Chapter 11
Water Pricing, Demand Management, and Allocative Efficiency

Mahmood Ahmad

Abstract Pakistan has moved from having excess water to having problems managing demand. It has gone through several distinct phases in its devolution to water scarcity which shed light on the nature of the issues shaping water policy discourse. Pakistan has under-invested in water demand management and needs to chart a new water strategy to address the underlying causes of problems, not just the symptoms. Productivity in terms of actual water use in Pakistan is among the lowest in the world, at the same in value terms (economic output per unit of water) is also quite low in Pakistan. A growing body of literature has highlighted the benefits of adopting technologies and practices such as precision land leveling, zero tillage, and raised bed-and-furrow planting, which enhance water productivity in both physical and value terms. There has been very little uptake of High Irrigation Efficiency System (HIES) technology whose adoption depends on two factors: appropriate water pricing and the profitability of agriculture, Neither are the case in Pakistan. The government should consider a broader framework that entails three aspects: (1) enhancing the marketable commodity (or yield) of crops for each unit of crop transpiration; (2) reducing non-beneficial atmospheric depletions and outflows that are not retrievable; and (3) enhancing the effective use of rainfall, water of marginal quality, and stored water. The chapter underlines need to increase the price of irrigation water and also provides case studies from Pakistan and other water scarce countries looking at the tradeoffs between productive and allocative efficiency in future policy paths.

Keywords Demand management · Water pricing · More crop per drop · More value per drop · Environmental cost · Water policy in Pakistan

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11.1 Introduction

A number of technical, policy, and environmental issues affect the Indus Basin. The Indus Basin is a supply-driven system with open-ended demand that comes largely from population and income growth and is now characterized by an erratic supply. Furthermore, cropping intensity far exceeds (120%) the original design capacity (50–70%), with an equal or slightly higher amount of water being stretched to irrigate larger parcels of land.

Another major concern is the reliability of existing irrigation systems to deliver water in a timely fashion when and where it is needed. During the winter seasons, low mean annual precipitation and temporal variability often lead to growing uncertainty about the river flows. Further, conveyance losses in canals and watercourses and at farm level add to growing water shortage, with the end result that only about 30% of water flowing through the system is available to farms. In addition, farmers at the tail end of the irrigation distribution system are vocal about increasing water shortages. The large irrigation system system is also facing problems of maintenance due to low-cost recovery from water charges and there is a lack of vision in rebuilding better using lower-cost indigenous technology.

Climate change, also a major concern for the Indus Basin, can best be characterized as too much water with flooding or too little water with droughts. The weather patterns of the last decade and especially the year 2022, with droughts and ongoing floods should serve as a wakeup call to revisit Pakistan's crop calendars. Finally, planners and policy makers continue to focus on costly supply-side solutions even though low-cost demand management options are readily available.

Is Pakistan a water scarce country? In our view, no. Compared to other countries, Pakistan is well-endowed with water resources. Instead, our failed policies, irrational use of resources, and, in particular, explosive population growth have led to this much-discussed water scarcity (Table 11.1). The agricultural sector uses 96% of water, wastes a larger part of it, and pays the least, while contributing only 20% to the GDP. On the other hand, the services and industrial sectors contribute 80% to the GDP while using only 5% of the country's water (Young et al., 2019). Furthermore, the way the irrigation network was designed is an in-built incentive to waste water and adopt and stick to low-value crops (Nawaz, 2019). In the future, the agricultural sector needs to produce more-diversified and better-quality food using less water to meet the growing demands from competing sectors including the environmental needs of water flow. We have enough water; we need policy corrections to improve productivity, allocate water efficiently and bring about better governance.

Table 11.1 Population v/s water availability in Pakistan. Source: MTDF (2005–10)

Year	Population (million)	Per capita water availability (m^3)
1951	34	5650
2003	146	1200
2010	168	1000
2025	221	800

Policy discourse needs to be redirected from the supply side to demand management, from large dams to small dams (or construction of a cascade of dams based on the run of the rivers), and towards the potential of low-cost water harvesting. During the last three decades, we have missed out on these supply-side options because our policy makers have persisted in a strategy of building large dams—with foreign financing—while neglecting to raise local financing through pricing water and other economic instruments which are being used globally. At the same time, the demand management options that could have mobilized an extra unit of water at a much lower cost were never considered, aside from a few piecemeal investments in canal lining and laser leveling, and now poorly designed High Irrigation Efficiency Systems (HIES).

This chapter makes the case that the demand side of the equation has not been prioritized in terms of mobilizing marginal units of water in a cost-effective way to meet not only growing agricultural demand, but also demand from competing sectors that are much more willing to pay for water. Defining Water Demand Management (WDM) in layman's terms: WDM encourages better use of existing supplies through a set of economic measures and better and efficient management as opposed to pushing for further increasing supply (Global Water Partnership, 2017). Some currently untapped supply-enhancement options include eco-based infrastructure rehabilitation, water harvesting, and the use of unconventional water. Unfortunately, planners and policymakers are still obsessed with grand supply-side options. However, change is coming slowly as traditional donors are starting to lay greater emphasis on water productivity and governance as key areas of reform.

11.2 Policy Options—Supply vs. Demand Management

Pakistan, like many other countries, moved from a position of having excess water to problems in managing demand. It has gone through several distinct phases in its devolution to water scarcity which shed light on the nature of the issues shaping water policy discourse.

The first phase—the pre-partition era—saw the creation of one of the world's largest contiguous irrigation systems, with an excess supply of water, developed in one of the oldest and most accomplished civilizations. The second phase begins with the Indus Basin Treaty, marked by the damming of rivers, the construction of the Tarbela and Mangla dams, and the associated link canals. This era also saw low-cost drilling technology become available, groundwater come into use as a source of supplementary irrigation, and the ushering in of the "green revolution", which was driven largely by the mobilization of sizable water supplies (both surface and groundwater), new wheat and rice varieties and increased use of fertilizers. But the continued demand for more water to meet the food security requirements of a rising population, combined with massive migration from rural to urban areas, led to such a significant drop in per capita water availability that Pakistan within a short span of time has joined the list of water scarce countries or approaching fast as detailed in Chaps. 3 and 4.

So now that the time to panic is upon us, there are two schools of thought on how to avoid the problems that will occur because of perceived water scarcities. The first school of thought believes the solution lies in building large dams (*The News* 2017). However, a growing number of multidisciplinary water sector scientists, and now even a few civil engineers, have begun to question the wisdom of investing in large projects that have huge investment layouts, uncertain benefits, poor environmental records and, most importantly, reduce the money available for a wide range of other investment opportunities (Ahmad, 2000; Kamal, 2009; Mustafa, 2010). Young (2017), while debating the need for more storage, highlights:

> Unlike many countries, in Pakistan the timing of flows is not vastly different to the timing of demand, although some storage is needed to capture the monsoon peak and release this water later in the Kharif season and in the early Rabi season. Additional storage would certainly yield additional useable water, but any increase in water use will inevitably reduce the flow to the sea, which is already at an environmentally unsustainable low level. Given Pakistan's low economic productivity of water in irrigation and rapid rates of reservoir sedimentation, it is hard to justify the costs of major new storages. Hydropower generation does justify new dams, but these could be run-of-the-river facilities (not storage), with lower social and environmental impacts.

In our view, in Pakistan, as in many other countries, supply options are reaching their physical and financial limits, but there is considerable policy space to promote water demand management options, providing a large set of tradeoffs between supply and demand management and also within demand management options, discussed in coming sections.

11.3 A Policy Framework for Water Demand Management (WDM)

Compared to supply management, Pakistan has under-invested in water demand management. Pakistan needs to chart a new water strategy to address the underlying causes of problems, not just the symptoms (Ahmad, 2000). Moreover, these demand management options should be eco-based solutions which would both cost less and add much-needed value to the larger economy. The equation is simple: agriculture uses 96% of available water—if even 5–10% of agricultural water was saved,[1] it would be enough to meet the growing needs in other competing sectors while also resolving challenges from climate change. According to a World Bank Report (2019), as agriculture continues to consume a major share of demand, much of the increase in demand will come from other sectors of the economy. Between 16 and 32% of the increase in water demand by 2050 could be due to climate change, mainly because of growing water requirements in agriculture (World Bank, 2019).

[1] *Water saving* refers to the capturing (in part or in total) of the water fraction that would no longer be available to a system, after that same system has used its allocated water.

The policy options are broadly categorized as improving productive and allocative efficiency of water use in agriculture also addressing issues related to the environment and climate change, as detailed in Fig. 11.1. In layman's terms, improving productive efficiency means getting more crop per drop while improving allocative efficiency often refers to more value per drop of water. The concept of climate change in water context can be "too much (floods) or too little water (droughts)" and rise in global temperature.

To Turton's work, we have added another key area of water management that highlights the importance of eco-services which include providing food, water, regulating climate seasons, pollination for crops and building soil health and, most importantly, recreational values. Young (2017), citing the case of Pakistan, highlights the importance of environmental flows, which are often ignored or not given the attention they deserve. First, the literature constantly mentions the perception that irrigation in the Indus Basin area is inefficient. However, the reality is, at the basin level, the Indus Basin's global efficiency is estimated to be as high as 84%, because water is picked up again and again by downstream users through groundwater use. According to Young (2017), only a small portion of water is lost through evaporation and transpiration or non-productive plant use, but the larger loss—rarely mentioned

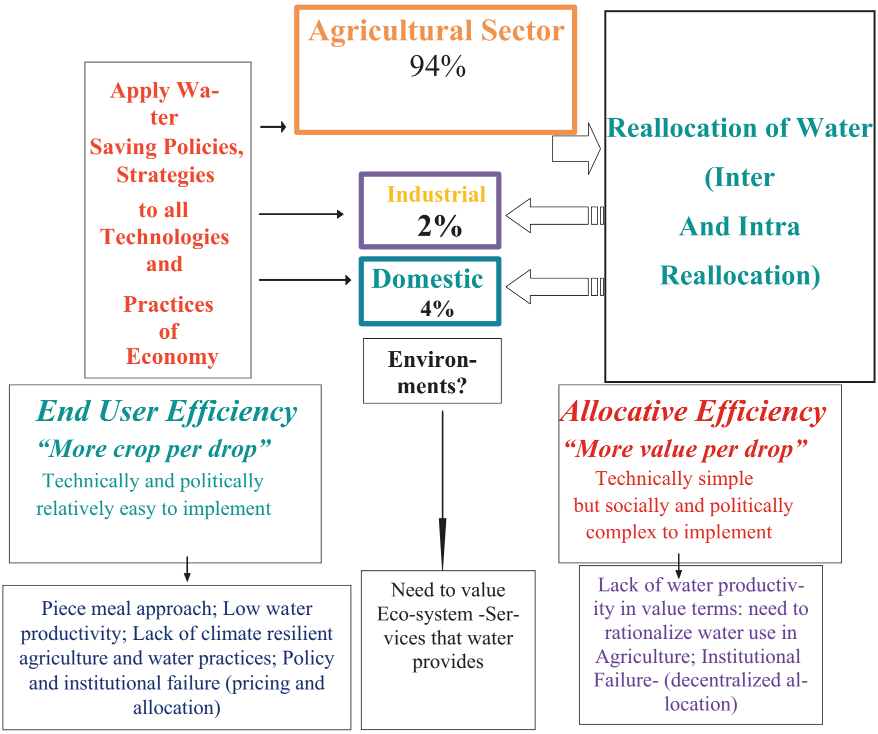

Fig. 11.1 Demand Management Policies. Source: Authors' work, adopted and updated from (Turton, 1999)

by researchers—is that the drainage water which returns to the river and the groundwater seepage which is pumped again are both of lower quality.

The second myth is with regards to the fact that water that flows to the sea is perceived as water wasted. Yet it has been well-documented for the last eight decades that the average flow to the sea has been declining, which has resulted in a poor ecological profile of the lower Indus and which has devastated eco-services that affect poor communities that rely on fishing and eco-tourism, not to mention its contributes to improving the role aquatic systems such as wetlands, coastal mangroves, seagrass meadows in carbon sequestration and sustainable management of coastal regions.

11.3.1 Water Productivity

11.3.1.1 More Crop per Drop

Productivity in terms of actual water use in Pakistan is among the lowest in the world. To support this argument, two figures are presented: Fig. 11.2A, highlights cotton water productivity in Pakistan in comparison to other countries—the most important crop for value added exports[2]—needs a sizable amount of water to produce one ton of seed cotton, especially when compared to India and China, our main competitors. Furthermore, India uses green (rainfed) water in cotton production as opposed to Pakistan, which uses expensive canal or groundwater.[3]

Pakistan produces 0.13 kg of cereal per cubic meter of water (m^3) as compared to 1.56 kg/m^3 in the USA, 0.82 kg/m^3 in China and 0.39 kg/m^3 in India (Kumar, 2003). Even within South Asia, as can be seen in Table 11.2, the level of water productivity is very low, with average productivity of 0.23 and 0.36 per m^3, for rice and wheat, with Pakistan at .25 and .40 per m^3 respectively as opposed to the 1 Kg/m^3 as recommended by the FAO (Haq, 2013). To put a positive spin on this situation, low productivity in Pakistan provides enormous potential—fulfilling it would result in more income, better food security, and more exports.

11.3.1.2 More Value per Drop

As with actual water productivity, in value terms (economic output per unit of water) is also quite low in Pakistan. Figure 11.2B shows water productivity in value terms with rice the lowest and maize the highest. It should also be noted that vegetables, sugarcane and cotton are also water intensive. The country generates only $2 per cubic meter of water, as compared to $19 for East Asia and the Pacific,

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[2] It refers to export-oriented export valued at economic prices using our domestic resource such as land, labour and capital all valued at their economic value.

[3] An unpublished paper, for ICID conference in Lahore.

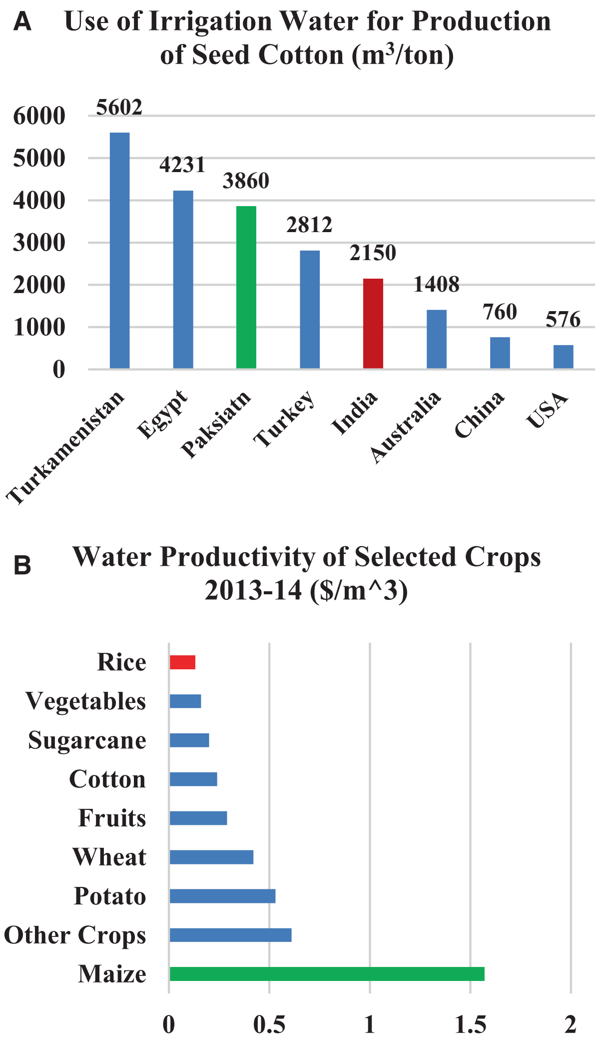

Fig. 11.2 A Water productivity of selected crops. Source: Authors' work, using data from *Pakistan: Getting more from water*, World Bank, 2019

ranking in the ten lowest countries of the world. A donor-supported reform process set a target to increase it to $5 by 2023 and to $12 by 2047. A World Bank report (2019) highlights that such a paradigm shift could help the country's agriculture survive in an era of water scarcity. The report also shows that physical crop water productivity varies between and within locations and systems by factors of from 0.2 to 20 kg per cubic meter, and economic crop water productivity varies by factors of from 3 to 30 US cents per cubic meter.

Table 11.2 Water productivity in South Asia. Source: (Haq, 2013)

Country	Average yield of Rice (t/ha)	Average Yield of Wheat (t/ha)	Water productivity* kg/ m^3 Rice	Water productivity* kg/ m^3 Wheat
Bangladesh	3.501	2.001	0.3	0.34
Pakistan	3.501	2.381	0.25	0.4
India	2.981	2.841	0.25	0.48
Nepal	2.912	1.981	0.24	0.32
Bhutan	2.111	1.141	0.17	0.18
Sri Lanka	3.371	NA	0.28	NA
Afghanistan	1.793	2.64	0.15	0.44
Maldives	0	NA	NA	NA
Average	2.88	1.85	0.23	0.36

Based on author's work reported in the 9th Annual Report (2016) of the Shahid Javed Burki Institute (BIPP), the key policy steps needed to enhance water productivity are, among others, (1) enhancing the marketable yield of crops for each unit of crop transpiration (2) reducing non-beneficial atmospheric depletions, and (3) enhancing the effective use of rainfall. Figure 11.3 outlines the actions needed at each level and the overall framework.

11.3.1.3 Rationale for Increasing Water Productivity

Cai and Rosegrant (2003) outline the need to enhance water productivity in agriculture, as the global population, which reached 6 billion in 1999 and is expected to reach 7.8 billion in 2025, is already putting greater pressure on limited water availability as demand in agriculture and other competing sectors grows. Irrigated agriculture, which accounts for 72% of global agriculture—and 90% for developing countries—has to produce more and better quality food with less water. Many countries with growing water scarcity have underinvested in rainfed agriculture, with estimates that water productivity will have to increase 30% and 60% from rainfed and irrigated agriculture, respectively, to meet food security demands.

To achieve the sustainable agricultural growth necessary for food security, all three levels—the basin, the system, and the farm levels—need to be considered. Given the scope of this chapter, we will focus on further elaborating the necessary actions at the farm level. There is growing literature coming up starting with Resource Conservation technologies to Regenerative Agriculture that highlight the benefits of adopting technologies and practices such as precision land leveling, zero tillage, and raised bed-and-furrow planting. After the success of tubewell adaptation in Pakistan, laser leveling is another success story, with 60% of farmers adopting the technology, and with groundbreaking localized versions being improvised—replacing costly imported technology. On the other hand, High Irrigation Efficiency Systems have been slow to take off because of the high initial cost, a lack of trained

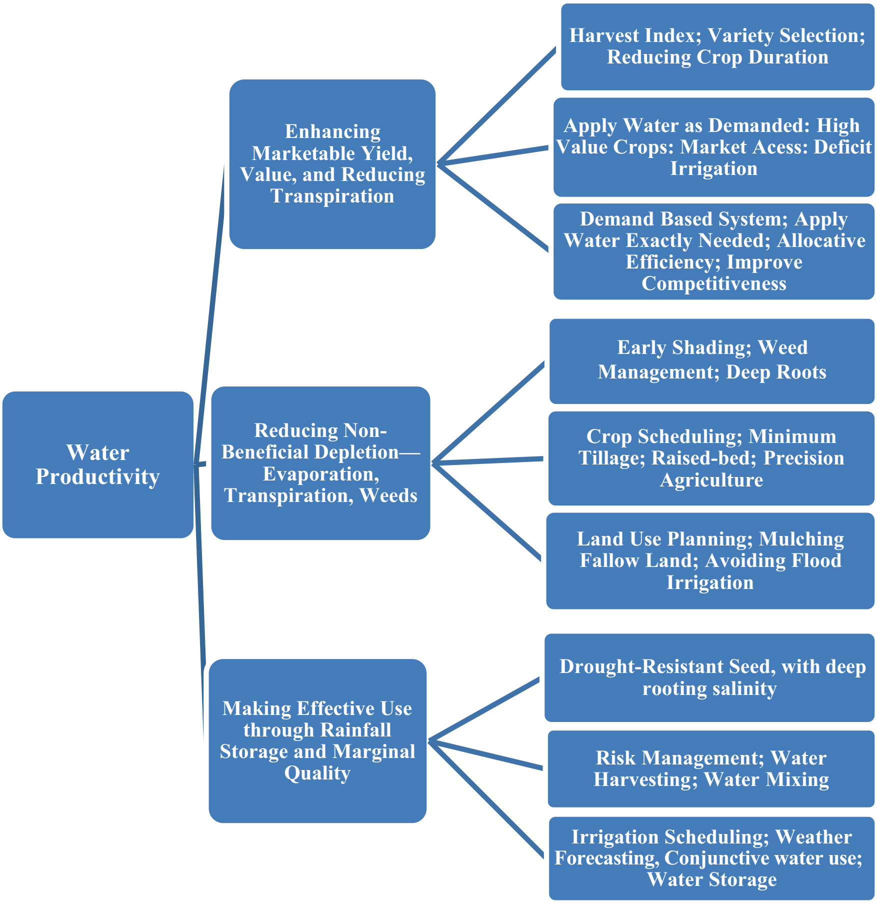

Fig. 11.3 Actions to increase water productivity. (Source: Author's work and analysis)

manpower to run the system. Only 150,000 ha are using these systems and their use needs to be expanded (See Chap. 10).

11.3.2 Water Pricing and Allocation—An Unfinished Policy Action

As in many countries, in Pakistan government plays a key role in managing water resources, but poor governance is reflected in the inefficient use of water and the inability to recover costs even for operating and maintenance expenses (let alone investment costs). On the other hand, the cost of new projects continues to rise but the quality of the service provided to end users is declining. Such a state has led to a search for alternatives that make water allocation and management more efficient. Dinar et al. (1997) outlined the basic principles on how to treat water as an economic good and about allocating it among competing sectors, using marginal cost pricing, social planning, user-based allocation, and water markets. However, there is not just one way to set water prices; options range from cost recovery to full cost pricing. Within this broad framework and keeping in mind our overall policy objectives, we have outlined three financial, economic and societal goals for sustainable water resource management.

- Financial: Meeting financial objectives to generate sufficient revenue to meet the operating and maintenance costs of irrigation systems, and to avoid the well-known trap Pakistan has been caught in (build-neglect-rebuild). At the very least, operation and maintenance costs should be met.
- Economic: Meeting economic objectives by encouraging water allocation to the most water-efficient crops or other high-value agricultural and non-agricultural uses. This kind of allocation would maximize the economic growth benefits of a scarce resource. Again, this should recover the original investment costs of each system, in addition to providing revenue for operation and maintenance (O&M) costs.
- Taking the environment into account. Incrementally moving towards full cost pricing that will also minimize the environmental problems with irrigation, especially those coming from the excessive use of water.

Figures 11.4 and 11.5 highlight the building blocks of pricing water resources: both costs and benefits. We often try to balance these out; in some cases, the full costs or the full benefits are not accounted for, which often explains the poor returns on investments (Rogers et al., 1998). These methods differ in their implementation, the institutions they require, and the information on which they are based. There is a growing literature on irrigation water pricing (Sampath, 1992). Several studies (Sampath, 1992; Dinar & Subramanian, 1997; Ahmad, 2000, 2005) focus on the water pricing methods in various countries.

From an economic perspective an ideal price would be where value (Fig. 11.5) would just equal the full cost of water (Fig. 11.4) as classical economic models postulate, meaning the social welfare function is maximized.

In Pakistan, to put the pricing debate in the correct context, before partition the sub-continent recovered almost all of O&M costs as well as part of the investment cost from irrigators. Then, in 1970, politics intervened: large farmers holding political power started to raise the fear that any spike in the water price would negatively affect private profitability (which was not true), and water charges started to fall below what was needed to fund and maintain the huge irrigation infrastructure (Ahmad, 2000). Farmers, especially the smaller farmers at the tail ends of the canals, held the view that they were willing to pay enhanced water tariffs provided that service was rendered (See Case Study 2 on Sindh). In other words, it is not the water per se but the service (the delivery system) that should be priced if we want to sustain this vital service in the face of serious public sector financial constraints and

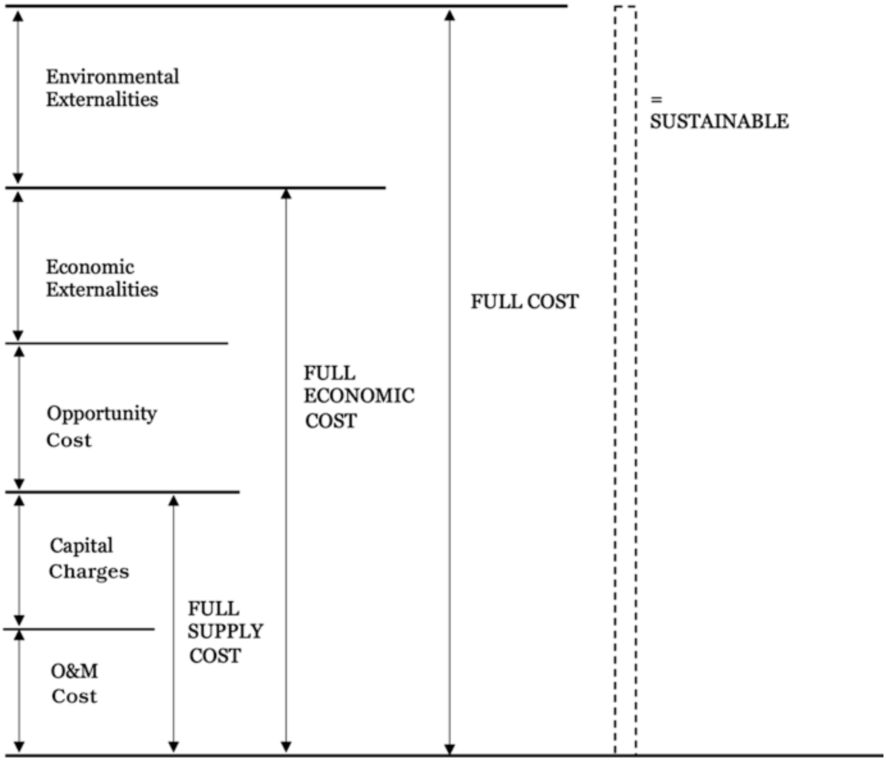

Fig. 11.4 Types of costs in water management. (Source: adopted from (Rogers et al., 1998))

ever-growing competition for water. The growing gap between the required total O&M cost and the income from water payments illustrates the problem: in the year 2003, only 28% of the cost was recovered, and even that fell to a mere 9% in the year 2016 in Punjab (Qamar et al., 2018). On the other hand, the budget allocated to run the system continues to climb, supporting farmers' arguments that water charges are raised to support and extend an already bloated bureaucracy.

So in Pakistan, the institutional character of irrigation pricing is still following the policy discourse of "build-neglect-and-rebuild" (Briscoe & Qamar, 2008). To fully recover the cost of water, user fees need to be 1% of the value of the stock of the infrastructure. This makes it Rs 1800/hectare for Punjab. Considering just simple maintenance and operations, at least 0.5%, or Rs 900/hectare is required. The actual *abiana* (water rate) collected in Punjab is Rs.150/hectare (World Bank, 2005). These numbers reflect the real water dilemma: an attitude that creates new water assets without a sound financial plan that recoups the cost from end users.

The study on water Pricing and Implementation Strategies for the Sustainability of an Irrigation System within the Command Area of the Rakh Branch Canal is one

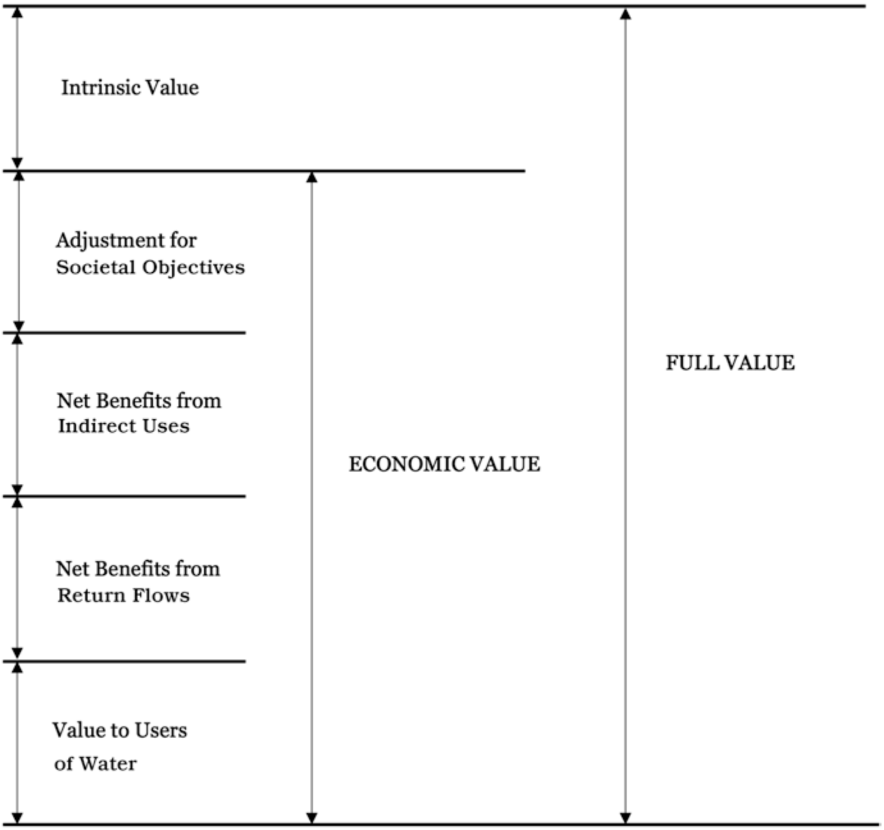

Fig. 11.5 Types of value or benefits in water management. (Source: adopted from Rogers et al., 1998)

of the few that compares current water charges with prices and also considers the cost of just maintaining the infrastructure in Punjab. Their work clearly shows that the irrigation water in the command area of Rakh branch canal has been severely underpriced ever since the flat-rate irrigation pricing system was introduced. The study shows current prices, the rates for each crop, and compares the water used.

Figure 11.6 shows that sugarcane—which consumes the most water (25,406 m^3 per hectare compared to rice at 14,478 m^3 and wheat at 4,065 m^3)—being priced at Rs 333.6 per acre. In order to recover the O&M cost, it would need to be increased to Rs 945.1 and to recover the full cost of supplying water the rate would need to increase to Rs 2852.8. Still, this figure includes neither the opportunity cost, nor the economic and external environmental costs. Pilot work at WIT/LUMS using extended versions of the policy analysis matrix show that both rice and sugarcane lose their comparative advantage if these costs were fully accounted for.

The International Water Management Institute (IWMI) has undertaken an in-depth study on the implications of alternate water charging policies in Pakistan. The study is based on data sets collected through household-level surveys from 891

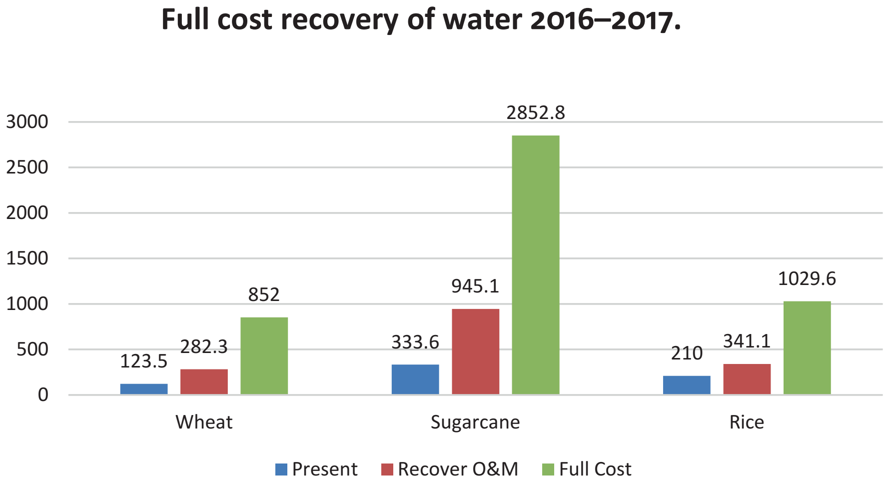

Fig. 11.6 Full cost of recovery of water. (Source: Author's work using data from Qamar et al., 2018)

farm households from 10 canal distributaries in four large scale surface irrigation systems in the upper Indus basin (the Upper Jhelum Canal system, the Lower Jhelum Canal system, the Lower Chenab Canal system and the Hakra canal system). The survey covered the 2001–2002 agricultural year. The key findings include (1) the average annual water charge per ha (area weighted) was Rs 420 per hectare in 2001–2002 across surveyed households; (2) the average per hectare water charge was found to be inversely related to land size categories; with landholders of between 1–5 hectares paying significantly more than the overall average, and those with more than 10 hectares paying less than the overall average; (3) average groundwater cost per hectare is also inversely related to farm size categories, with the smaller-sized farms using more groundwater and incurring higher costs and vice versa.

According to the IWMI report, these policy changes could be implemented within existing ministries, such as Ministry of Agriculture and Ministry of Irrigation with better coordination mechanism in place. Major benefits would include: (a) mobilizing more funds for the operation and maintenance of irrigation systems, leading to increased efficiency in water supply and productivity; (b) small and poor landholders benefiting most with cost reduction; and (3) changing existing inequities in water charges.

11.3.3 Technology Take-off and the Price of Irrigation Water

The cost of water and the adoption of modern technology are real issues in many countries of the region. The adoption rate of a system will depend to a large extent on the rate of return on each technology. The financial returns of a new technology are a function of the amount of water saved and the cost of water to the farmers. For example, in Yemen, the high investment cost of $3100 per ha to $4000 per ha is difficult to recover given the lower value of the water that would be saved. The low value of water is reflected in the high subsidy of diesel. Furthermore, in most areas water, not land, is the binding constraint. Any water saved because of the adoption of efficient technologies would simply encourage farmers to bring additional land under cultivation (Ward, 1995).

In the case of Iran, according to IWMI (Perry), the value of water use in agriculture is $.004 per cubic meters, one of lowest in the world, while the cost of saving water through adoption of modern technology is estimated at $ .11 per cubic meter. This means that as long as the cost recovery value of water is less than $. 11 per cubic meters, farmers have no incentive to adopt modern technology. In other words, in the absence of increased water charges, instituting a cost-recovery regime (volumetric or otherwise modified) would not have any effect on either water saving or on intra-sectoral allocation (that is, water going to high value crops).

In the case of Pakistan, problems in scaling up HIES face the same dilemma—farmers may well be aware of technological options, but they will not invest in them unless they are pushed by (1) cost incentives (rising water prices); (2) pulled by profitable market opportunities; or (3) water is scarce. It is clear that both technology transfer and market development and incentive questions need to be addressed. If water productivity-enhancing technologies or management practices generate more on-farm costs (including uncertainty or risks) than additional benefits, their adoption may not be a priority for some or all farmers (as the farming community itself is not homogenous) (Giordano et al., 2017).

We close this section with five key policy actions to improve irrigation efficiency as recommended by FAO along with other innovative demand management options.

- Move to raised bed technology with zero tillage, mulching, and intercropping
- Reduce seepage loss through canal lining, especially where groundwater is saline.
- Reduce evaporation by avoiding mid-day irrigation
- Promote deficit irrigation and
- Increase water harvesting

11.3.4 Water Allocation Among and Within Sectors

When water is used for production, low water costs allow for the cultivation of water-intensive crops, which would not otherwise be grown if water commanded a high cost. Thus, the cost of water may be a factor which determines the cropping pattern of an irrigated area, along with farmers' capacity to produce certain crops, particularly popular food crops. Crops such as rice, for example, require large amounts of water, and are often produced where the cost of irrigation water is low. As water scarcity and its rising cost become a factor, farmers would allocate their scarce resources to growing commodities that generate the highest returns on water. Based on analysis from Chaudhry et al. (2009) (Table 11.3) sugarcane does not have

Table 11.3 Key policy indicators sugarcane versus cotton

	Sugarcane	Cotton	Comments
Domestic resource cost	1.14	.57	Cotton has comparative advantage but SC does not
Value added per acre (Rs)	10,222	19,709	Cotton adds almost twice value added
Water productivity (Rs per inch of water)	724	1383	Cotton water productivity is much higher

a comparative advantage in southern Punjab, but high private profitability compared to cotton gives farmers an incentive to grow sugarcane. Yet the research shows that if water was priced according to the opportunity cost, growing sugarcane would not be the most economical option, since it would cost Rs 114 in investments of land, water, and labor to add just Rs 100 to the economy—clearly a losing proposition. On the other hand, investing Rs 57 into cotton provides a return of Rs 100, far greater than that of sugarcane. Further analysis reveals that the water productivity of sugarcane is almost half that of cotton. The message is that water pricing plays a key role in improving allocative efficiency and at very little cost compared to the other policy options being pursued.

It would be interesting to compare water pricing for other uses with that of agriculture.

According to Nawaz (2018), agriculture uses a whopping 60,000 liters at a price of one Rupee (.0067 cents), whereas domestic and industrial water, provided by the public sector, uses 350 and 85 liters of water for same value (Fig. 11.7). Last but most importantly, multinational companies sell 1 liter of bottled water at PKR 50 all over the country, which amounts to 0.02 liters per 1 PKR. It is very difficult to obtain the actual extraction cost with so many multinational and local brands competing. In Pakistan, as in other countries, bottled water is a lucrative market where groundwater is being misused by big business: from low-cost extraction to solar technology (See Baluchistan Case Study below).

11.3.5 Water and Ecosystem Services

The points discussed in the above sections can be summarized as policy failure (subsidizing the key resource, water) and institutional failure (poor governance), than a case can be made that pervasive market failure, the externalities (unpaid cost) generated from non-point sources are quite dominant in agriculture sector, ground water depletion, and failure to recognize the eco-services water provides are good example (Ahmad, 2000). This section highlights the often-overlooked ecological benefits that water provides: food and fresh water, regulation of the climate, water purification and aesthetic and recreational needs. These benefits are linked to human wellbeing by securing access to resources, providing the basic material required for a good life (i.e., sufficient food) and access to clean water, as well as delivering

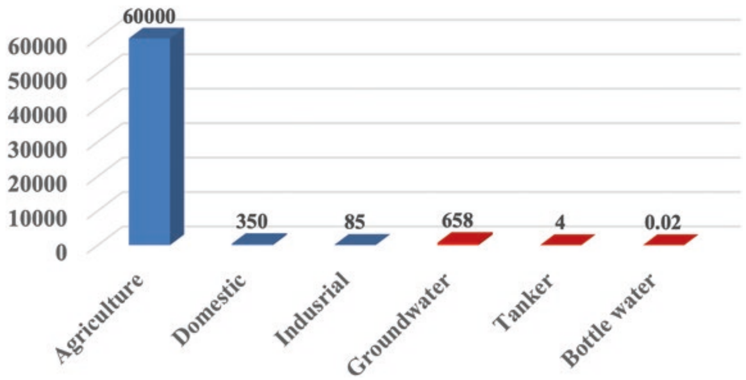

Fig. 11.7 Water pricing (liter/PKR). (Source: Author's work using data from Nawaz, 2018)

more intangible aesthetic, spiritual, educational and recreational (Millennium Ecosystem Assessment, 2005).

The deterioration of the ecosystem can have a serious adverse impact on Pakistan's economy, for example the question of needed environmental flows has still not been considered on its economic merits—badly affecting ecology downstream beyond Kotri. The environmental benefits that mangroves bring in terms of carbon sequestering are barely accounted for. TEEB (2010) and Bennett et al. (2009) highlight the fact that to achieve water and food security, the value of the ecosystem and the benefits of different options need to be worked for all investment possibilities or alternatives, including tradeoffs.

Pakistan would be better off investing in groundwater than investing in mega projects. According to Hussain and Abbas (2019), the groundwater system underneath Pakistan's flowing rivers in the Indus plains has at least 400 million acre feet (MAF) of good quality water, which amounts to more than 3 years of the mean annual flow of the Indus (or 1000 days of storage, after excluding polluted areas). They further explain that the quality of this valuable resource is being deteriorated through arsenic contamination of the groundwater. Such uninformed groundwater pumping, besides raising the cost of pumping, causes the deterioration of the quality of the aquifers, increases secondary salinization, and causes the loss of fertile soils. The policy message here is that if groundwater was managed properly and considered to be a possible investment alternative, the large sums spent on dam construction could have been used for other investments in the water sector.

11.3.6 Missed Opportunities—Unconventional Water Use Options

Whereas some countries have benefited a great deal from using technology and best practices to mobilize a marginal unit of water, both in terms of supply and demand management, there has been little to no policy debate on these issues in Pakistan.

These include: watershed management, wastewater management, reuse of drainage water, rainwater harvesting, and using eco-practices in water management or the circular economy in the water sector. Because of the growing water shortage, many countries, unlike Pakistan, are relying on non-conventional water resources such as drainage water and urban and industrial wastewater. Israel, for example, has successfully managed to meet large part of its agricultural needs using wastewater as explained in later section.

Pakistan can also benefit from global experience in policies that promote water scheduling and supplementary irrigation. Oweis and Hachum's (2012) extensive work in Syria showed that a small incremental dose of water (supplemental irrigation) during water-stressed periods could reduce the yield gap. Droughts, which now are common phenomena under climate change, apparently have limited impact when farmers store water, either on or below ground, and harvest rainwater.

For Pakistan, water storage at the farm level is as important, perhaps more than water storage via large dams. This would allow farmers more control on when and where to use water, make water available on demand, and also give them the flexibility to balance water and other agro-input requirements during critical periods of crop growth. This would also provide greater opportunities for crop diversification and thus increase both the productive and allocative efficiency of water. In the plains of Punjab, KPK, and Sindh, sometimes the farmers do not need water, particularly during the winter and monsoon rains (Qureshi & Ashraf, 2019). Water given on supply basis with existing *warabandi* system (water distribution) sometimes leaves farmers no choice but to stop this unwanted water, called "awara pani" in the local language, or "unattended water." Storage at the farm level in the form of community ponds near the villages would help not only provide water on demand but also help in recharging groundwater.

Turning Wastewater in Generating Values—Case of Israel

In Israel, wastewater has been transformed into a valuable water resource, reducing waste and garnering tremendous environmental benefits. The price of treated wastewater per cubic meter has been set below that of fresh and brackish water to provide an incentive for farmers to use it (Fig. 11.8). This triggered a major policy shift and provided an incentive to shift fresh water to urban use—one example of how a pricing tool can be designed. The end result is that recycled water, which in 1985 formed a minor share of the water used in agriculture, now is the major source of water used in agriculture, with the expectation that all agricultural water demand can be met through recycled wastewater.

The present crisis calls us to learn from mistakes and accept the need to shift from past development paths, assess where things went wrong and chart a strategy that fulfils the potential value in the water supply chain. Today, we find ourselves in a moment of reckoning, in which we must address three main issues facing the water

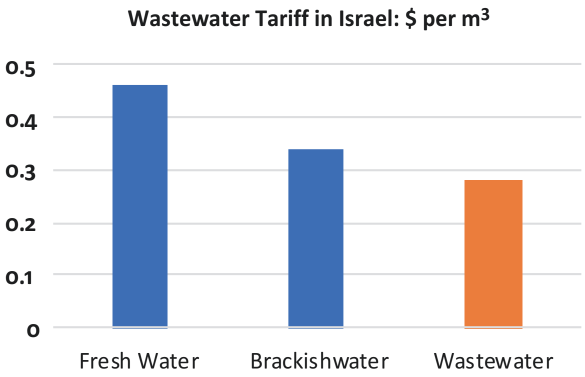

Fig 11.8 Wastewater tariff in Israel: \$ per m[3]. (Source: Marin et al., 2017. Released under CC-BY-SA license)

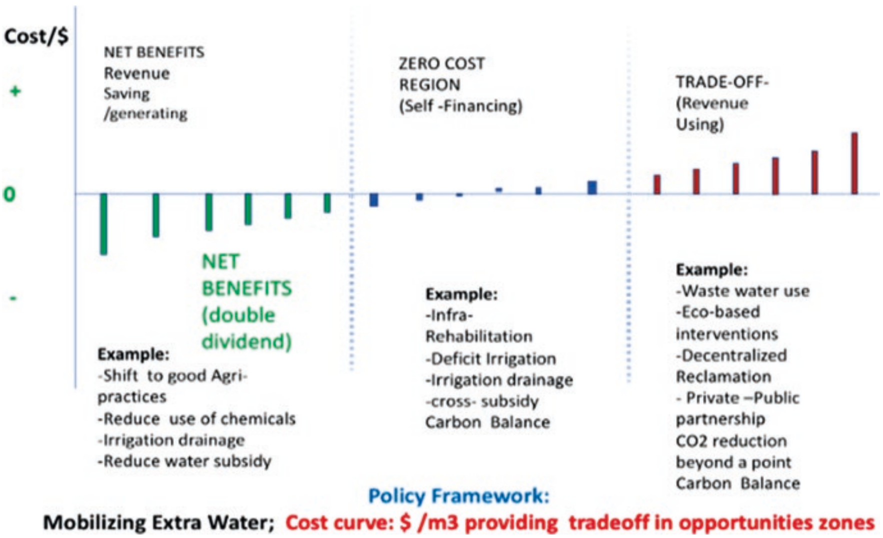

Fig. 11.9 Cost curve. (Source: Author’s work and analysis)

sector: shifting emphasis from supply to demand management, water value addition by improving the productive and allocative efficiency of water use, and promoting and adopting eco-based technology and practices. Promoting such a strategy would bring huge benefits to the end user in terms of profitable and competitive agriculture business with cost reduction and provide water for other uses. Figure 11.9 shows the enormous tradeoff such a strategy would entail. The graph is based on data and study from India, where conditions and issues are fairly similar.

11.4 Key Lessons

- Is Pakistan a water scarce country? The answer is absolutely not. If water use in agriculture can be rationed and better governance can be brought to its management, there is enough water available to meet competing demands.
- In fact, availability of water after the completion of the Tarbela Dam has increased as shown by the supply of water.
- Pakistan has underinvested in demand management options where an additional unit of water can be mobilized at either at a much lower cost, at no cost or even at net benefits.
- The piecemeal approach to improving the productive efficiency of water use had mixed results. There was very little uptake of HIES technology. Widespread adoption of this technology depended on two factors: water pricing and the profitability of agriculture. Neither of these factors held in Pakistan.
- In order to improve water availability, the government's priority is to enhance water productivity. The government should consider a broader framework that entails three aspects: (1) enhancing the marketable commodity (or yield) of crops for each unit of crop transpiration; (2) reducing non-beneficial atmospheric depletions and the outflows that are not retrievable and are lost; and (3) enhancing the effective use of rainfall, water of marginal quality, and stored water.
- The new policy priority should be directed at better resource mobilization to develop and maintain irrigation infrastructure in Pakistan, since the cost of no or little action will be huge.
- Creating economic incentives is key: Economic incentives include market prices, taxes, subsidies, and other regulatory instruments that are designed and implemented to play a major role influencing the use of both surface and groundwater.
- In the short- and medium-term, water charges should be increased to cover O&M costs. According to the World Bank's calculations, doubling water rates for two consecutive years, with a 75% increase in the third year, would bring abiana revenues to a level that would cover actual O&M expenditures at the 2015–16 level.
- Time is running out to develop sustainable groundwater polices and implementable laws and regulation. With greater water demand from competing sectors, a stricter regulatory framework is needed, in addition to innovative solutions, that address the issues of solar energy, virtual water exports, and drought management.
- Use or redirect environmentally harmful subsidies to promote cost effective nature-based solutions in agriculture and the water sector. Key areas such as fossil fuels, water, agriculture, and transport can generate significant benefits for the eco-system while minimizing the fiscal cost to taxpayers and the cash-starved government.

- A new structure of governance is needed if we want serious reform in the water sector. As long as the agricultural sector is the major water user, there is no justification for so many other water-related ministries. The main stakeholder—the farmer—does not get the services Ministry of Irrigation (MOI) is expected to provide. Governance in the water sector should only be determined based on need, service delivery, accountability, and financial discipline.
- Rebuild Irrigation Infrastructure Better: The frequency of floods and droughts has increased over time, especially extreme floods that require the rebuilding of infrastructure in the post-disaster phase. Build Back Better provides opportunities to use eco-friendly technologies that will ensure greater resilience of the infrastructure to future floods and drought, with the advantage that these interventions are also water smart.
- Moreover, the optimization of water resources is a major issue for the country and a national water policy was adopted by the government in 2018. In the implementation phase, the focus at the macro levels should be to not avoid further postponing key reforms: (1) ration water use in agriculture (2) water costs and values rationalized (3) unbundle water rights from land rights as a starting point in developing prudent water allocation policy.

11.5 Case Studies

Case Study 1 Baluchistan a special case of water mangement in Pakistan

In order to help increase fruit production in the province, the government (Government of Balochistan, 2019) introduced a policy of subsidizing the pumping of groundwater through electricity-powered tube wells. Farmers were to be charged a very low fixed cost (currently Rs 6000 per month regardless of the hours worked or the amount of water pumped). The difference between the price charged and the actual cost is to be shared between the provincial and federal governments (ibid.). This policy—after growth in fruit production and the increased installations of tubewells in the province—has resulted in a huge fiscal drain on the government, currently about Rs 8 billion per year, as well as overexploitation of the aquifer and a rapid lowering of the groundwater table. Farmers' response to the falling water table is to dig deeper and install larger-capacity tube wells, both of which exacerbate the overexploitation of groundwater as well as increase the fiscal cost.

The context to this is that 30 years ago a few progressive farmers invested in a technology called a "jack pump," which triggered this process. In the next phase, this inefficient technology was replaced with submersible pumps from Italy, which later were replaced by solar-powered systems, causing another set of problems. Because of the unreliability of the power supply, solar-powered technology was adopted by farmers and now the farmers use both solar power and municipal power. Unfortunately, solar-powered pumps have been promoted without putting an appropriate regulatory framework into place, and this has resulted in an unaccounted environmental cost. Furthermore, CPEC and urbanization is putting enormous pressure on dwindling water resources.

11.5.1 Actions at the Micro Level

In addressing these issues, evidence based policy research is needed to better understand where the demand for water comes from. Based on author's FAO lead ongoing climate-smart policy work in Baluchistan the needed policy actions include:

1. Typology of ground water technology and its detailed costs (financial and economic) with and without solar options.
2. Hydrological profile of ground water in different regions.
3. Cropping patterns and how they change over time.
4. Preparing financial and economic budgets, using different identified technologies and cropping patterns in calculating farm income analysis, water productivity and improving allocative efficiency of water use for these crops.
5. Simple spreadsheet based analysis to communicate policy tradeoffs with stakeholders in developing a climate smart agriculture and ground water management policies.
6. Train and involve young professionals from the MOA and Planning Department to be part of the above policy work.

11.5.2 Actions at the Macro Level

In Baluchistan, the water dynamic also needs to be understood, since it is different from that of the Indus Basin and perhaps a different perspective is needed to address these issues. For example, Baluchistan has an 18-river system that is being managed (or mismanaged) as opposed to one main river in the Indus Basin. Furthermore, groundwater contributes only 7% to the overall supply, which illustrates the need to invest more in building storage for storm water.

Further, prudent policy interventions are needed to manage both the *salaba* and *kushaba*[4] lands. The policy options entail using large volumes of water to promote water harvesting at all levels—from farm and community levels to community-based small dams. On the other hand, large farmers and associations of small farmers living in key fruit production areas need to collaborate to reduce groundwater extraction in overexploited areas, and enhance recharge (evaluation of delayed

[4] About 50% of the area is irrigated through *sailaba* (flooding) and *khushkaba* (water harvesting), the other 50% through canals, karezes, springs and tubewells.

action dams, leaky dams, and other structures), combined with support for alternative energy and productivity enhancement (Draft Agriculture Policy 2019). In contrast with investing in HIES in Punjab—without much thought to its terrain—and getting mixed results, there is a perfect economic case to invest in such technology in the highlands of Baluchistan. There is also a pressing need to introduce a system of realistic (i.e., which fully recoups the cost of water) pricing to privately extract water from public aquifers.

Case Study 2 Climate Change and Water Shortage in Sindh- Farmers Response in Omerkot District of Sindh

Like other provinces agriculture drives the economy of Sindh province and water shortage is at the heart of the problem. At same time, proper drainage has not been developed in spite of huge investments made by donors (WB and ADB). Sindh, is very famous for growing the dandi cut variety of chili pepper, which commands a premium price in the international market. But production and growth has slowed down in the prime districts of Omerkot and Mirpukas.

The province and farmers are at the tail end of Indus Basin often complain they have less water. Farmers have coped with these problems through acting collectively. Progressive farmers in the Omerkot district of Sindh, led by Mr. Mustafa are trying to practice sustainable agriculture and are dealing with water challenges by:

- Continuously remodeling their water courses, and digging water courses deeper and deeper to access water at the tail, even though it entails pumping the water instead of using the flow of gravity, which is cheaper.
- Investing in storage ponds that are larger than specified by the Sindh Irrigated Agriculture Productivity Enhancement Project (SIAPEP) program supported by World Bank.
- Capturing unused water when there is excess supply (Awara Pani).
- Diversifying cropping patterns (farmers responding to markets by growing a cropping mix with more income).
- More investment in mango orchards, moving from traditional to high-density farms, thus increasing income and reducing the enormous risk they face with vegetables.

The greatest impact of water shortages is reported in the villages located at the tail reaches of the irrigation canals. In the opinion of these villagers, the shortage of irrigation water is mostly man-made, caused by unfair water distribution and lack of equity. They stated that because the upstream users in the area tamper with available water shares so less and less flows to downstream users, the land has become dry and impossible to cultivate. According to these villagers, other powerful individuals in the area also divert water to their land and the villagers cannot get it back.

Another water related innovation is the successful running of the community-based weather station in Kunri, demonstrating how farmers are looking at local solutions to address climate change.

Progressive Community Based Weather Station in Umerkot—Creating a Resilient and Climate Smart Agriculture

Given how critical it is to dry chilies properly, farmers in Kunri area are prone to devastation of their entire crop because of rains. Farmers lose two out of every five crop seasons because of them. According to progressive farmer Mahmood Khan, who lives in the Naukot area, if a proper rain forecast was provided to farmers during this critical period, losses could be minimized at both the farm and national levels. Mr. Khan is one of the few farmers who uses computers to plan his farm budget, and track weather patterns in the region to minimize post-harvest losses. He was very proud to explain that two seasons before, when rain had destroyed most of crops in the region, he was able to, through the internet, assess rain forecasts. He instructed his manager to take the necessary measures to cover the crop from expected rains. While his manager was very skeptical of this assessment, the preventive measure turned out to be instrumental in saving most of his produce in the region. He emphasized that support from the government, specifically with regard to the dissemination of information on production and post-harvest losses, is totally lacking and advise in this direction could impact farm income, providing sustainable delivery of volume for exports and benefiting both producers and consumers.

Case Study 3 Is India exporting Rice or Water?

In the mid-1960s, India was highly deficit in food grains. However, with the introduction of high-yielding Mexican dwarf varieties of wheat along with guaranteed minimum prices on agricultural commodities, there was a major increase in food production. The policy support of an effective procurement was also a major factor in this enhanced food production. The shift in cropping patterns that occurred because of the introduction of high yielding dwarf varieties made India self-sufficient and also a major exporter for rice and an on-and-off exporter of wheat. As compared to wheat, rice production is very water intensive—using 1670 liters of water per kilogram, critics often say the country is virtually exporting water.

A few years ago, Columbia University-led research said many parts of India experience "chronic water stress due to heavy-water extraction for irrigated agriculture," noting that in the states of Punjab and Haryana in particular, growing rice requires increasing amounts of irrigation.

India uses more groundwater than anywhere in the world—24% of the global total—and 1 billion people there live in water-scarce areas (Gerretsen, 2019).

An unpublished report discussing the crop diversification project in India reiterated that the depletion of underground water resources, the deterioration of soil health, the deficiency of macro and micro nutrients, the toxicity in soils at several places in the intensively cultivated areas, the pollution of soil, water and air, and the decline in total factor productivity in field crops, etc., started happening by the early 1980s. Now, after three-and-a-half decades of extensive exploitation of the state's soil and water resources, the situation has become so serious that more than 70% of the water required to irrigate rice crops comes from tubewells. The canal water supply is less than 30% of the water required by this crop (2.5 million hectares).

Through excessive pumping of groundwater, there is more extraction than recharge. As a consequence, the water table in the central Punjab is receding at an average rate of over 42 cm per annum. Furthermore, according to this report, it is estimated that if groundwater withdrawal continues at this rate, soon it will render the production of rice, as well as of wheat, totally uneconomical and will have a serious impact on the economy, ecology, and resource base of the state. This will have disastrous nationwide consequences, with more than 10% of the centrifugal pumps in central Punjab becoming dysfunctional and underground water shown to have selenium and other toxic contents, making it unfit to drink even by animals. In fact, nowhere in Punjab is the water free from chemical residues and harmful elements.

The final analysis is that short term gains were achieved at the cost of long term options for rational use of valuable resources—in fact, Indian Punjab has exported virtual water all these years. While the environmental cost was never officially accounted for, future generations will, in fact, pay for it. If the situation is not corrected and these problems are not handled with vision and determination, the economic conditions of the rural populations cannot be ameliorated and the poverty of rural populations dependent upon the agricultural sector cannot be alleviated. This will soon have a serious negative impact on the social fabric of the society in Punjab.

The often proposed action to ration water use by agricultural/rural populations, through restructuring production patterns that promote moving from low- to high-value crops and from industrial to nature-based agriculture that uses far less water (See Chap. 10). The case provides policy lessons for Pakistan, as major rice exporter, country is beginning to face similar groundwater management issues, but in our view country is in a better position to rationalize water use policy towards rice cultivation.

Case Study 4 Morocco—Improving productive and allocative allocation

Pakistan and Morocco followed different policies to meet their food security objectives. Pakistan followed an incentive policy to promote wheat, whereas Morocco invested more in growing high-value crops for export, thus paying to import food. The World Bank study concluded that Morocco could achieve self-sufficiency in cereals by 2017, if Moroccan farmers made reasonable increases in cereal productivity and increased the amount of their cultivated area. However, it turns out that the cost of increasing cereal production by transforming or converting land use to grow high-value crops (i.e. the forgone revenues from reduced production of high-value crops) would climb from $21 million in 2007 to $6 billion in 2017 (the year self-sufficiency would have been attained). According to the study, the total value of income forgone in order to enforce national cereal self-sufficiency over an 11-year-period would be a staggering $16 billion. While the tradeoffs between producing high-value crops and cereals vary by country, a drive towards greater self-sufficiency comes at a great cost in terms of forgone income and this cost can increase exponentially.

The important question is this: despite the fact that Pakistani producers have enjoyed a consistent comparative advantage in growing high value crops, why haven't their agricultural exports performed as well as Morocco's, Egypt's, or Jordan's? All three of those countries have been able to capture a greater share of the growing demand in export markets. To a large extent this can be attributed to the fact that this comparative advantage was not translated into competitive advantage, particularly because the large number of small-scale farmers were ignored. A large quantity of Pakistan's exports remain in their raw form without much value added and most products (asides from rice and cotton) also stay in low-end markets. In the context of our chapter, among other policy options, we did not improve either the productive or allocative efficiency of water used in agriculture, an instrument that was very effectively used in Morocco, Jordan and Israel.

The experience of Morocco, Egypt, Jordan, and Israel provides lessons for Pakistan in how to shift policy in order to expand horticultural exports and add value to per unit water used. First, current policies and subsidies in Pakistan encourage farmers practice a rigid cropping system rather adopting a diversified cropping pattern. Ninety percent of the cropped area in Punjab grows major crops (dominated by wheat), while only 9% is devoted to higher-value crops. The fiscal cost of supporting the wheat subsidy has been very high, the direct cost of which is now more than Rs. 5500/ton. Indirect costs are also substantial and include ground water depletion, physical losses because of poor storage and high spoilage; pilferage; over-production of wheat and a consequent under-production of other higher-value commodities; diversion of credit from the banking system; and a disincentive to the private sector to build storage facilities that would also be available for other crops besides wheat. There is an effort through the World Bank SMART project to bring policies adopted by Morocco to Pakistan.

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