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REVERSING THE INDUS BASIN CLOSURE

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ABSTRACT

After independence, a swift and extensive development of Indus river basin has intensified commitment of water resources. During dry period, the indication of over commitment and basin closure are visible. In the beginning 2000s, the river basin water resources were committed to more than 99% without any environmental flows. The paper tries to unfold drivers closing the Indus basin and the scope for change. Defining and implementing water allocation mechanism to ascertain equity, sustainability and more productive uses of rare water resources for both human benefit and environment conservation through a basin-wide approach for water resources development and management will act as turning point.

Keywords*:* Indus River, basin closure, irrigated agriculture, over-commitment, (re)allocation.

1. INTRODUCTION

Progressively river basins have considered as natural entity and basic spatial units for an optimal management of water resources. As growing human pressure to access and control over water resources through available technology and engineering feats, for domestic use and food production brings actual water use closer to potential ceilings. The societal response to particular condition is adopting conservation measures and by reallocating water towards more beneficial uses (Molle, 2003). The multipurpose river basins development especially large dams has doubled the irrigated (140-180 million hectares) in second half of the 20th century (Molden *et al*., 2007) and many Rivers basins became dry during a part or entire year in lower reaches (Postel, 1995; Smakhtin *et al*., 2004; Pearce, 2006) with some region observing dire drop in groundwater levels (Shah *et al*., 2003; Foster and Chilton, 2003). The ability of river basin water resources to fulfill growing demand from different sector and interest has reduced dramatically (Falkenmark and Molden, 2008). According to Molle *et al*., (2007) due to ‘overbuilding’ of water infrastructure for extraction of surface water and groundwater, more consumption by agriculture, industry and human than its renewable available resources, a basin closure occurs, the fact that no water reaches to sea/lake for part or all of year. The river water supply unable to fulfill their commitment in terms of quality and quantity at the mouth of river give rise to issue concerning unequal access to and control over, water within the actors due to current water infrastructure and water use systems (Sexton, 1990).

Indus River Irrigation System plays a life line role for the agriculture and economy of Pakistan. The Indus River Basin has served a learned laboratory for international and national research on a variety of problems with water allocation, development and management, particularly to subject of water efficiency, equity, hazards and environmental quality (Michel 1967; GOP, 2002). The record of water development extends back six millennia through the Harappan period. The most dramatic changes have occurred after the independence of Pakistan (Wescoat, 1999). Forty million irrigated acres have come under coordinated management, consuming 100 million acre-feet of water annually or approximately 70% of annual basin runoff (WAPDA, 1990). New water management institutions have developed from the community to international basin scales. At the same time, water for riverine, deltaic and coastal environments is diminishing and polluted (GOP, 1996; Akhtar *et al*., 1997; IUCN, 2003). Urban and peri-urban populations suffer frequent water shortages. Water logging, salinity, groundwater depletion and irrigation inefficiency continue to threaten agricultural production (Whitcombe, 1995). Inequities range from the tail-ends of canals to inter-provincial water allocation disputes (Mustafa, 2007). As the Indus basin closes, persistent accounts of water conflicts advocate that there is not sufficient water for all existing users and the environment: overdevelopment of infrastructure generates dissatisfied needs and stimulate a sense of scarcity, mostly for irrigation schemes in the lower reaches of a river basin (Molle *et al*., 2007).

This paper attempts to figure out that how Indus river basin drove towards closure. In section 2, we present the major characteristics of the Indus basin and we define the stage of closure in Indus basin. In section 3, we see how Indus basin was developed and water use trend in Indus basin. In section 4, we characterize the different drivers of this closure. In section 5, we study different possible solutions that may help to alleviate the problem. Section 6 presents some concluding remarks.

2. THE INDUS BASIN AND ITS CLOSURE

The Indus basin covers an area of about 1, 140, 000 sq.km. A large part of the upper basin lies within the Hindu Kush, Karakorum, and Himalayan mountains. Afghanistan, China, India and Pakistan share the basin territory. Snow and glacial melt contribute more than half of the annual average flow of the Indus River and its tributaries (ICIMOD, 2010). Major tributaries of the Indus River include Jhelum, Chenab, Kabul, Gomal Ravi and Sutlej rives (Figure-1). Most of the water resources are shared between two nations Pakistan and India while with in Pakistan Indus water is shared among four Provinces (Punjab, Sindh, Khyber Pakhtunkhwa and Baluchistan).

The climate of the Indus plains is arid to semi arid yet all rivers are naturally perennial. About 85% of the primary water resources of Pakistan, constituted by river inflow and precipitation, are limited to four months of the Kharif season, from May to August. The average annual river inflows amount to 147 MAF (Saifal, 2009). The rainfall in the basin varies from 1200 mm to 100 mm from north to south with an average of 238 mm (GOP, 2002). The Indus Basin is formed by alluvial deposits carried by the Indus and its tributaries and is underlain by an unconfined aquifer covering about 15 million acres (6 million ha) in surface area. In the Punjab about 79% of the area and in Sindh about 28% of the area is underlain by fresh groundwater with an estimated total recharge ranging 45.58 MAF (WAPDA, 1990) to 50.47 MAF (NESPAK, 1991). The average safe yield is estimated 53.3 MAF (Associated Consulting Engineers and Halcrow, 2001).

Figure-1. Indus river basin (major rivers, reservoirs and barrages).

Pakistan's agricultural sector is dominant in the economy of Pakistan. About 85% of all cereal grain production (mainly rice and wheat), all sugar production and most of the cotton production are contributed by irrigated land. The sector provides around 45% of the total labour force of the country whilst 67% of population in rural areas depends directly or indirectly on agriculture for their livelihoods. Textiles comprise 64% and food products 11% of total Pakistani exports, both are wholly dependent on agriculture. The connection between water resources, through irrigation demand, to the economic wellbeing of the state is hence established (Archer *et al*., 2010). From 1950 to 1980, Pakistan's population grew to double (40 to 80 million) and to an estimated total of 173 million in 2010 (UN, 2011). Groundwater is main sources of drinking water for most people in rural and urban Pakistan except Karachi and Islamabad depend largely on surface water sources.

The Indus Rivers inflows had a major decline from an average of 150 MAF during 1962-1967 (pre Mangla Dam) to an average of 115 MAF during a dry spell of 2000-04 (Saifal, 2009). Mean while there is also an alarming reduction of outflows towards Arabian Sea from Kotri barrage (Figures 2 and 3) from 138 MAF in 1960 to almost zero in 2000-01 (0.79 MAF) and 2004-05 (0.28 MAF) indicating major sign of Indus Basin river closure. There was even no flow during Rabi season and the number of the days reached to more than 250 days (Inam *et al*., 2004; Inam *et al*., 2007). The Indus Basin is closed for six to eight months during a year. The high outflows observed in 2005-2008 (20 MAF/year on average) demonstrate that Indus basin is in transition where droughts exaggerate the interconnectedness of water users and direct to water shortage at downstream.

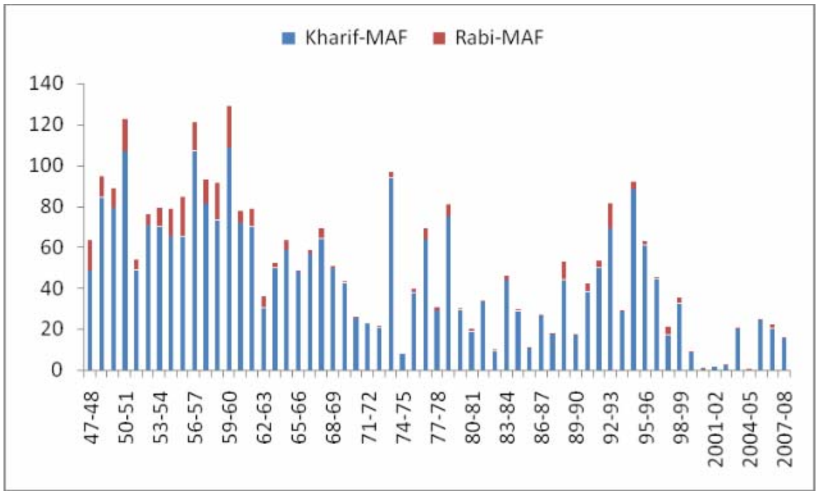


Figure-2. Seasonal outflow from Korti Barrage (1947-2008).

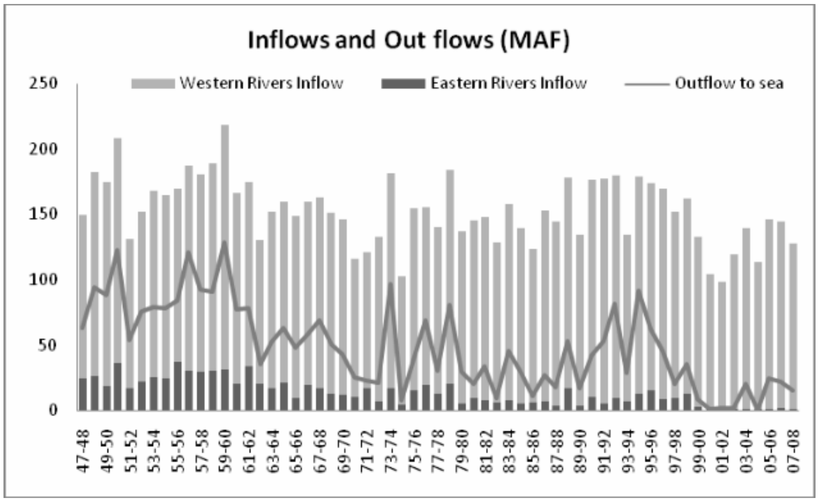


Figure-3. Rivers inflow and outflows, ssource data: WAPDA.

According to Molden *et al.*, (2001) Indus basin is closing as more water depletion takes place through evaporation process than the gross inflow. The additional water depletion beyond gross inflow is derived from groundwater storage with zero useable outflows and a narrow prospect to deplete more water within basin. In severe case of overdraft (but undoubtedly if this imbalance in inflow and outflow continues) this unsustainable patterns water depletion will lead permanent closure. This might be an indication of the prospect defining management intervention for sustainable water use at the basin level. This involves discovering the spatial and chronological dynamics of water use and understanding the drivers of the closure of Indus Basin.

3. A JOURNEY TOWARDS CLOSURE

The record of water development extends back six millennia through the Harappan period. Indus Basin irrigation system was initiated in the middle of nineteenth centuries with a weir control canal across the Bari Doab (land between Ravi and Beas rivers) in the Punjab (Ahmad, 1993). The motives to carry out the expensive civil works of irrigation systems in Indus Basin by the colonial administration (1850s-1947) include famine prevention, increase state tax revenues by introducing cash crops specially cotton, promotion of new layers of local elites that followed the development of the irrigation system (Gilmartin, 1995; Whitcombe, 1995).

Despite distressed post-independence era, irrigation development policy in subcontinent illustrated a strong permanence with the colonial period and had parallel proclaimed objective complementarities and contradiction (Venot *et al*., 2007) but Pakistan mainly relied over foreign assistance as compared to India (Michel, 1967). The conflicts between two nations over eastern rivers water urged Pakistan to accelerate development process and complete on going British projects. In 1950's irrigation system of Pakistan consisted of 10 barrages and 35000 miles of canal mostly inherited. The settlement of the water issues with help of World Bank resulted in Indus Water treaty in 1960. A massive irrigation river link canal scheme (construction of 2 large reservoirs, many barrages, major link canals and remodeling and modernizing of existing infrastructure) was undertaken under the slogan of Integrated Indus Basin development. By 1980s, The Indus Basin irrigation System is now comprised of three major reservoirs, 19 barrages, 2 head-works, 2 siphons across major rivers, 12 inter river link canals, 45 canal systems and more than 107,000 water courses. The aggregate length of the canals is 60,376 km. In order to boost food production to meet the needs of the rapidly increasing population and secondary to achieve economic stability and wish to control over people's hearts and resources which increased the pressure on the managers, administrative and politician of Pakistan to adopt available of innovative technology, in order to make it possible to maximize the exploitation of natural resources to their full utilization (Kahlown and Majeed, 2004).

At the end of the 1980s improved management and efficiency of existing irrigation systems with reference to environmental attracted more attention in Indus basin (Wescoat *et al*., 2000) and the tempo of extensive infrastructure development was slowed down slightly. However, local private or community initiatives sustained to be profoundly promoted all over South Asia (Barker and Molle, 2004) with no exception for Indus Basin. A silent revolution (Molle *et al*., 2004), of scattered irrigated plots through accessibility of private pumps and shallow tube wells persistent by the price incentive and enhanced power generation during 1980s and while during 1990 the withdrawals of the subsidies and increased charge of electricity gave initiative to farmers to install diesel tube wells (Randhawa, 2002). In 2000, the numbers of tube wells in the Indus basin were 560,000 but at present near about one million tube wells have been installed (Nadeem, 2010). This colossal anarchy negatively influences the environment in terms of aquifer depletion and surface runoff reduction (Mukherji and Shah, 2002). In first decade of 21st century, rehabilitation projects of the exiting infrastructure got attention like Mangla Raising project and barrages rehabilitation in Sindh. The international donors especially World Bank diverted its attention towards institutional development rather than investment in developing infrastructure.

Total storage capacity in large reservoirs of the Indus basin reached about 15.7 MAF near about 11% of the River flows but now it has run out to 12.7 MAF in 2001. The volume of regulated water through canal diversions is higher than the 70% of total average rivers inflows. Gigantic construction of irrigation network provoked a growing weight of the agricultural sector as a whole. National programs for improvements of seeds, fertilizer, pesticides, processing and marketing were set off. Agriculture progressively became more of a commercial, market-oriented undertaking and farmers became production oriented (Jurriens *et al*., 1996). Marketable crops like rice, sugarcane and cotton became more widespread (Aslam and Prathapar, 2006). Consequently, the total cropped area in Pakistan increased from 11.6 to 23 Mha from 1947 to 2008 while irrigated area increased more than double from 8.5 to 19.27 Mha. Share of irrigated area in Total cultivated area increased from 61 to 81%. The land use intensified from 62 to 71 percent. Irrigation intensity for the Indus basin/Pakistan, it has upward gradual trends from 61 to 81 per cent. The cropping intensity in the Indus basin has increased from 81 to almost 100 percent indicating that almost all of the cultivated area is now cropped in a year (Khan, 2006). Cultivation in dry period became frequent due to irrigation expansion. In the early years of the twenty-first century, about 50% of the irrigated area was irrigated by groundwater versus 10% in 1960: Indus Basin waterscape is under alteration with groundwater becoming one of the main sources of water supply for farmers. In an environment of basin closure, this move towards further local influenced patterns of water use, spatially re-allocates water from downstream regions to upstream regions, and might inflame more disagreements and water management concerns.

3.1 A water use-scape in the Indus basin

Figure-4 shows that the gross inflow in the basin is about 201 MAF (River inflows 133 MAF, un-gauged tributaries 7 MAF, Rainfall 61 MAF). The groundwater pumping accounts for 41.6 MAF (while actual recharge is 42.6 MAF) near about 90% taking place in Punjab. Out of these gross inflows about 107 MAF (50% Punjab, 46% Sindh and Balochistan, and 4% NWFP) is available for canal diversions. Through Kotri barrage about 29 MAF of water was released as outflow to sea. The crop water requirements in Indus basin estimated is 109 MAF (74% for canal command area while 24% outside canal command (7.94 mha sailaba and rain fed area). Net beneficial evapotranspiration from irrigated agriculture is 98 MAF (64% in Punjab, 31% in Sindh and Baluchistan, 5% in NWFP). Non-beneficial evapo-transpiration is computed 68 MAF (54% from conveyance and water user process in agriculture, 26% from water logged areas and 20% from outside water use processes evaporation from rainfall). Highest conveyance and process use in Punjab losses while about 86% evaporation from water logged area occur in Sindh. According to Eastham *et al*., (2008), current waterscape in Indus basin is dominated by irrigated agriculture in the lower catchments of the Indus Plains, as irrigated water use ranges from 50% to 80%. Rain fed agriculture is the major water use in only the Kalabagh where its depletion is 22%. The woodland + other land depletion is significant in the lower Indus basin (16%). The municipal and industrial uses are usually fulfilled from Groundwater abstraction or from irrigation network.

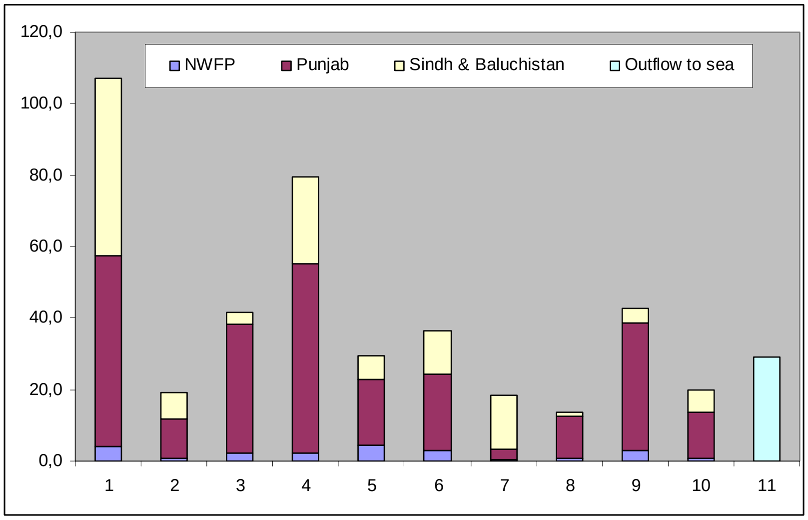


Figure-4. 1. Canal diversion; 2. River and link canal losses; 3. Gross pumpage; 4. Crop water requirement canal command; 5. CWR rain fed; 6. Non-beneficial Evapotranspiration on farm; 7. Water-logged area evaporation; 8. Evaporation rainfall; 9. Actual recharge; 10. Drainage.

The simple water balances in Lower Indus basin Sindh (Table-1), show that there is substantial decrease in Indus river inflow at Guddu due to increased depletion of surface water in upstream. About 50 percent of the water in Sindh is depleted through beneficial Evapotranspiration by the crops in the irrigated area.

Table-1. Two periods water balance for lower Indus basin, source: saifal, 2009.

Period	1977-81	1996-2000
Inflow River at Guddu	95	81
Rainfall Basin	18.6	7.2
Total Inflow	113.6	88.2
Canal diversions	43.6	47.7
River and link canal losses	12.6	11.5
Net Pumping	1.02	2.64
Available recharge	30.5	30.9
Evaporation from river, irrigation network	8.6	7.6
Crop water Req.	28.1	29.8
Forest and Sailaba ET	9.7	9.93
ET free surface and water logged area	19.5	13
Drainage and other uses	8.5	6.1
Outflow to Sea	38.5	21.8
Water depleted in Sindh	75.1	66.4

Non-beneficial evaporation has decreased but remains still a prominent water depletion factor. By excluding other uses (e.g. municipal and Industrial uses), drainage factor is very small to check sea water intrusion. Progressive decreased inflows, increased depletion, decreased sub-surface drainage and outflow to sea indicate that Indus basin is swiftly moving towards its closure and lower Indus basin is under direct environmental and social threats.

3.2 Environment: Appearance of new large water users

Water and infrastructural development to fulfil mounting human consumptive uses has engaged with little consideration to availability and sustainability of renewable resources. This has resulted in considerable degradation of a range of ecosystems. Indus River has manifested a ray of bleak crisis especially in the arid regions of Sindh Province. The once-mighty Indus has shriveled to a canal, and in some areas turned into a little more than a puddle, downstream in Sindh. The environmental degradation has manifested itself by water logging and salinity, increasing pollution, disappearing mangroves and wetland desiccation (Kugelman and Hathaway, 2009; Ahmed, 2008; WCD,2000; Shah *et al*., 2007; IUCN, 2003; Memon, 2005; ADB, 2005; World bank, 2005; Inam *et al*., 2007; Brugere *et al*., 2007; WAP, 2000; HBP, 2000; Talpur, 2008). With increasing confirmation of the unsympathetic impacts of water and land degradation on people's livelihoods, environmental concerns are underway to gain vigour and the notion of environmental flows is ascertaining itself firmly and challenge the very concept of "surplus water" frequently called upon to rationalize new infrastructure. Environmental water quantified to preserve the ecosystems of the Indus basin in recent status would require an environmental flow allocation of about 25.6 MAF with an every 5 year flood release of 25 MAF (Chaudhry, 2010; Ahmed, 2008; González *et al*., 2005). Under such conditions, the rate of water resources commitment will be 95 to 99% leading to fully committed resources under average conditions.

4. DRIVERS TO INDUS RIVER BASIN CLOSURE

The major reasons that increased pressure on available water resources undergone by the Indus River basin during past years can be as follows:

There is considerable reduction in eastern rivers inflow (Figure-3) near about 25 MAF while 2 MAF for western (Habib, 2006) due to major construction in Indian part. Massive development through interlink canals in upper Indus plains to compensate this water deficiency has decreased water flows to lower Indus basin by 20 MAF (Saifal, 2009).

Due to fast industrialization and urbanization, the demand for domestic and industrial abstraction amounted to 9 MAF/yr (i.e., 6% of current withdrawals), against 2.5 MAF/yr in the early 1975s (FAO STAT). At time of water scarcity uses will be preferentially met by depriving water users in rural areas (Molle and Berkoff, 2006) and sharpen conflicts at the local level (see Mustafa, 2007; Gizewski and homer-Dixon, 1996). Finally, groundwater overexploitation and degradation is problematic for meeting the domestic water needs.

Irrigated agriculture is indeed one of the main activities responsible for the current dramatic over-depletion of surface water and the basin's aquifers. Now Agriculture is main user (more than 90% of withdrawals) of the country's scarce water resources. With completion of irrigation infrastructure and improved irrigation management efforts, the canal diversion in the Indus Basin mounted from 67 to 105 MAF an average (40% improvement during Kharif and double in Rabi season) (Haq *et al*., 2008). Water availability at farm head has increased to 60% in the nineties equitant to the water available at barrages for canal diversion. The water use in the non irrigated areas remains almost same but after the inception of the Tarbela dams the increased well irrigated area in Punjab. The crop water depletion has increased near about 60% during 1965-2000. The uncoordinated groundwater pumping and small scale irrigation in Indus basin in the same period has increased 5.5 fold especially in Punjab. This has led to decreasing base flows and aquifer overdraft that ground water balance once 20 MAF in 1965 has dropped to -15 MAF in 2000 (Habib, 2004). Table-2 shows the evolution of water uses in irrigated agriculture.

Table-2. Irrigated agriculture water use-scape, Sources: Habib, 2004.

Period	Total irrigated area Mha	Crop uses rain MAF	Ground water pumped CCA MAF	Canals head MAF	Net crop use MAF	Recharge MAF	GW balance MAF
1965	12.5	7.3	8.0	81.7	56.8	28.0	20.3
1975	13.6	10.4	14.4	79.4	65.2	33.3	19.5
1985	15.8	15.2	27.8	91.7	82.6	34.1	-0.9
1994	17.13	12.9	37.1	100.0	88.6	40.9	-0.4
2000	18.09	5.7	43.9	98.3	89.4	38.6	-14.6

The infrastructure development and changing agricultural environment induced demand from individual farmer who desire to cultivate high yielding verities and high delta crops over all area in both seasons instead of one and planned intensities. Table-3 shows that now rice is the principal water consumer by a sizeable margin, while sugarcane utilizes nearly as much water as cotton or wheat despite being cropped on a much smaller area (WWF, 2003). In the mean while, over-irrigation practices exaggerated the not only depletion of the non-beneficial depletion of the water at farm but also causing environmental hazard, inequities and managerial problems in Indus basin.

Pakistan is using more than 90 percent of its allocated water resources to support one of the lowest productivities in the world per unit of water (Kamal, 2009). The reasons for the over exploitation and degradation of water resources in Indus basin lie reflective in governance and institutional failures at all levels (World Bank, 1994, Brugere *et al*., 2007). The inconsistency of irrigation design parameter with agro-climatic environment despite the deceptive perception of equitable water distribution in an inter-connected irrigation system (Habib, 2004) and water scarcity was synthetically forced ''by design'' (Jurriens *et al*., 1996). The continuity of unhampered vice regal development and management (Mustafa, 1998), lack of accountability (World Bank, 2005), deficit investment in human and social welfare, weak institutional operational and structure of government had lead to inequitable development and ultimately to

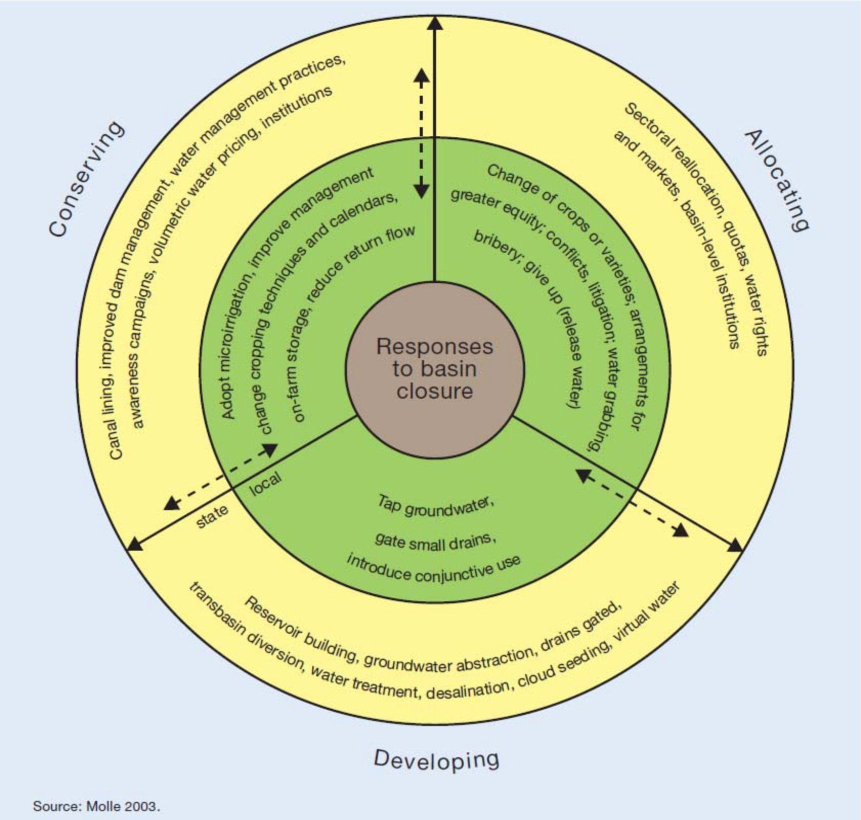
Structural scarcity and conflicts. This combination of forces encourages resource capture, the marginalization of the poor, rising economic hardship, and a progressive weakening of the state (Gizewski and Homer-Dixon, 1996).

Table-3. Water consumed by different crops in Indus basin source: WWF, 2003.

Crop	Area in hectares	M m3
Wheat	7,554,000	51,418
Cotton	2,955,000	51,427
Rice	2,419,000	70,508
Sugarcane	1,059,000	48,882

5. THE RESPONSES TO THE BASIN CLOSURE

Water challenges, in the form of scarcity, excess or pollution, can be responded to in many different ways. Although droughts seem to call for dams, floods for dikes and water pollution for treatment plants, response options are often much broader. Flood damage can be controlled locally by infrastructure (upstream dams, dikes, pumping stations) and also by more careful land-use planning (avoiding settlement in flood-prone areas), efficient flood warning, changes in upstream land cover, restoration of buffer areas, etc. The responses to basin closure can be categorized as developing, conserving and allocating (Figure-5). Conservation and allocation responses are often pooled together as demand management, which can be typified as “doing better with what we have,” as opposed to supply augmentation strategies (Molle, 2003).



Source: Molle 2003.

Figure-5. Responses to basin closure.

5.1 Development/supply augmentation options

The stage for the construction of the new mega projects was set during the planning of Indus basin water works. High silt load and declining storage anticipated called for replacement plan of Mangla and Terbela dam. The supply side imbalance implications (Kharif and Rabi season imbalance, multiyear imbalance and climate change imbalance i.e., drought and flooding) to meet burning issue of water requirement for agriculture, urban, environmental uses and energy and to deal with the limited number of days storage capacity are driving decision maker imperative to exploit remaining water resources by developing more infrastructure on Indus river basin. The ambition of the Indus basin managers with esteem to development of water resources are reflected in WAPDA’s Vision 2025. WAPDA is intended to undertake total storage capacity of about 65 MAF (80.2 BCM) and hydropower capacity of 23,000 MW. It also included construction of canals to increase irrigated area and drainage infrastructure to dispose effluent into sea over 25 years and beyond. At local level the sinking of tube well is still on boom. These efforts in basins will not only intensify the pressure on water resources but exacerbate the closing process. How much imperative are these storage projects are in Indus basin but their primary objective should be improvement of reliability of meeting existing demand for historically deprived environmental users and not for creating and serving new demands by curtailing existing downstream users (World Bank, 2005).

5.2 Conserving water by improved efficiency

In effectively "closed" basins, with no prospect of using extra water, there is a large prospect through closing the gap in agricultural productivity. There is need to realize the unexplored potential through better water management and innovative changes in policy and production techniques e.g. supplemental irrigation, resource conservation technologies, revitalization, improved irrigation systems and auxiliary storage (Sharma *et al*., 2009). The reduction of non-beneficial evapotranspiration through discouraging over irrigation wills most appropriate response. The adoption of these physical involvements on large scale through enabling policies has potential for sustainable production with less input. Installation of a good and reliable data communications network, maintenance, repairing, rehabilitation and modernizing of current irrigation infrastructure to reduce convenience losses (32-65%). Molden *et al*., (2001) revealed that real opportunity for significant water savings in Indus basin is limited because a high degree of beneficial depletion of the water resources is already taking place while water conserving and saving measures can lower the benefits in case the non-adopters and down stream users try to use all the saved water through area expansion and excessive irrigation leaving limited impact of irrigation efficiency on water availability and productivity of irrigated cropping in Indus Basin (Eastham *et al*., 2008).

5.3 Reallocation

In Indus basin there exists an already on going scientifically unplanned and unassisted reallocation as an alternative of the management to act in response to a changing demand. In Indus basin, despite a low overall production, a sustainability threat and a variety of inequalities in irrigated agriculture, there exists a scope for water reallocation and management without big physical interventions with physical capacity and flexibility, the river inflow available in Kharif, the present groundwater potential, the existing water demand and the modifications in the seasonal uniform targets, as anticipated by WAA are considered (Habib, 2004). A reallocation of surface water supplies between fresh groundwater areas with relatively low surface irrigation duties and fresh groundwater areas with high irrigation duties and saline groundwater areas, would set off a long way to cut groundwater mining in the former areas and to water logging in the latter areas (Ahmad and Kutcher, 1 992). There is a possibility that each province looks into authorized water allocations of various canal commands and reallocates water allowance based on evapotranspiration, cropping pattern, and cropping intensity to have sustainability on long-term basis. This will dramatically increase the economic productivity of water, both under the deficit and excess canal commands. Implementation of defined entitlements from national to farm level and, eventually and extension of the entitlement approach to cover both surface water and groundwater such a management system will help to reallocation from high value use, emergence of voluntary, and consensual approaches making reallocation both politically attractive and practical (World bank, 2005). The present pattern of water allocation, extracting water from nature to agriculture uses must be reversed (Molle *et al*., 2010) and definition and application of environmental flow is good starting point. This calls for the redesign and effective implementation of water accord (1991) allocations within the framework of the present Indus Basin River Authority.

6. CONCLUSIONS

Signs of basin closure and Over-commitment of water resources are manifest in dry periods in the Indus Basin. However, regardless of growing sectoral, regional and provincial tension, there is continuation of expanding irrigated agriculture sectors. This development trend cannot be sustained without re-distribution of water among sectors and regions and additional damage to the environment. The water availability is not only vital in explanation of the evolution of water use: with mounting burden on water resources, there is informal adjustment by the water users, adapting to water scarcity and its ill-effects on the basis of economic, sociopolitical, institutional factors. The basin closure magnifies the interconnectedness among water users and environment: local interventions are likely to have unanticipated aftermaths somewhere else in the basin. The implementation of demand management with a keen check on expansion of irrigated area can serve as better strategy. The supply augmentation ventures can open the basin but there is careful need for evaluation of their economic, social and ecological effects. To deal with the complexities that uncoordinated adaptive mechanisms could generate (contest among users, rent seeking, increasing disparity) and this obviously requires confining alternatives that safeguard a equilibrium among water use efficiency of scarce resources, equity and sustainability and for both human benefit and conservation of the environment. There is need to accomplish formal, efficient and adaptive allocation mechanisms that would based on sustainable river basin management that reconcile hydrologic and ecosystem complexity, uncoordinated development interventions, sociopolitical administrative fragmentation (Molle *et al*., 2007).

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