and McCornick, 2008).

On the other hand, there is broad agreement that water charges in a centralized system should be volumetric if possible, and water fee collection needs improvement. Surface water is currently nearly free, and groundwater volumes abstracted by farmers virtually uncontrolled. This provides farmers few incentives to switch to high-efficiency technologies and results in water shortages at the tail end of watercourses. Meanwhile, farmers in other areas are paying as much as one-third of their produce for pump irrigation services, suggesting that the value of on-demand irrigation far exceeds what is currently contributed by canal water beneficiaries (Shah 2007). It is also known that water rights trade can improve efficiency by placing an opportunity cost on more items, and incentivizing water savings. Relatively little is known, however, about how the market will function when exchange is voluntary but when market participants have unequal human capital, or when information is weak[22].

Finally, since surface water and groundwater are both affected by the resistance to technical, institutional and political reform, we will defer the discussion of this to the end of this section. Having discussed the issues of irrigation at the system level, we now turn to issues at the level of the farm.

We have already discussed how surface water prices are too low. Meanwhile, groundwater pumping is largely unmonitored in South Asia, and hence goes untaxed. Energy for pumping is even subsidized in some significant cases, the most important of which is India, where groundwater levels are fast shrinking. (Rodell, Velicogna and Famiglietti, 2009) The biggest hurdle to efficient and careful use of water is therefore that farmers have no direct economic incentive to be efficient or careful in how they use water. Ironically, a water-stressed region, which as a collective would happily conserve water as a resource, is unable to incentivize the individual farmer to turn the tap off.

The weak incentives to conserve water that do exist are largely indirect and insufficient – over-application of water at the farm can create water drainage issues, or reduce the effectiveness of fertilizers and pesticides. Similarly, frequent power outages can increase water application times and unlined waterchannels absorb too much water as it lays dormant when a brownout occurs – farmers respond by lining waterchannels to deal with these issues, and water application efficiency increases as a side-effect.

Instead of bemoaning the tragedy of the commons, however, pragmatic policy-makers would do well to embrace it and use it to organize their thinking for at least the short to medium terms – the pitch to a farmer for saving water cannot be a vague appeal to the common good, but a demonstration that doing so is likely to carry real economic benefits, in the shape of better produce, fewer pests or savings in other inputs. Every new technology that is a candidate for a widespread adoption drive should be evaluated in terms of whether it carries these benefits along with the water-saving. No matter how attractive in theory, a technology that saves a lot of water but carries none of these ancillary benefits is unlikely to be widely adopted.

5.2 Obstacles to private take-up

The question that then follows is: if a technology carries economic benefits for farmers, why don't they adopt it without government support? First, it is argued that smaller and medium-scale farmers are often cash-strapped and unable to make large initial investments into irrigation infrastructure on their own. As the initial cost of much irrigation infrastructure, from waterchannels to drip irrigation systems, is high, this creates a financing gap for farmers.

Second, and relatedly, adopting new technologies can be very high risk - farmers are unlikely to invest in new technologies without having witnessed their productivity and reliability first hand.

[22] The theoretical predictions are that trade will not be welfare-diminishing in the former, but may be so in the latter case. However, far less is known about these problems in this real-world context.

Third, there is a lack of technical know-how in the private sector – even if a farmer has the money and the risk-taking appetite to want to adopt new technology, there are often few private firms accessible that have the ability to install, calibrate and maintain some of the newer technologies.

Finally, since the adoption of many newer technologies also requires a move to different, unfamiliar types of produce, the farmer needs access to all the associated resources involved, such as different inputs, transport, and access to markets. Any link missing in this chain can raise the costs of switching to the point of rendering the move infeasible (Beggs, 1989).

5.3 Policy Options

The government can react to reduce each of these obstacles but must do so carefully. First, it must decide what not to do. It should not, for example, react to the financing gap of the private sector by providing subsidies for this reason, because it faces a financing gap of its own and needs to apportion its resources to the provision of public goods. Moreover, subsidies tend to be politically hard to remove once they are in place, and rent-seeking behavior can render their long-term effectiveness dubious at best[23].

Instead, the causes of the credit constraints have to be recognized and efforts made to remove them. A major reason smaller farmers in particular do not have access to credit is the absence of sufficient collateral because property rights are either ambiguous or because rival claims to property cannot be properly resolved in courts. The solutions to this problem lie in long-term improvements in the enforcement of contracts, in resolution of court cases, and their effective enforcement, which are all beyond the scope of any irrigation policy.

Second, in the short term, both the fact that a new technology is high-risk for an adopter and that there is a lack of private-sector providers of support can be tackled by attempting to increase relevant knowledge in the economy. It is fairly uncontroversial that education has positive externalities, and the first policy that can be adopted is to set up or expand farmers' teaching facilities. Besides general agricultural education, farmers can learn about more efficient irrigation technologies as well as improving farming techniques. A similar curriculum, but at a more basic level can be used in awareness campaigns and extension services.

Possibly even more important than these, however, is the demonstration of the potential success and efficacy of new technologies. As noted earlier, farmers tend to be risk-averse when considering the take-up of innovative tools and processes, since these require a sure cost up front, but have the very real possibility of failing. The government can build a record of success stories and develop material that explains to farmers how others with similar backgrounds, education and resources have adopted the technology. Moreover, the government can take the lead in adapting the technology to the region if necessary. There are multiple ways to increase water use efficiency, including reliance on irrigation scheduling, various new mechanisms for irrigation management to increase precision, etc. Some of the challenges for research in extension is to take advantage of new knowledge in technologies and develop new ways to improve water use efficiency. Furthermore, changes in prices of energy and commodities should also trigger effort to improve water use efficiency.

[23] This should not be read to imply that subsidies should never be used. Indeed, we do discuss a stronger justification for subsidies later in this section. The point here is that using subsidies specifically to 'solve' financing gaps is an unsustainable and myopic policy.

Besides developing and transmitting a technical literature, the government can try to seed awareness by targeting subsidies and supporting technical help for a small number of farmers specifically in areas where success stories do not exist and lower subsidies as technology takeup increases in the region. As mentioned in Appendix A Punjab province in Pakistan followed this model very successfully with laser land leveling in the recent past. The literature suggests that subsidization and adoption of modern irrigation technologies should be done selectively when they increase water holding capacity or the precision of irrigation significantly, which may occur in locations with sandy soil or uneven land. (Schoengold and Zilberman, 2007) Adoption should also occur with higher value crops so the gain in net value can pay for the investment.

In the medium-term, the government can also help address the problem of high switching costs. The government can help develop the value-chain for the innovative product. There may be a need to develop public goods, such as infrastructure. In some cases simply subsidizing the move would be sufficient. It may even be that simply signaling the presence of a subsidy serves to reassure dispersed early adopters that their private adoption of the technology will not be unilateral, but part of a wider adoption that will mitigate the risk of a failure to build momentum.

In the long-term however, prices must increase to encompass all costs of production. If handled naively, such a policy will encounter severe political backlash, since it creates losses for some (those enjoying inefficiently low prices now). Close attention must be paid to the sequencing and implementation of any price increase. Awareness of the reason for price increases must be created: the public must understand both the extent of the water scarcity arising in the region, and the fact that the point of the increase is not to extract a region or subgroup's surplus, but to engender good decisions on the margin. A credible public commitment should be made to invest the money collected back into the local area, if political resistance is to be averted or tackled successfully[24]. Before prices are increased, credible alternatives should be provided, in the form of subsidized access to water saving technologies, and it should be announced that the subsidies are explicitly with the intent of ensuring that those bearing the costs of higher water prices will not suffer.

For surface water, it is then a simple matter of increasing prices gradually. For groundwater, the complication is that there is no feasible infrastructure to directly monitor usage and price water extraction. In the short term, these are largely intractable, and the workaround of possibly taxing the energy source (electricity or diesel) needs to be studied. Careful study of existing electricity usage, the possibility of arbitrage, and the calculation of an appropriate price is required, but it is likely that the problem of unintended consequences will remain, and there is a real danger that in trying to force water use efficiency through such a blunt policy instrument, energy use efficiency will be harmed. In the longer term, as discussed earlier, any move to directly regulate extraction requires monitoring, which requires both technological and institutional advances.

[24] Theoretically, it would even be possible that the extra money generated due to unit price increases be paid back to the tax base such that for each village or town, any extra money generated is credibly routed back. This would change a user's decisions on the margin, but produce no wealth transfers across distant regions.

5.4 Obstacles to policies

Echoing our earlier question about farmers' lack of technology take-up, why doesn't the state pursue the policies outlined above? South Asian states are financially weak: they often do not have the resources to pursue infrastructure or technological improvements or provide wide and sustained subsidies. Technical capacity is low: governments lack dedicated and capable personnel, are beset by bureaucratic inefficiency and corruption, and further lack reliable data and physical mechanisms for controlling water use.

The institutional frameworks governing irrigation in South Asia are weak: over the past half century, irrigated area has grown faster than the institutions needed to regulate this growth (Barker and Molle 2004). There is a confusion about areas of responsibility and policy options and failure to predict consequences. The prime example of this is the explosive growth in groundwater exploitation in South Asia over the past 50 years and the entailing resource degradation. Groundwater rights remain undefined. In many cases governments have subsidized electricity used to power water pumps. Groundwater depletion is now a serious threat for many regions in South Asia and can only be addressed through improved resource management on the parts of government as well as by governments supporting the conjunctive use of surface and groundwater to facilitate optimal flexibility in delivery combined with sustainable recharge of underground aquifers (Shah 2007).

Lastly, it is important to also consider the incentives that government officials face in implementing irrigation policy, and the role of politicization of decisions. For example, Pakistan's four provinces are in deadlock over approving the construction of new dams because downstream provinces do not trust that they will receive their fair share of water and because strong interest groups in the downstream provinces benefit from recession agriculture as a result of floods, which will be reduced if new storage is constructed. This demonstrates that provincial government interests do not always align with national interests in water resource development. Similarly, on the lower end of the bureaucracy, publicly commissioned irrigation managers may not find their incentives aligned with those of their clients, the farmers (Mukherji et al. 2010). Furthermore, governments may seem myopic and neglect the upkeep of existing irrigation schemes because they know that donors are more likely to fund rehabilitation projects than simple maintenance programs (Kikuchi et al. 2003). A more detailed discussion of the political economy underlying irrigation in South Asia is provided in Appendix C.

Some of the problems discussed here can clearly be worked around – substantial existing subsidies suggest that financing is likely not a concern for any but the largest infrastructure projects; technical capacity is low but can be slowly increased by providing enough rewards to attract foreign trainers; government officials' incentives can be weak, but this is true all across the world – competent oversight, monitoring, and a system of rewards and punishments can make dramatic improvements.

The harsh reality, however, is that South Asian states have an entrenched track record for fundamental and consistent failure to provide service delivery to their citizens. The most fundamental consequence of this is that security of life, property and contract is weak. Political upheaval, such as experienced most notably by Sri Lanka in the past and Pakistan in the present immeasurably harms economic activity. The danger of theft or destruction disincentivizes investment in tangibles. The inability to write and contest contracts means that partnerships are mostly informal and are limited and bear greater costs as a result. These problems have nothing to do with irrigation policy – they are law enforcement subjects – but they have everything to do with whether private actors engage in the sort of dynamic work needed to improve irrigation outcomes, as well as outcomes in every other sphere of economic activity. They also mean that inputs of the highest importance, such as an educated workforce, are largely absent. This means both a less dynamic private sector and a less sophisticated and internally competitive civil service. The bottom-line then is that we must focus our attention very carefully on solving the issue of security and service delivery. To focus on advanced irrigation policies at the expense of these will just be rearranging the deck chairs of a sinking ship.

CONCLUSIONS

At its core, the commercial allocation and use of water can be understood in terms of its similarities with the allocation of other economic goods with dispersed benefits and the requirement of relatively high initial investment. The realities of operating in a third world context add other relevant considerations.

Water is a natural resource, but one that often requires the building and maintenance of complex and large-scale transport, storage and distribution systems. The provider must therefore often be a large enterprise, and often this is government. As a natural resource, states must come to decisions about the initial assignment of property rights, and then be ready to back these decisions with fair enforcement. These rights must include provisions for the Human Rights to water, but water beyond that required for a person's healthy functioning can be treated as commercial.

In South Asia, there are two-pronged pressures on the efficient provision of water. On the one hand, there is the strong need for good provision because of large, poor and untrained populations. Governments need to take the lead in research, education, extension and training. On the other hand, these countries carry the additional burden of, generally, old and inefficient infrastructure. Much of South Asia currently evidences the gradual decline of institutions inherited from a colonial past or transplanted in through foreign aid.

Much can be done in the short term and at the level of the farmer to alleviate the water stress developing across the region. In the long term however, irrigation and water use efficiency will evolve in each country as the direct result of its progress towards political maturity and good governance.

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APPENDIX A - INNOVATIVE TECHNOLOGIES FOR INCREASING WATER USE EFFICIENCY

Following on from our preceding discussion about water use efficiency, this section looks at particular technologies that can be implemented at the farm-level to increase the efficiency with which water is used. Agricultural productivity in South Asia is low and non-sustainable due to declining levels of groundwater and increasing climatic variability (Jat et. al. 2005). A number of new technologies are being adopted to reduce water use, increase water productivity and enhance agriculture's profitability. These technologies include, inter alia: pressurized irrigation systems, laser land leveling, furrow-bed technology, zero-till planting of wheat in rice-wheat system and watercourse improvement. (IWMI 2009; CGIAR.2006; Jat et. al. 2005; OFWM 2002; Timsina and Connors 2001; World Bank 2009; IRRI 2008).

In our discussion of specific technologies, we shift our usage of the term efficiency from system-level efficiency to conveyance efficiency . It is entirely possible for a system that can achieve high conveyance efficiency[25] to continue to function with low system efficiency because water prices are too low to incentivize changing prevalent behavior. The last sub-section of this section will reconcile the two meanings of efficiency and help answer the question why, in the presence of technologies demonstrated to be efficiency-enhancing, take-up remains low in many cases.

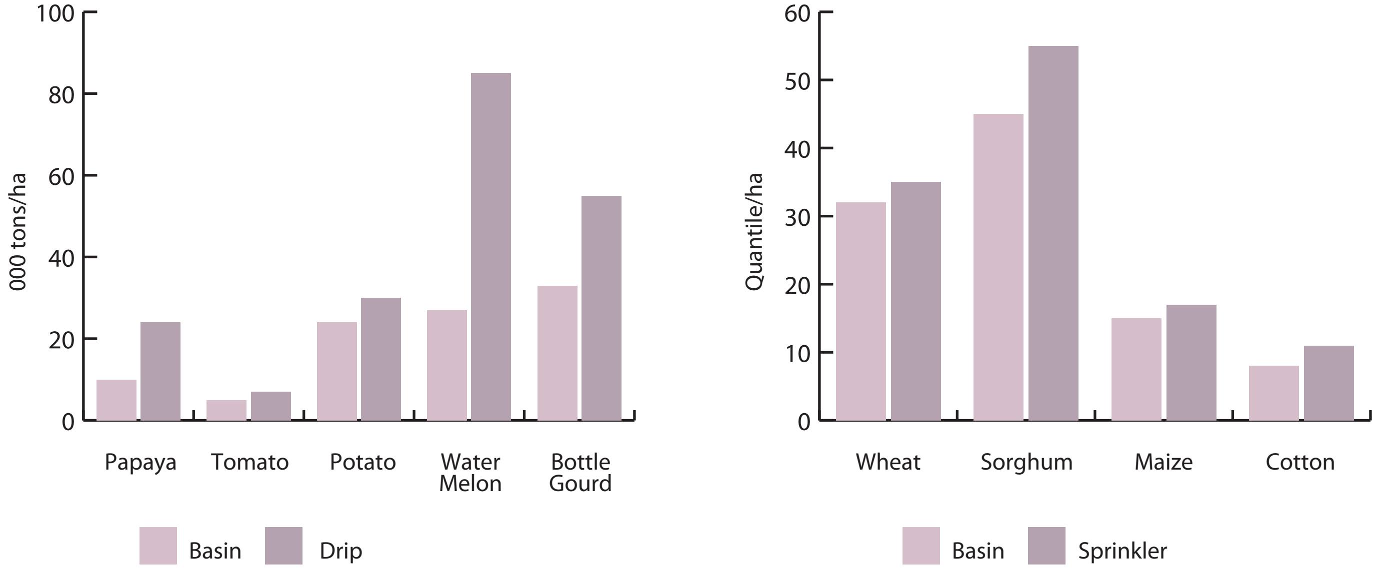
Below, we discuss the existing evidence of the performance of these various technologies.

I. Pressurized Irrigation Systems

Drip and sprinkler irrigation systems are much more water-efficient than conventional basin irrigation practices. They have a conveyance efficiency of 100%[26] and an application efficiency of 70-90%[27] , while the corresponding figures for basin irrigation are 40-70% and 60-70%, respectively (Narayanamoorthy 2006). It has also been reported that water productivity[28] is substantially improved under these systems compared to basin irrigation (Figure 5).

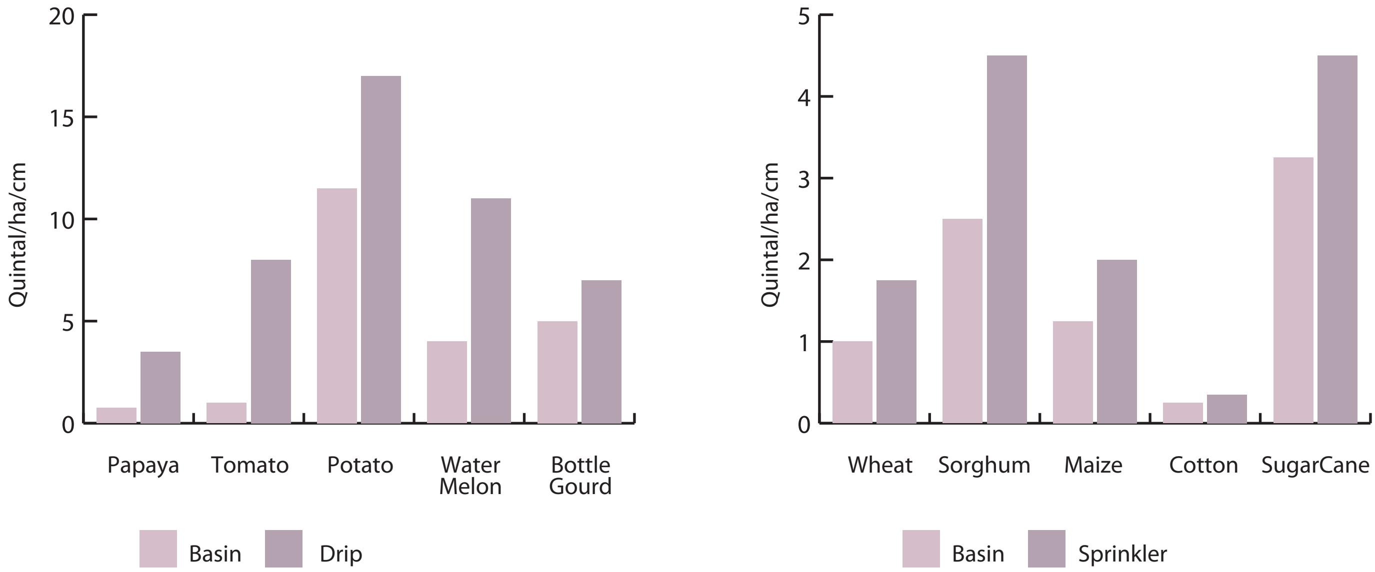
[25] We would like to thank Professor Douglas Gollin for pointing out the need to clarify this in comments on an earlier draft. See also footnote 8 supra for definitions of relevant terms.
[26] i.e. practically no water is lost between its entry and exit from the system.
[27] i.e. this proportion of water being applied reaches the plant.
[28] Greater water productivity means that more produce is produced per unit of water.

Figure 4
Crop productivity under Basin Irrigation compared with Drip and Sprinkler Irrigation



(Source: Narayanamoorthy 2006)

Figure 5
Water Use Efficiency of crops under Basin Irrigation compared with Drip and Sprinkler Irrigation



(Source: Narayanamoorthy 2006)

Surveys conducted in Punjab and Sindh provinces of Pakistan indicated an increase in cropping intensity of up to 200% per annum with the use of PISs as well as savings in water use of 60-70 % in drip, 50-60% in sprinkler and 45-75% in center-pivot sprinkler compared to surface irrigation. The time needed for irrigation was reduced by 60-70% in drip and 30-40 % in sprinkler irrigation, whereas center-pivot sprinklers irrigated 205 acres in 26.4 hours compared to 30 days under flood irrigation. Moreover, the use of sprinkler and drip irrigation systems led to a doubling of yield for sugarcane, vegetables and fruits and an increase of 30-40% in income.

In most of South Asia, pressurized irrigation technologies (sprinkler and drip) are now being used, albeit on a small scale (FAO 2011). In India, pressurized irrigation schemes were promoted starting in the 1980s with a 50% state subsidy, and some progress has been made, as discussed in Box 3 above. However, the potential for further scaling up is massive: potential area for drip and sprinkler irrigation is 21.09 and 50.22 mha, respectively but only 5% area is under these systems (Narayanamoorthy 2006; GOI, 2006). In Bhutan, drip and sprinkler irrigation technologies are at an infant stage (Bhutan Climate Summit 2011), and although Nepal was assisted in the promotion of PISs by the ADB for in the 1980s and by NGOs in 1990s, they are still not widely adopted in the country (IWMI 2005). PISs are also a recent development in Pakistan, where they are, however, gathering significant support (World Bank 2009). Pakistan initiated a National Programme on "Water Conservation and Productivity Enhancement using High Efficiency Irrigation Systems" during 2007-8. Sprinkler and drip systems have been installed on 25,000 acres, but due to the devolution of agricultural policy to provinces, the project has since been transferred to the latter. One notable early success in Pakistan has been the active involvement of the private sector in the production and installation of pressurized irrigation systems (FODP 2011). As in the case of India, however, much potential for expansion remains.

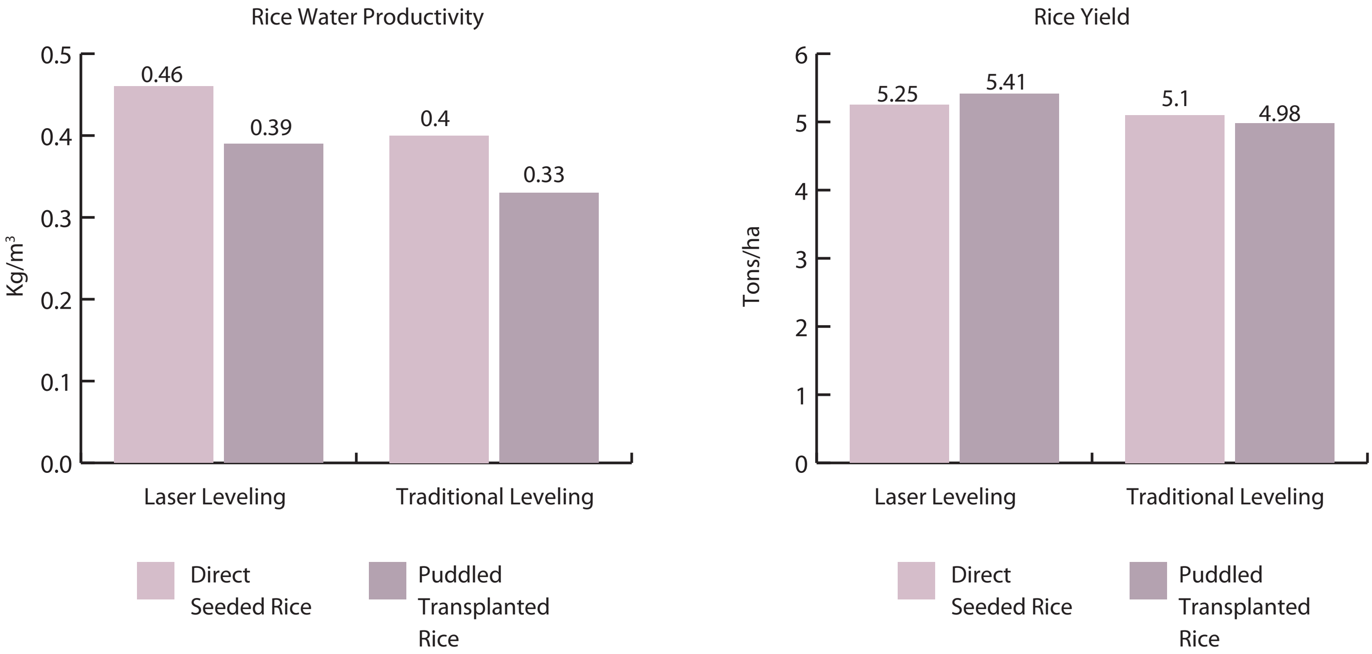
A major problem in the adoption of PIS is the high initial cost due to its capital intensitiveness. The World Bank estimates that unless subsidized by at least 50%, PIS's are beyond the reach of most farmers (World Bank 2009). Furthermore, although rural areas in West-Nepal have seen a high payoff from vegetables on drip with an NPV of US $16.1, BCR of 2.4, IRR of 37.9% and a pay-back period of 1.6 years (IWMI 2005), the payoff might be less significant on fields cultivating lower-value crops such as cereal grains. For now, governments have made initial purchase subsidies available to ease farmers' initial financial constraints, but more research is needed to determine where subsidies are appropriate and whether loans could be employed instead to ease the financial burden on the government.

II. Laser land leveling

Precision land leveling can significantly improve water use efficiency and land productivity and also reduces waterlogging and salinity. Farm trials in the Indian state of Bihar found that laser leveling reduced water use by up to 40% and increased application efficiency by up to 50%. It cut time for irrigation by half and labor requirement by 35% and it increased irrigated area by 2% and yields by 20-25% (IRRI 2009). Field trials were also conducted to evaluate effects of rice planting and leveling on 16 farmers' fields in Western Uttar Pradesh and results showed that on a custom hiring basis, laser leveling for wheat production was beneficial (Figure 6; World Bank 2009; IRRI 2009). Additional cost and benefits analysis over an eight-year period demonstrated that there are significant economic benefits to precision leveling; the costs allow for extra fertilizer in the first and second years. The benefits include reduced weeding costs of 40% (Rajput and Patel 2003). BCR of 2.71 and 2.04 for wheat under laser and traditional-leveling was reported (Choudhary et al. 2002).

Despite its various benefits, laser land leveling has yet to become a popular technology across South Asia (RWC-IGP 2006). There is a particular lack of precision n leveling in the eastern Gangetic plains, where traditional methods leave up to 15 cm of deviation in the field. On the other hand, the Punjab province of Pakistan has made significant albeit early-stage progress in promoting this technology. The provincial government provided 2,700 laser units at 50% subsidy to private individuals from 2005 to 2008, with the intent that a significant proportion of private cost-recovery will come from renting the machinery for use on others' land. The Precision/Laser land-leveling is now practiced on 1.6 million acres(Government of Pakistan, 2012).

Figure 6
Rice water productivity and yield under leveling and plantation techniques



(Source: RWC-IGP 2006)

III. Furrow Irrigation and Raised Bed Planting

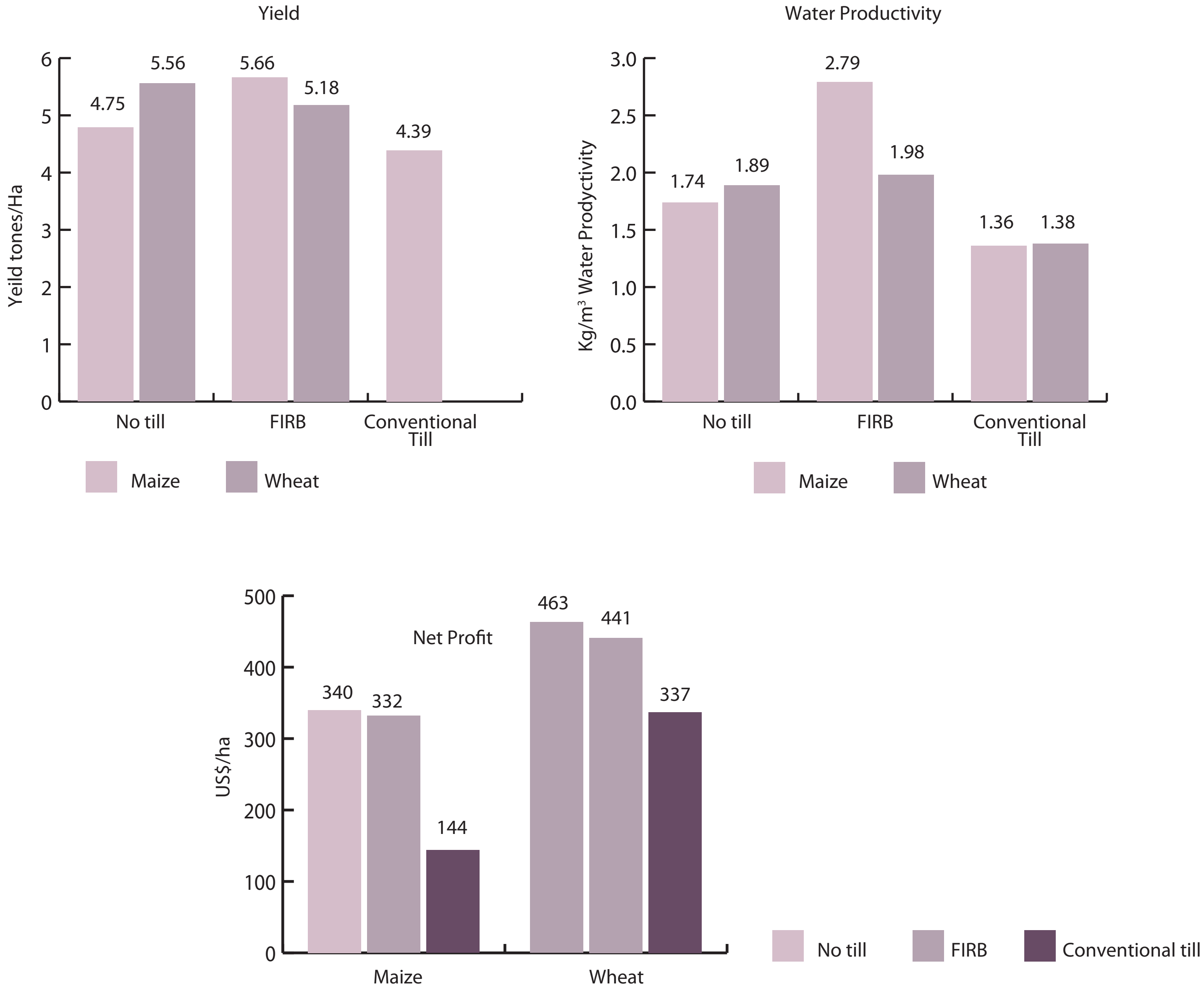
Permanent raised bed and furrow irrigation for rice–wheat was developed by CIMMYT, Cornell University and the ACIAR (Meisner. et. al. 2005). The adoption at the farmer's field is still very much at the initial stage; yet, over the last decade this technology has emerged at a greater pace in the Indo-Gangetic Plains (IGP) (Jat et. al. 2005).

In a study by He, a notable increase in yield of maize of 19.2 and 28.9% with furrow-bed irrigation compared to flat no-till and conventional-till irrigation, respectively, was reported (Figure 7). The productivity of wheat was also found to be higher by 7.3 and 8.6 % compared to no-till and conventional-till, respectively and water use for both the crops was reduced. The same study found that water use efficiency improved, that water use in wheat reduced by 35% and yields improved by 10% under furrow-bed as opposed to basin irrigation (Jat and Sharma 2005).

In another World Bank study carried out in Pakistan, use of furrow-bed technology in saline and waterlogged soils resulted in reduced water use by 30-50%, increased yields of wheat by 10-20% and maize by 30-40%, boosted farm profitability by 50-100%, and increased net benefits from maize and wheat cultivation by 54% and 35%, respectively, compared to basin irrigation (World Bank 2009). The same report found no increase in cropping intensity in Pakistan since farmers were already cultivating at 200%; however, reduced irrigation time of 90-140 minutes/acre as compared to the 180-200 minutes/acre needed for conventional tilled wheat was observed with similar or higher yields (World Bank 2009).

Other studies in the IGP found water savings of 12–60 % for direct seeded rice on beds as compared to puddle rice (Gupta et al. 2002; Jehangir et al. 2002; Hossain et al. 2003; Khan et al. 2003; OFWM 2002) and even reported savings in fertilizer use as a result of furrow-bed irrigation (Hulugalle et al. 2002).

Figure 7
Yield, Water Productivity, and Net Profits for Maize and Wheat under different planting and irrigation techniques



(Source: Jat et. al 2005)

Water productivity of maize and wheat was higher under furrow-bed system followed by no-till and lowest in conventional-till. The net profit was highest in no-till followed by furrow-bed and lowest in conventional-till for both maize and wheat (Figure 6).

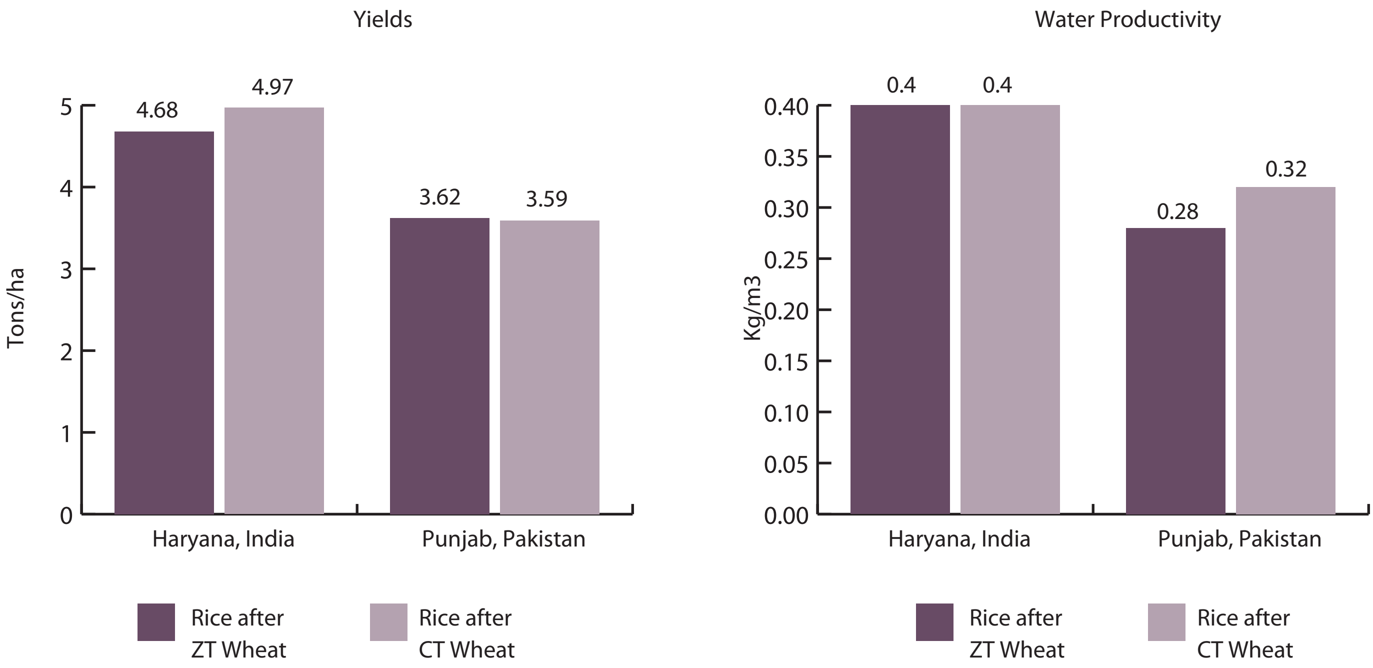
IV. Zero Tillage in Wheat and Rice systems

Zero-till is widely adopted in rice-wheat and wheat cultivation in South Asia, covering more than 5.6 million/ha in wheat fields alone in IGP (IFAD 2008). It is used on 14% of wheat area in project villages in Pakistan and India, 12% in India and Nepal, but none in Bangladesh (Singh et al. 2009). Local capacity to manufacture and diffuse technology at competitive cost was created with the private sector (IFPRI 2009).

Reported benefits of zero tillage in wheat production include a reduction in land preparation and in tractor time (60-90% saving), fuel savings (36 liters/ha), lower water usage (20-35%), increased yield (5–10%) and reduced cost of production with a BCR of 2.28 compared to 1.81 in conventional tillage (Erenstein and Laxmi 2008; Hobbs and Gupta 2003; UK Aid and DIFID 2010; and Bakhsh et. al. 2005).

Results regarding rice production with zero tillage are less encouraging. In a study undertaken in India, IWMI researchers found (2007) that yield of rice was 6 % lower under zero-till than conventional-till in Haryana, whereas in Punjab it was negligibly higher than conventional-till. Water productivity of rice in zero-till was equal to that of conventional-till in Haryana and lower in Punjab (Figure 8).

Figure 8
Rice yield and water productivity under zero till (ZT) and conventional till (CT)



(Source: RWC-IGP 2006)

V. Improved watercourses

The practice of watercourse lining was initiated in Pakistan during the mid-70s at the MONA Reclamation Experimental Project, Bhalwal (World Bank 2009). At the time, a structured survey was conducted in Gujranwala and Sheikhupura on the upper Chenab canal to determine the impact of improvement on 11 sample watercourses. On each of the watercourses, the farmers from head, middle and tail were interviewed and reported average irrigation savings of 1 hours and 33 minutes per ha as a result of the canal lining. Water application time and labor were reduced by 28%, physical water savings were 20%, and an increase of 20% in cropping intensity was observed due to additional water availability and 13.15% higher yields (Khan et al. 2001).

Further surveys conducted in Punjab and Sindh have shown similar results from watercourse lining with water savings of 16-28% and yield gains of 12-36% for three canal commands accompanied by an increase in cropping intensity of 29 and 42%, respectively. An increase of 20% savings in water, 17.5% in yield and 16% in cropping intensity was observed (World Bank 2009).

Another survey of 30 watercourses in fresh, marginal and saline groundwater zones of the Bhakra canal command zone was conducted in Haryana, where watercourse lining was carried out in 1975-96. Out of Haryana's 13000 watercourses, 8700 (66%) have been lined since 1973 and benefits of lining were found to include: water availability at the remotest end of the watercourse; improved water supply for irrigation; changed cropping pattern such as production of oilseeds, especially in the tail end of the watercourse in Sirsa; reduced time and number of labourers needed for irrigation; improved conveyance efficiency and increased time for the rostering for each farmer. Following the lining, the majority of irrigated area is now occupied by high yielding varieties (IWMI 2001).

VI. From Technical to Economic Efficiency

This appendix has reviewed the literature on how technological improvements result in greater water conveyance efficiency, higher yields and lower costs. It is worth noting here that technical efficiency may not translate into economic efficiency. When water prices do not fully reflect all costs at the margin (in other words when they are lower than efficient), application efficiency is not fully incentivized, ceteris paribus. Water use efficiency will, in such environments, result only as a by-product of the farmer's efforts to increase yields, produce size and quality, or lower input costs, and will be lower than socially efficient.

While inefficiently low water prices may be the single most important reason why these technologies are not more prevalent, this is not the only reason. The fact that the technologies listed in this section all improve farm productivity but are not more widespread suggests that there are barriers to their take-up. We explore some of these below.

Policy makers are often quick to take the efficiency results that a technology exhibits in controlled conditions as evidence that, but for the lack of financing or technical education, farmers will be quick to adopt the technology because it results in greater productivity. Little consideration is paid to how this change of behavior impacts the other incentives a farmer has. Two examples of such incentives should suffice to highlight that due diligence must also be done to get feedback on farmers' experiences and difficulties with the technology when applied in practice.

First, in many developing countries including the South Asian ones under consideration, law enforcement in rural areas tends to be weaker than in city centers. In particular, the danger of theft is non-trivial, and farmers have to spend not insignificant resources and energy protecting their high-value, fungible property. If a technology being considered is easy to remove but difficult to identify, register, or recover subsequently, it is more likely going to be the target of theft, and will not be widely adopted in a region of high crime.

Second, much land in South Asia is owned by absentee landlords, who either rent their farms out or manage their activities through few or irregular visits. Renting land out tends to yield a low productivity outcome, since tenants are often relatively unskilled laborers from the area with little incentive to educate themselves on better farming practices or support investments in land that is not theirs. Also, as the land gets converted to higher value use and rent goes up, the problem of trust increases, since tenants have greater incentives to default. Absent law enforcement and strong contracts, the lower value practices and produce from traditional application methods might generate greater private profits for the farmer than the higher value produce associated with high efficiency technologies which might encourage greater default. Moreover, absentee landlords might be more susceptible to have their property stolen, bolstering the point in the previous section. Finally, if absentee landlords are running their farms themselves, they cannot invest as much time in leading the adoption of high efficiency systems as is necessary: many then prefer to keep the low efficiency-low return, traditional mode of production even when high-tech systems seem to make more sense on paper.

APPENDIX B - THE ECONOMICS OF IRRIGATION AND WATER USE EFFICIENCY

I. Water transmission to the farm - Surface Irrigation

Many decisions about large-scale surface irrigation systems have historically been linked with, and been considered secondary to, decisions about hydroelectric power generation. The decision to build a dam, and decisions about the flow of water must be made keeping both power generation and water use as part of the calculus. For the sake of simplicity, this document does not explore decisions of joint importance, but this is clearly an important dynamic for policy-makers to explore.

As discussed above, South Asia is home to many large surface irrigation systems. In developing these systems, there are two difficulties that make their provision by the private sector difficult. These are high costs, and the problem of holdouts.

(a) Large size

Since all but the most trivial surface irrigation system are complex, large-scale operations, they require the outlay of large costs upfront, and potentially large maintenance costs. Although private sector firms do exist and reach large scale in underdeveloped countries, they tend to be few and far in between. Growing in size is especially difficult for firms that do not enjoy the state's patronage. This is because property rights tend to be severely underdeveloped in poor countries, and access to credit critically low. When a firm wishes to expand in the global south, it finds it harder to borrow without physical collateral, or to raise money through a public offering, because both of those actions require the lender (or investor) to trust that any initial outlay will be recoverable. Whereas the reaction to default or appropriation in a country with strong law enforcement would be legal proceedings, in an underdeveloped country potential partners and investors are wary, ex-ante, of investing due to the risk of appropriation ex-post (De Soto, 2001)[29].

Because of this, few firms grow to be large enough to undertake the investment and maintenance of medium or large sized irrigation system on their own. Instead, the responsibility of designing and managing the system is uniformly considered the public sector's domain, although it is possible for the government to apportion smaller parts of the system to be provided by the private sector.

[29] It is trivial to show this result game-theoretically using the famous Agency Game (also known as the Investment Game or the Trust Game).

(b) Holdouts

Moreover, even if property rights and contract enforcement are secure, private firms have an even bigger obstacle to building a large irrigation system. A canal, dam or other large installation requires the use of a large parcel of land; if the land on which the installation is to be built is divided into small landholdings, purchases of many sufficiently contiguous parcels of land is necessary before work can commence on any.

When a private firm sets out to purchase adjacent land parcels, for say the purpose of building a canal, it is restricted in terms of which properties it can use for this purpose. In many cases, the firm will find itself in a situation of having purchased many pieces of land but negotiating over buying the final connecting plot. Because the firm's negotiating power is severely weakened as a result of having made its previous purchases, the existing owner of that plot can then threaten to hold out from selling, and thus demand a price far in excess of market rates. In economics, this dynamic is called the Tragedy of the Anti-Commons (Heller 1997) – too many owners of private property have the ability to exclude others from its use – and it becomes more and more problematic as a) the size of individual parcels of land becomes smaller and b) the firm does not have many attractive alternative routes for its canal or other installation.

Countries the world over recognize that situations can arise where contiguity is required but privately blocked, and most states allow the government to engage in "Takings" or "Eminent Domain" actions, in which the government engages in the forced purchase of said property from citizens for the greater good. While most countries define parameters within which such actions must occur (e.g. the 5th Amendment to the US Constitution states "nor shall private property be taken for public use, without just compensation", and South Asian countries have broadly similar clauses), it is widely accepted that the development of large irrigation infrastructure is an acceptable area for public intervention.
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These arguments for a public role in surface water infrastructure development should be read cautiously – the existence of credit constraints in the private sector and the need for Eminent Domain actions validates a public role in infrastructure development, but that role can be limited to providing a line of credit to private developers and to the purchase of land to be developed by private construction companies. The choice between employing the public or private sector needs to be taken on a country-to-country basis, taking into account the prevailing relative extents of government and market failure.

II. Water pumping at the farm - Groundwater Irrigation

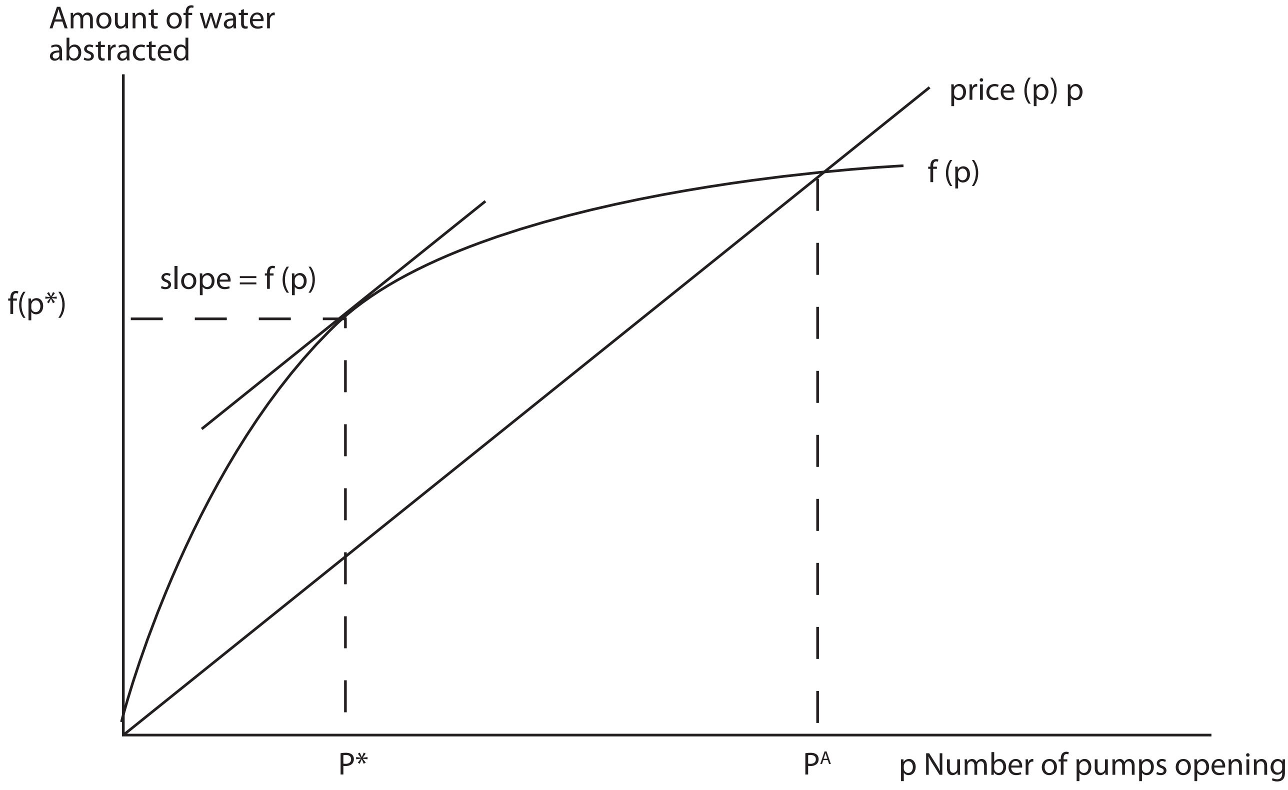
Groundwater irrigation is predominantly done using individually-owned pumps. The relatively small outlay requirements and capacity of these pumps makes them amenable to private ownership, but this brings with it an entirely different set of economic and legal issues.

In the law, groundwater in an aquifer that traverses surface property boundaries is an example of fugitive property, i.e. that which moves freely from one property to another. Since anyone whose property lies over the aquifer can pump the water, it becomes a rival but non-excludable good, whose dynamics can be understood through the well-known Tragedy of the Commons. Generally, since consuming a rival good places social costs or negative externalities on others in the area, and since private costs do not take this into account, the consumption of the good tends to be greater than socially optimal.

We can demonstrate this in a formal model: the profits of an economy (defined here to include everyone using the aquifer) equal the value of what is produced minus the cost of producing it. Assuming that water abstracted is a numeraire, the value of what is produced equals 1.f(p), where p is the number of pumps installed on the aquifer and f(p) is the production function (the relationship between number of installed pumps and water abstracted, assuming each pump abstracts an equal amount). The cost of production is the Price of a pump multiplied by the number of installed pumps. Therefore, Profits $\pi = f(p) - Price(p).p$

If the decision about the number of pumps to install is taken by a centralized authority, it would choose the amount p*, which corresponds to the greatest gap between f(p) and Price(p).p. This is the point at which the two curves have the same slope, or where Price(p) = f(p).

Figure 9
Tragedy of the Commons leads to greater-than-efficient water abstraction



Each pump by assumption pumps an amount of water identical to all other pumps. The average revenue from a pump when p* pumps are installed is therefore f(p*)/p*, which is the slope of the ray from the origin to the point of tangency. Since $f'(p)>0$ and $f''(p)<0$, it follows that when the socially efficient amount of pumps are installed, the revenue generated from an individual pump is greater than its cost. The reason that a centralized decision-maker does not add a pump beyond p* is that the gain in profit from installing that pump is not enough to compensate for the combined losses all other pumps experience from the added burden this last pump places on the system – in making decisions on the margin, a centralized system, in other words, considers the tradeoff of costs versus benefits not merely for the marginal unit, but for all infra-marginal units also.

The Tragedy of the Commons occurs because in decentralized decision-making, individual producers consider the cost-benefit situation on their land, disregarding the effect on others. It makes private sense to continue adding pumps far beyond p*, till such point that the marginal revenue product equals the cost of the input, or p^.

Can the Tragedy be averted, and if so, how? Again, the law provides a clue: two rival rules have historically been used to adjudicate Fugitive Property cases: First Possession and Tied Ownership. The rule of first possession allocates the fugitive property to whichever party can 'capture' or possess it first; the rule of tied ownership assigns rights for the fugitive property according to existing rights for a non-fugitive property. In the context of groundwater, first possession implies that whoever can pump water out first has the right to it. In the absence of laws or law enforcement, first possession is the de facto law governing groundwater in South Asia. On the other hand, tied ownership in this context would be in place if the amount of water each property was allowed to pump was proportional to the size of the property.

Since switching from first possession to tied ownership would move users from pumping as much as they privately desire to more regulated pumping, a switch from first possession to tied ownership would have the benefit of reducing the problem of overuse or congestion of usage, but would carry the cost of greater boundary maintenance (i.e. policing and implementing a pumping level lower than privately desired).

This discussion sharpens both our predictive powers as to when tied ownership is likely to succeed and refines our prescriptions: licensing and permits, which are manifestations of tied ownership, will likely fail until we can keep track of, and enforce limits on, abstractions from the common resource, i.e. the shared aquifer. Passing groundwater laws that assign de jure property rights will matter little until rival users of the aquifer can be monitored either by the state or by neighbors who forward the case to the authorities.

The technology to monitor water pumping clearly exists – tamper-resistant smart monitors attached to the pump transmitting to a GPRS network would allow remote monitoring of water use, and a rudimentary processor could flag usage over allowance or even temporarily disable the pump. In fact, even old-fashioned 'dumb' meters, regularly checked to record usage and deter tampering, could be used for the purpose. However, monitoring requires far more than merely the technology to monitor. This is painfully evident when one considers the state of electricity metering in South Asia. Electricity has an extensive and established metering infrastructure, but one that is mired with substantial theft and discrepancy in much of the region (Golden and Min, 2012)[30]. The underlying socio-political forces resisting metering often prove very resilient to attempts at narrow reform. (Banerjee et al. 2008) However, as technology improves and becomes cheaper, improved information communication technology (ICT) is beginning to provide innovative new ways to hold government officials and citizens accountable (Duflo, Hanna and Ryan, forthcoming; Callen, Hasanain, Gulzar and Khan, 2012), and there is cause for hope that at least some progress will gradually be made in the direction of more accountability.

[30] Interestingly, Golden and Min find that the intensity of electricity theft increases with the prevalence of tubewells.

Why is the adoption and enforcement of a groundwater law so difficult to achieve? If a groundwater law is put in place, current users of the land lose relative to future users, society is better off in the Rawlsian sense[31], but everyone has economic incentive to break the law. If inheritance laws are respected and the motivation to bequeath is large enough, the source of the trouble should not theoretically come from farmers themselves ex ante, or at the time of deciding on whether to have the law in place or not – when given a chance to vote on rules, the participants in a Tragedy of the Commons scenario, i.e. the people over-pumping from shared aquifers, should always all accept a Tied Ownership rule that would reduce their pumping, provided implementation costs are low enough. One reason this does not seem to hold is that, perhaps, farmers were not originally sufficiently aware that their neighbors share access to the water under their land and that depletion is a serious problem[32], and choose the immediate and concentrated benefits of pumping versus the dispersed and uncertain benefits of conservatism. Another reason might be that people with pumps are a subset of people with land, and so changing the law has a redistributive effect. The potential losers (i..e people who are already pumping unfettered) will then oppose the law.

The usage of energy prices as a tool to reduce overpumping of water seems potentially practicable at first glance, but the trouble is that electricity is used for other things also, and so being charged a higher rate for energy in the hope of reducing groundwater abstraction is a very blunt policy instrument to use and may have many unintended consequences. Crucially then, and in a theme repeated throughout this paper, the choice of policies counts for little if there is a lack of implementation.

III. Transactions Costs, Efficiency and the Definition of Property Rights

In much of South Asia, land holdings are fragmented. Moreover and naturally, smaller land holdings tend to belong to poorer farmers. Since the use of water requires cooperation across users in some cases, and creates externalities in others, policy makers need to consider the ability of farmers to work cooperatively.

The Coase Theorem states that, if transactions costs (the costs of cooperation – including, inter alia, search for a partner, negotiation, contracting, and enforcement) are low, the assignment of property rights does not matter to efficiency, but only to distribution. In other words, as long as cooperation is practically frictionless, the size and shape of land holdings does not matter, and land boundaries are irrelevant to decisions about how to extract the maximum economic efficiency from the land: a large corporate farm and a comparable, equivalently sized bevy of small, poor landholdings will be indistinguishable in terms of production decisions, but differ only in the sense that in the former, one person pockets the profits and in the latter, it is divided across many.

Very few real-world environments have low enough transactions costs that the description above applies (publicly floated companies in a country with excellent corporate governance arguably separate management from ownership). In most cases, transactions costs do matter, and they certainly do in South Asia, where contracting is costly and onerous.

[31] i.e. members of society, from behind the veil of ignorance, should always prefer to have the law than not, following John Rawls (Rawls 1971)

[32] In the absence of cheap information, this may be an example of Rational Ignorance (Hill, 1999) and might be a particularly fruitful area for policy intervention in that policy makers could try to spread knowledge

When transactions costs are high, a corollary of the Coase Theorem states that the assignment of property rights matters both to efficiency and distribution. In other words, land holdings can indeed be too small or too large, in terms of the implications for water use efficiency.

What does this implication imply for policy? In a country with well-function courts and quick law enforcement, it means that a more laissez-faire mindset can and should be adopted. Without these, it means that countries need to potentially consider land reforms or think of other ways to lower the hurdles to cooperation between citizens.

APPENDIX C - THE POLITICAL ECONOMY OF IRRIGATION

One of the main assertions of this report is that despite readily available technologies and widespread agreement over what policies would foster a more sustainable, efficient and effective irrigation sector, south asian governments have a poor record of implementation. This section draws from the literature on political economy to shed light on why this is the case and what, if anything, can be done to move governments to "do the right thing".

I. Corruption in irrigation

South asia is recognized as one of the most corrupt regions in the world with an average score of 3 on transparency international's scale from 10 (highly clean) to 0 (highly corrupt) (transparency international, 2011). The corruption of bureaucrats means that government services are delivered inefficiently and inequitably, leading to large amounts of government funds not fulfilling their intended purpose. For example, maintenance contracts may not be awarded to the most efficient provi¬der, but rather to the provider who can offer the largest bribe. This compromises the quality of the maintenance work and discourages innovation and entry of more efficient firms who lack the connections necessary to succeed in the corrupt environment. Furthermore, corruption encourages lobbying and rent-seeking behavior, leading to wastage of real economic resources and even misallocation of public funds to projects with high opportunities for rent-seeking (e.G. Construction) over projects with high social value (e.G. Education) (jain, 2001). The availability of subsidies throughout the irrigation sector encourages rent-seeking and gives incentives to farmers, irrigation workers and contractors to overestimate benefits, underestimate costs and lobby legislators for more subsidies. Maintenance works are also susceptible to corruption as the quality is difficult to measure and corrupt officials may have an interest in encouraging a constant flow of maintenance projects to maximize their own revenue from bribes from competing contractors. Irrigation officials can control the amount of water that flows to every farmer or village and request bribes for releasing volumes beyond the allotment, providing water at certain times, and even providing water at all. In such an environment, the move to regulate groundwater abstraction may still see the resulting abstraction levels settle above optimal as farmers are able to bribe officials to overlook quota violations. Officials also have an incentive to under-report surfaces under irrigation and pocket the difference between collected charges and reported collected charges (rijsberman, 2008).

Empirical findings suggest that these concerns over corruption in irrigation development are justified. For example, it is typical for tail-end users in Pakistan and India to receive a mere third of the water used by head-end farmers indicating that head-end producers have agreements with irrigation authorities to let them divert more than their fair share of water from the system (UNDP, 2006). Moreover, a study conducted in the Punjab in Pakistan found that a few large farmers were illegally appropriating large amounts of water, leading to benefits of $55/ha/year for them and losses of $7/ha/year for producers further downstream (Rinaudo et al., 2000). Small farmers cited corrupt legal systems and high legal costs as the major constraint to contesting this illegal appropriation of water resources (Azam and Rinaudo, 2004).

In the Indian state of Andhra Pradesh, officially irrigated area quadrupled between 1996 and 1998, coinciding with the transfer of irrigation management from government officers to water user groups. This strongly suggests that there is massive underreporting of irrigation in government-managed schemes so as to allow officials to pocket some of the water fees for themselves (Huppert, 2005 in Rijsberman, 2008).

Lastly, in one of the most detailed studies of corruption in irrigation services available, Wade (1982) analyzed a state irrigation system for paddy in southern India. He found that by long-established convention, every O&M contract yielded kick-backs of a minimum of 8.5% to various officers, clerical staff, and supervisors. On top of this, savings-on-the ground (read savings through agreed-upon reductions in quality, e.g. using less cement or removing less silt than officially negotiated) often brought the total rake-off to officers to 25-50% of what is officially invested into the irrigation system. Wade estimated that the Executive Engineers (EEs) could expect to generate roughly ten times their official salary in this way, which demonstrates the profitability of corruption and suggests that corruption is deeply entrenched in these systems. As Assistant Engineers (AEs) and EEs depend on their superiors (EEs and the Minister of Irrigation, respectively) for their next posting (they are rotated every three years) and postings vary significantly by profitability, they generally have to ensure that their superiors get a satisfactory amount of "extra" income. In order to achieve this, AEs must turn to extracting bribes from farmers for water allocation (granting illegal additional water rights, charging for officially entitled water rights, or providing emergency water supplements). Wade thus discovered a well-established internal hierarchy of corruption which reached from the farmer to the Minister of Irrigation in which it is almost impossible to not be corrupt due to various pressures from all sides. Wade estimated that the effect of this corruption on the demand for irrigation by farmers was negligible as the cost of bribes per acre (typically between Rs 10 and 25 for two seasons) were too low to have much impact on production decisions. Rather, he argues, it is the supply side that seriously suffers. Officials have no incentive to adequately maintain systems, rather the opposite. Furthermore, officials are incentivized to keep irrigation unpredictable and uncertain so as to create the most opportunities for bribe extraction from farmers. This, of course, affects water productivity. Corruption of this sort also means that government officials have no desire to see water prices rise as they are worried that this might reduce their rents. Wade further points out that since O&M posts are the most lucrative for Irrigation Engineers, those who are assigned to design and implement new projects want to get these projects done as quickly as possible in order to move on to an O&M position, leading to poor initial design.

The evidence presented suggests important nuances to the answers as to why the problems of South Asian irrigation are as they are today. Firstly, the abysmal present state of older irrigation systems is due not only to lack of funds allocated to maintenance but also to the siphoning off of allocated funds by corrupt officials and their contracting partners in crime and the resulting low quality of actual maintenance work done. The unreliability of water supply and its negative effects on agricultural productivity seem to be explained not only by technical shortcomings but also by the selfish interests of corrupt officials and the ability of head-end farmers to capture water intended for lower-end riparians through bribery. Lastly, government officials may not be in favor of policy reforms such as raising the price of water or electricity lest opportunities for rent extraction should be lost.

In order to increase the productivity of irrigation systems, there is thus a dire need for improved transparency and greater monitoring of irrigation workers. The involvement of farmers themselves in irrigation management, although likely to be resisted by those currently profiting from the corrupt system, seems to be the most promising way of achieving this. In addition, efforts are needed to strengthen the legal system and empower small farmers to protest against unjust appropriations of water rights.

II. Electoral Competition, Interest Group Politics and Public Discourse on Agriculture

Corruption arises as the result of government officials abusing the powers entrusted to them by the public for personal monetary gain. In addition, officials may also make certain policy decisions in order to be elected or stay in power. In some ways, this may be seen to constitute corruption; in other ways, it may simply be the result of information asymmetries. Moreover, politicians are influenced by ideas and public discourse that sometimes run counter rational arguments.

It has been widely recognized that even under democratic systems of government (which are supposed to be systems of majority rule), certain groups of citizens have a high degree of influence on politicians and are able to effect policy change in their favor even if it is not in the interest of the larger populace. Sometimes, these “interest groups” outright bribe politicians to get their way and often legislators have their own personal interests regarding policy direction that may be aligned with certain groups over others. However, sometimes, whose interests are reflected in policy making is determined simply by who is most organized.

There are three key theories of public choice that try to explain why policies are not always first-best (Hill, 1999):

a) Rational ignorance: Voters are generally uninformed since it is not in the interest of a single voter to spend time and resources on being well-informed on policy as his/her individual vote is unlikely to have any decisive power
b) Special interests: It makes sense for politicians to pass policies which concentrate benefits and disperse costs as this will maximize their political support
c) Short-sightedness: Policy makers (and to a large extent voters) favor policies with clearly defined present benefits in exchange for ‘hard-to-identify’ future costs, even if rational cost-benefit analysis speaks against them (this is especially pronounced in democratic systems as politicians are constantly facing the threat of losing an election)

Combining the first two principles, one can easily see why lobbying arises. Those who have a lot to gain from a certain policy will rally together and lobby for it, those who have a little to lose from such a policy will do nothing, and policy makers will yield to the lobby. It also follows from the third principle that policies with highly visible present costs (e.g. raising water prices) will be very difficult to implement.

An IFPRI study of attempts at policy reform in the power sector in India found that the lobby of farmers and supplying industries was significant in preventing a reform of electricity subsidies to agriculture and even managed to obtain free electricity in some cases (Birner et al., 2011). Interestingly, a World Bank study in Andhra Pradesh and Haryana, India, concluded that reform to improve the quality of power supply to farms, even if partly financed by increased tariffs, would benefit farmers (especially small and medium-scale farmers) in the long-term. It found that power subsidies mostly benefit larger farmers and that unreliable power supply imposes significant costs on farmers by causing damage to pumping equipment, by causing foregone irrigation, and by distorting investment decisions (World Bank, 2001). This may be taken as indirect evidence of the short-sightedness principle in action: Although reforming policy on electricity to agriculture would benefit farmers (and the environment) in the long-run and thus lead to political support for the implementers, the immediate costs associated with this reform (first tariffs must be raised, then the infrastructure can be improved and benefits be reaped) make it unattractive to politicians.

Meanwhile, the IFPRI study of attempts at reform in the power and fertilizer sector in India also highlights the importance of ideas and of institutions in hindering reforms. According to the report, subsidized electricity to agriculture was first justified on the basis of food security and continues to be upheld as part of populist political ideologies. Furthermore, it found that coalition governments were often less effective at bringing about policy reform as the various government departments involved in any agricultural policy have different and sometimes conflicting incentives, posing additional obstacles to the reform process (Birner et al., 2011). This highlights the important recognition that "government" is not a single entity and can be extended to explain issues of inter-provincial politics in countries such as Pakistan[33] and generally cross-border politics that affect irrigation development as most rivers are shared across national and international borders and governments must forge credible agreements before new dams and reservoirs can be built.

Lastly, another phenomenon of irrigation policy that may be seen as rational government behavior is the "political economy of neglect" or the "build-neglect-build" phenomenon. These terms have been used to explain the poor maintenance of irrigation schemes in developing countries resulting from decisions taken by rational governments who know that donors are more likely to provide funds for rehabilitation than for maintenance (Schoengold and Zilberman, 2007).

By understanding why governments make the decisions they make, one can design responses that tackle the problem at its root. Since politicians are very much concerned with staying in power, policy recommendations will only be taken seriously if they are in line with this goal. This means, for example, that in order to push for an increase in electricity prices, the recommendation must be accompanied by convincing evidence that farmers will benefit and this evidence must also be clearly communicated to farmers so that they will not withdraw their political support. Since politicians are further influenced by popular discourse, efforts should be made to inform and shape this discourse to reflect up-to-date knowledge of what works and what does

[33] In our meeting with the Chairman of IRSA, he stressed the political deadlock between the four provinces in negotiating the construction of new dams due to mistrust of down-stream provinces of the upstream provinces

not work in irrigation and what the real consequences of existing policies are. Moreover, in recognizing the existence of the "build-neglect-build" problem, donors may need to revise their lending practices and enforce maintenance as part of their conditions for future lending. When it comes to politics, information and cooperation is key and thus communication between governments and farmers as well as between governments is vital.

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