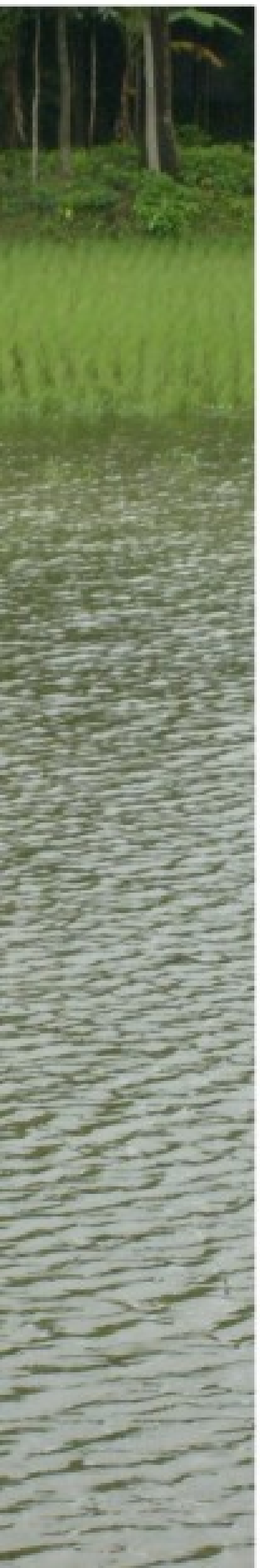
CPWF-IWMI Basin Focal Project for Indus-Gangetic Basin
Research Brief- Series I



# Water Resources of Indus-Gangetic Basin: Continuing Threats and Emerging Challenges

*Water resources in Indus-Gangetic basin serve as a powerful tool for development and for overcoming poverty in the region. Rapid agriculture expansion and subsequent utilization of available water resources of the basin has placed the basin at risk with water scarcity issues on one hand, and flooding problems on the other, the scales of which are further exacerbated by impacts of climate change. The transboundary nature of the basin adds more complexity to the water resource challenges confronted.*

## Water Rich or Water Scarce?

Indo-Gangetic basin region experiences two facets of water scarcity; regions with physical scarcity of water and those with an economic water scarcity. The total drainage area of 110 Mha in Indus basin contributes an average annual flow of upto 230 BCM (41 years average, 1957-1997). Even with this flow, Indus basin is faced with physical scarcity of water, with net runoff of only about 10% of total precipitation input and the rest appropriated by various uses of rainfed and irrigated agriculture, grasslands, domestic and industrial use. The basin also has a high level of groundwater use (105% developed). On the other hand, Gangetic basin having an average annual flow of upto 459 BCM (at Farakka barrage) is confronted with issues of economic water scarcity, where only 18% of the total resource is developed for irrigated agriculture due to inadequate human and financial capacity in the region. Increased efforts on development of unutilised surface and groundwater resources and a general improvement of the rural infrastructure can have a positive impact on agricultural productivity and poverty alleviation of Ganges basin. The scarcity issue becomes much more severe with the added impacts of climate change. A reduction in dry-season flows in the basin region is predicted by the retreat of glaciers and a reduction in snow cover in the Himalayas, the major contributor to the flows in Indus and Ganges.

Water resources development in the basin exhibits a stark contrast, with Western region having high levels of regional development, mainly attributed to infrastructure development in irrigation, which allowed maximum utilization of inputs. Indus basin houses the largest contiguous irrigation network in the world, the Indus Basin Irrigation System (IBIS), serving 17 Mha. The system diverts almost 75% of the annual river flows into the Indus basin. On the other hand, eastern IGB still have considerable undeveloped resource base and lack of infrastructure and enabling environment prevents this region from harnessing the true potential of the available

**Groundwater availability and its use in the Indus-Gangetic Basin**

| Basin Name | Groundwater Available (BCM) | Annual Groundwater Draft (BCM) | | | Stage of GW Development (%) |
|---|---|---|---|---|---|
| | | Irrigation | Domestic, Industrial & Other | Total | |
| **Ganga Basin** | | | | | |
| India | 168.7 | 94.4 | 8.2 | 102.4 | 61 |
| Nepal | 11.5 | 0.8 | 0.3 | 1.1 | 10 |
| Bangladesh | 64.6 | 25.2 | 4.1 | 29.3 | 45 |
| **Indus Basin** | | | | | |
| India | 30.2 | 36.4 | 1.6 | 38.0 | 126 |
| Pakistan | 55.1 | 46.2 | 5.1 | 51.3 | 93 |
| | 85.3 | 82.6 | 6.7 | 89.3 | 105 |

resources. Major challenge faced by water managers working in this region is to find suitable instruments to bridge this gap in development, possible to an extent by increasing the productivity of water and land. There is also a need to address the problem of generating political environment and regional cooperation among the basin countries conducive to such developmental activities. Targeting investment in the least developed areas of eastern IGB, where rural poverty is also at its highest, could offer the rural poor a way out of poverty.

## Growing Population and Urbanization: Drivers of Resource Degradation

With rapid population growth, water allocation among competing sectors remains a big challenge. The per capita water availability in the Indo-Gangetic basin under the projected water demand by 2025 is going to be reduced to the level that it will become a water stressed area In addition to the rise in water demand, land-use changes contributed by population growth is also adding to the pressure on water resources. Sub-basin scale analysis of Gorai-Madhumati sub-basin in Bangladesh has shown that outlet runoff is affected by land use within the catchment as well as the inflow coming from the Ganges.

Though Ganges basin is relatively underdeveloped with more than 40% of the total resources as net flows to the sea, the river in most part of its flows in the plains (downstream of Haridwar) is highly polluted in spite of it being declared as the National River of India and a much publicized Ganga Action Plan to reduce the pollution load in the river. Ganges and its tributary, Yamuna have turned into stinking sewers from industries and population on its banks. Studies show that 75% of the pollution in Ganges is from untreated municipal sewage, 88% of which is from 25 Class 1 towns situated on the banks of the river.

Quality degradation of groundwater is observed in Punjab, Sindh and Haryana states of Indus basin. Around 41% of the net draft in Punjab, Haryana, Rajasthan and Uttar Pradesh is predicted to be of marginal and poor quality. Almost 65% of the agricultural area of Haryana is confronted with groundwater quality problems; especially in central and western districts. A tremendous reduction in cereal yield could be the result of irrigation using marginal quality water. Studies have reported a 68% decrease in wheat yield in moderately saline land and 84% decrease in wheat yields in highly saline land.

Future pressure on water resources by urban and industrial uses advocates the need for suitable strategies to combat reduced water availability for irrigation based on whether the water available would be enough to grow enough food to meet the requirements of the population.

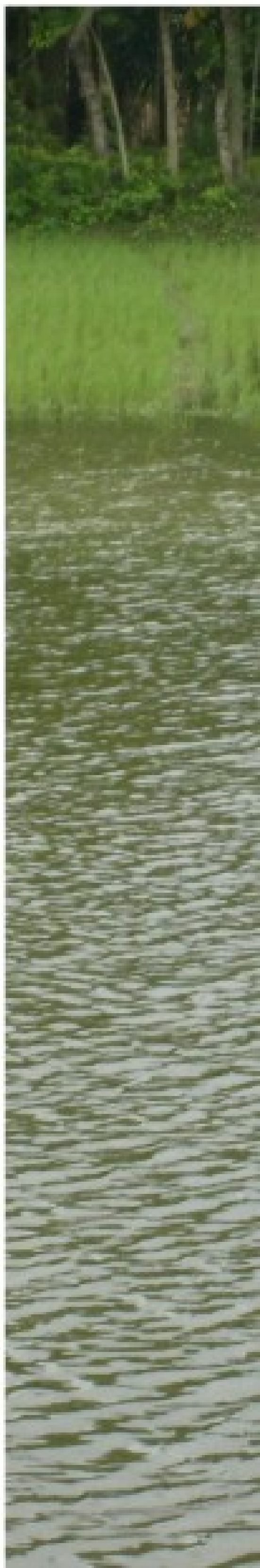
Over extraction of water for industrial and domestic purposes leave less flows available for environmental requirements. Intensified agriculture to feed the growing population steps up the use of chemical fertilizers, pesticides, herbicides etc. polluting much of the watercourses in the Ganges. This coupled with the alarming levels of industrial waste loads dumped to water bodies and sewage disposal in turn reduces the amount of utilizable flows. Challenges lie in checking sewage discharges from an ever-increasing population as well as effective implementation of policies to control industrial wastewater discharges.

**Total renewable water resources (TRWR) and per capita water resources in the Indus and Gangetic regions of India and Pakistan**

| IG Basins | TRWR ($km^3$) | Per capita water resources ($m^3$/person) | | | |
|---|---|---|---|---|---|
| | | 1990 | 2000 | 2025 | 2050 |
| Indus- India | 97 | 2487 | 2109 | 1590 | 1732 |
| Indus- Pakistan | 190 | 1713 | 1332 | 761 | 545 |
| Ganga - India | 663 | 1831 | 1490 | 969 | 773 |

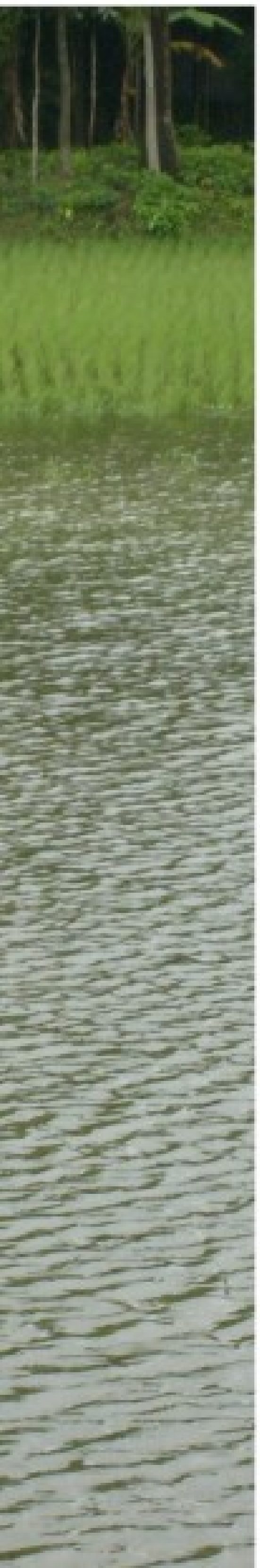
## Adding to the Threat: Climate Change Impacts

Water resources of IGB are at risk from changes in temperature, glacier retreat, floods and droughts and sea level rises. Predictions on alarming rate of retreat of glaciers, as for example the Gangotri glacier, signal the







| Country-wise climate risks for the Indus-Gangetic basin countries | | | | |
|---|---|---|---|---|
| **Climate risks** | **India** | **Pakistan** | **Nepal** | **Bangladesh** |
| Temperature rise | High | High | Very high | High |
| Glacier retreat | High | High | High | --- |
| Frequent floods | High | Low | High | Very high |
| Frequent droughts | High | High | High in some areas | High in some areas |
| Sea-level rise | Modest | Modest | --- | Very high |

*Adapted from Heatherman et al. (2009)*

reduction of river flows and their impact on food production. Average annual rate of retreat of Gangotri glacier, the source of Ganges, has increased from 14.6m during 1934-1976 to 35.4m during 1962-2000 (142% increase) and has retreated around 2 km since 1780.
In contrast, another study reports that glaciers in Central Karakoram, source of Indus river, is actually advancing, surveys done between 1997 and 2002 have shown 13 glaciers of intermediate size to be advancing.

The runoff potential of the Ganges and the Indus Rivers are on decline trajectory due to fast melting of the glaciers and ice and higher evaporative demands. Indus Basin Irrigation System (IBIS), relying heavily on summer flows contributed by winter snow and ice in Himalayas and Karakoram, will be faced with new challenges with the change in snow and ice potential.

Frequent droughts in dry western region and recurrent floods in eastern IGB, mostly in Bihar state of India and Bangladesh, cause huge economic losses, which gets much more severe with climate change. Studies suggest increase in the frequency and intensity of extreme events in most of the sub-basins of Ganga basin under the changed scenario. Farming systems and water use still has to find effective ways to adjust to such uncertainties in climate. Such adjustments has to be tapered to the regional needs as the level of adaptation needed for rural poor communities, especially in Bihar and Uttar Pradesh, to the impacts of climate change being different from those in urban settings. Technology aimed at developing and disseminating new varieties that can survive floods and drought spells are the need of the hour to build climate change adaptation.

## Concerns about the Role of Groundwater

The well-developed surface irrigation system in Indus basin does not deter it from being one of the biggest

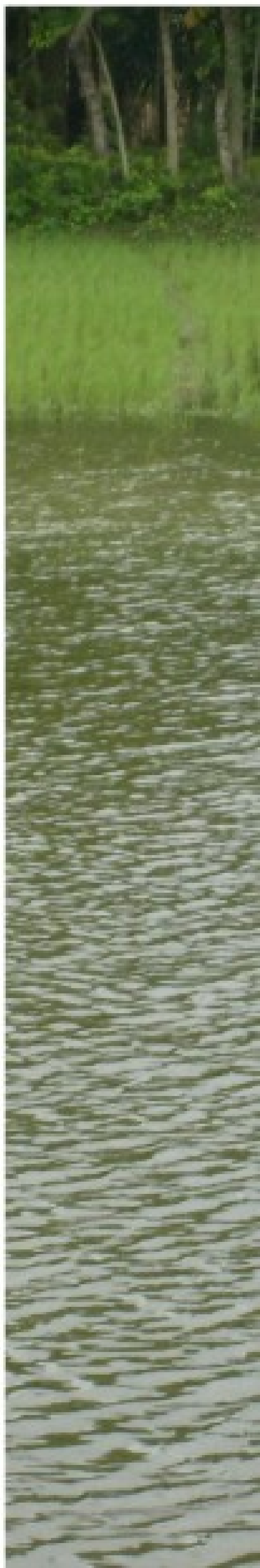
**The share of groundwater in the water footprint of IGB is considerably large and is increasing at a rapid pace.**

groundwater usage regions in the world. This is partly due to the aging and less actively managed canal irrigation systems. Over the last decade, share of area irrigated by groundwater has increased by 33% in IG basin countries. Continuous and increased agricultural groundwater extraction contributed much to the regional development of Punjab and Haryana in western IGB, but these came at a cost of environmental degradation in the form of depleting water levels. More than three fourth of Indian Punjab is experiencing issues on water table decline. On the other hand, seepage and percolation from canals leave Sindh and parts of Punjab provinces in Pakistan, with issues on waterlogging and salinity.

Eastern IGB has a rich endowment of groundwater resources, which is largely underdeveloped at present.

Lack of human, financial and political capital as well as poor infrastructure act as major impediments in groundwater development of the region. Presently, most of the poor farmers access groundwater through diesel-operated pumps, which are expensive to operate and manage. More than 50% of the farmers do not have their own pumps and depend upon alternate mechanisms to have access to the groundwater at a high cost. Large investment on rural electrification and devising of low-cost pumping technologies can help a long way in improving the current situation. Groundwater markets, with suitable pricing and contractual mechanisms, need to be established and encouraged to assure access to resource poor farmers.

Unsustainable levels of groundwater development in most areas of western IGB is favoured by inappropriate policy and energy subsidies, that often fail to regulate over-exploitation of this valuable resource. Politics play a substantial role in this and reforms aimed at eliminating subsidies would be politically difficult. Although regulations exist on limiting groundwater extraction from dark and grey zones, governance is not efficient enough for their effective implementation. The real challenge lies in defining a groundwater policy framework, which allows for its future sustainability, but at the same time acceptable to all the stakeholders. The framework should also be able to address the nexus existing between water, energy and food security in the basin. Policy-makers also need to understand and establish tradeoffs between sustainability and economic development.



## Publications:


1. Khan, Abdul Hakeem; Peter McCornick; Asim Rauf Khan. 2008. Evolution of managing water for agriculture in the Indus River Basin. Proceedings 2 International Forum on Water and Food, (Volume-III), Addis Ababa, November 10- 14, 2008, CPWF, Colombo. Pp120-123.
2. Sharma, Bharat R., Devesh Sharma. 2008. Impact of climate change on water resources and glacier melt and potential adaptations for Indian agriculture. Proceedings 33rd IAUA VCs Annual Convention on "Climate Change and its Effect on Agriculture", December 4-5, 2008; Anand Agricultural University, Anand, India pp. 86-101.
3. Qureshi, A.S., P G McCornick, A.Sarwar. B.R. Sharma. 2009.Challenges and prospects of sustainable groundwater management in the Indus Basin, Pakistan. Water Resources Management (Springer). 19 pp.
4. Scott, C. A., B. R. Sharma. 2009. Energy supply and expansion of groundwater irrigation in the Indus-Ganges Basin. Intl. J. River Basin Management, 7(1): 1-6.
5. Hosterman, H R., PG McCornick, EJ Kistin, A.Pant, B R Sharma, L. Bharati. 2009. Water and climate change adaptation: Focus on the Ganges- Brahmaputra river system. Duke University-IWMI Working Paper (09-03), 34 pp. Available at: www.nicholas.duke.edu/institute/ni.wp.09.03.pdf
6. Sharma, B.R., G.Ambili. 2009. Impact of climate change on water resources and potential adaptations for agriculture in the Indus-Gangetic basin. Paper accepted for ICID/ 5th Asia Regional Conference, New Delhi, India, 6-11 December, 2009.
7. de Condappa, D., L. Bharati, B.R. Sharma.2009. Assessment and planning of water resources of the Indo-Ganges with Water Evaluation and Planning (WEAP) model: Current situation and possible scenarios. IWMI Research Report ( in progress).
8. Sharma, B.R.; G.Ambili.2009. Water resources and hydro-geology of the Indus-Gangetic basin: Comparative analysis of issues and opportunities. Review paper accepted for publication, 41 pages



This note forms part of the Challenge Program on Water and Food (CPWF) sponsored Basin Focal Project for the Indus-Gangetic Basin (BFP-IGB). For detailed project report, log on to http://bfp-indogangetic.iwmi.org:8080 or write to:



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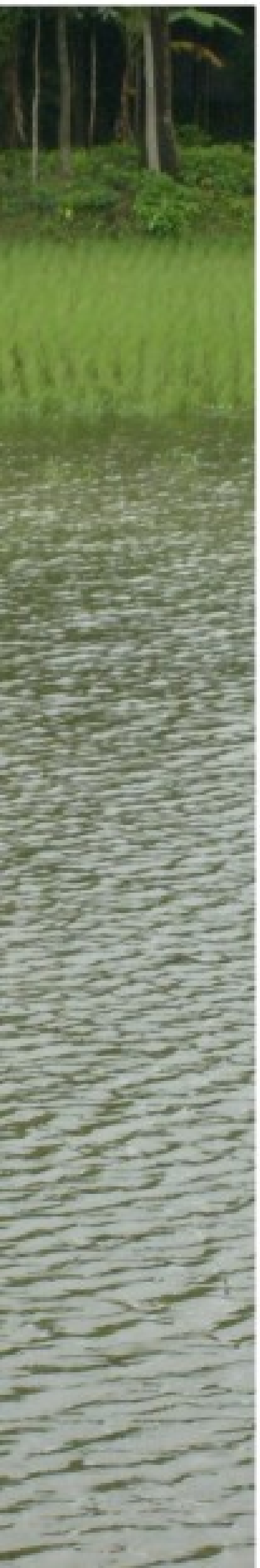

# Where the Potential Lies? Disparities in Water Productivity across Indus-Gangetic Basin

*Will there be enough water to grow enough food? Lack of water or access to water has emerged as a serious constraint to producing food for hundreds of millions of people. Irrigation is a critical factor in agricultural productivity in the Indus and Ganges basins. The increasing food demand and decreasing water allocation suggest that the agricultural sector has to produce more food with less water, that is, agricultural water productivity has to be increased.*

## Remote Sensing and Census based Assessment and Scope for Improvement of Rice and Wheat Water productivity in the Indo-Gangetic Basin

Traditional methods of water productivity assessment at field/ farm or small regional level have limited use in proper understanding and making basin level recommendations. This Project developed an innovative methodology by integrating the different interactive factors, which has the capability to estimate land and water productivity both at the pixel and basin and the intermediate levels. Water use, crop dominance, actual ET, yield and crop water productivity for rice-wheat cropping system of Indus-Gangetic basin was assessed by combining meteorological data, ground survey, national census with remotely sensed imagery.

### *Yield Maps:*

- The average rice yields for IGB Pakistan, India, Nepal and Bangladesh parts are 2.6, 2.53, 3.54 and 2.75 t/ha respectively.
- The "bright spot" in Indian Punjab state with some adjacent areas from Haryana and Rajasthan states has an average yield of 6.18 t/ha, which is significantly greater than most of other areas within the basin. There are small areas of very high productivity in Mechi district of Nepal and Rajshahi district of Bangladesh.
- The "hot spots" of low yield rice is found in Indian Madhya Pradesh, Rajasthan, Bihar States and Bangladesh Dhaka Division with average yield of 1.18, 1.49, 2.04 and 1.97 t/ha respectively.
- The "bright spots" of wheat productivity is found in Punjab and Haryana states in India whereas the "hot spots" were found in Madhya Pradesh, Bihar states of India and parts of Khulna and Dhaka province in Bangladesh.

### *ET Maps:*

- The seasonal average paddy rice ETa from June 10 – October 15, 2005 is 368 mm, ranging from 147 to 536 mm with standard deviation of 92.6 mm. The average ET for non-rice cropland of the same period is 305 mm, with a slightly higher standard deviation of 99.4 mm. These values are much lower than the potential ET of the crop indicating water deficit in different regions during the crop growth.
- The average wheat evapotranspiration over the averaged wheat growth period from November 24, 2005 to April 14, 2006 is 210 mm with standard deviation of 61 mm.

### *Water productivity (WP) maps:*

- Average rice water productivity in the basin is 0.84 $kg/m^3$, with minimum, maximum and standard deviation values of 0.2, 2.04, and 0.372 $kg/m^3$ respectively.
- The Indian Punjab and adjoining areas, covering 6% of total rice area, have very high rice water productivity with an average value of 1.51 $kg/m^3$.
- As much as 19% of total rice areas have WP less than 0.5 $kg/m^3$, which occur mainly in Indian Madhya Pradesh, Bihar States and Bangladesh Dhaka Division.
- A high rice WP strip, around 10 – 70 km in width, starts from 75.5°N (longitude), 29°E (latitude) in southern Haryana State and goes towards the east till the Southern Bihar State, India (85.2°N (longitude), 24°E (latitude)). The yield for this area is relatively low with an average value of 3.2 t/ha.
- The Bihar State in India has the largest areas with lowest WP.
- The average wheat WP is 1.36 $kg/m^3$ with standard variation of 0.66 $kg/m^3$. Due to the extremely low ET

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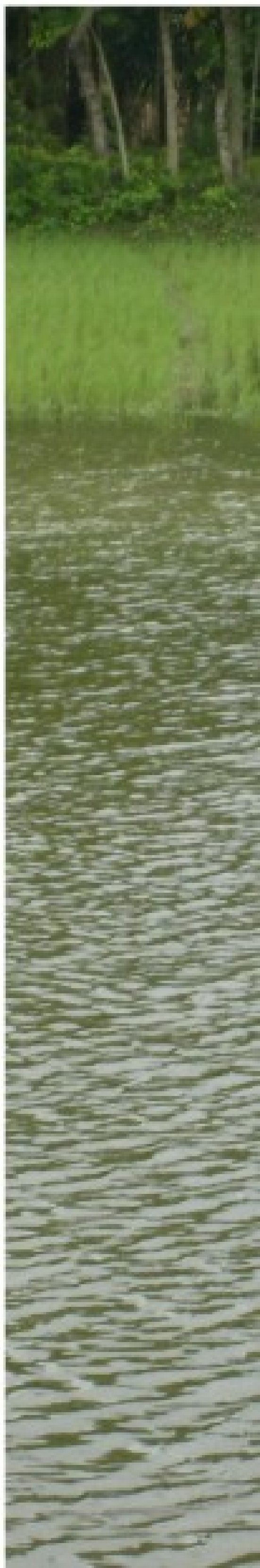
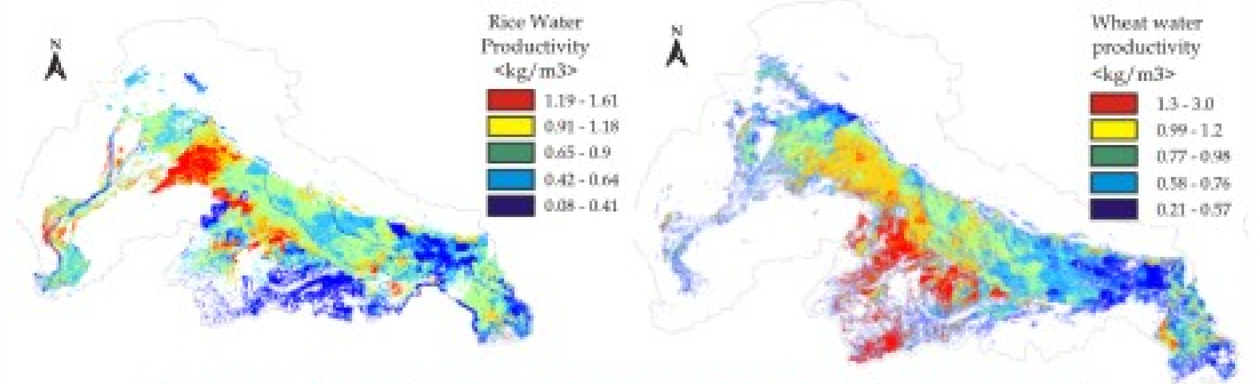




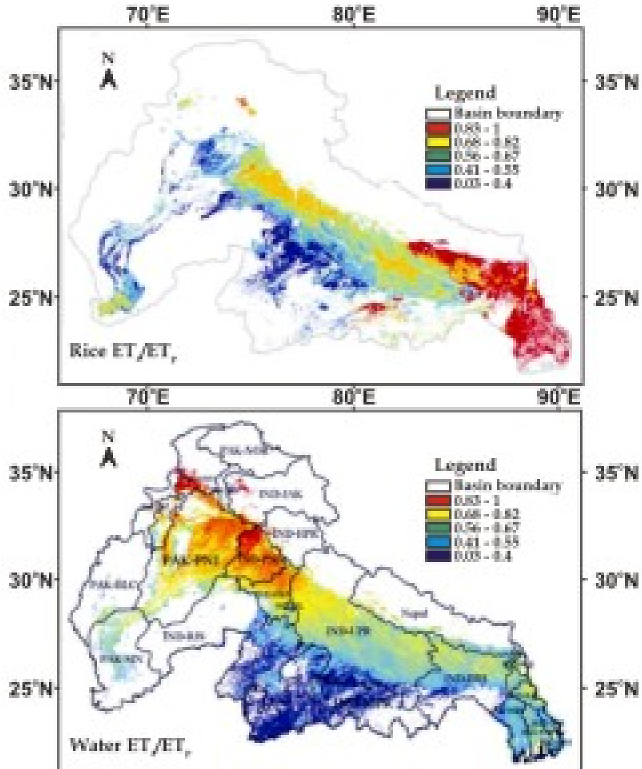

**Water productivity of rice and wheat in IGB for year 2005—2006.**

in the Indian Rajasthan and Madhya Pradesh states, water productivity in these areas showed higher values despite low yield.

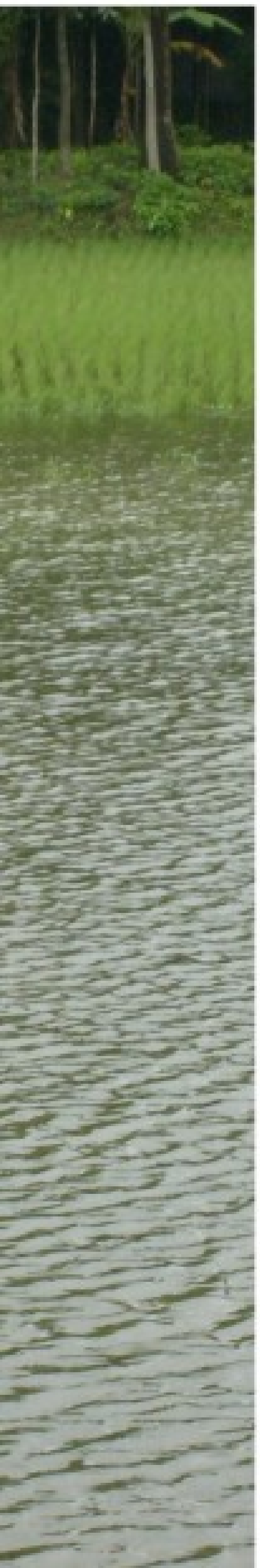
## Scope for WP improvement

Rice and wheat water use and water productivity are relatively low with tremendous variation in Indus-Gangetic River Basin, which indicates significant scope for improvement. The inconsistent yield and WP distribution against rainfall shows that the main constraint is not water availability, but the timing of water supply and others on farm management. Well-developed irrigation and drainage system together with matching management practices can help to maximize utilization of rainfall and achieve high yield and water productivity. Other land and crop interventions, e.g., levelling, insects and disease control, fertilizer, variety, are also important factors to be considered along with water management. Besides the variation in crop to be irrigated, the source of irrigation water also has major role for conserving/ saving water and thus improve the water productivity. Generally, irrigation with groundwater was found to be more efficient due to better control over the amount and timing and manageable flows. Surveys and analyses conducted in Punjab showed that the yields were lowest for farmers using only canal water for both paddy and wheat and farmers with conjunctive use of both canal and well water got higher yields

The bright spot in Indian Punjab State and adjacent areas, with 5% of basin rice and wheat cropping area, has




**Rice and wheat $ET_a$ to $ET_p$ ratio is higher in high rainfall areas.**

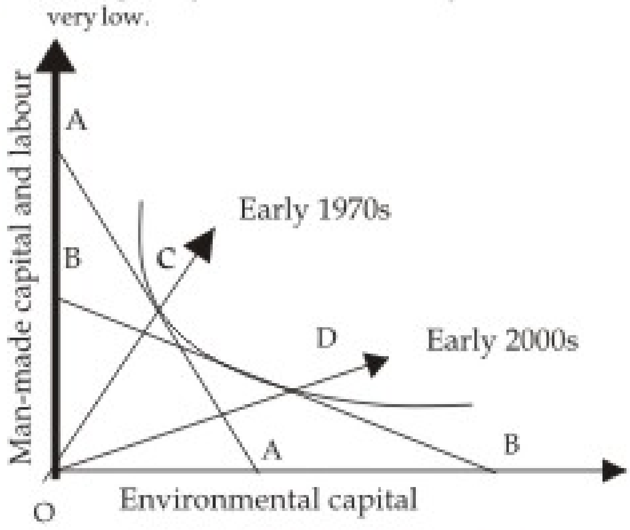


high WP of 0.433 US$/$m^3$. If the basin average value of 0.302 US$/$m^3$ could be increased to the same as in bright spots, the basin could then theoretically save 30% of agricultural water consumption with same quantity of production or increase 30% of production with same quantum of water input. Although this is limited by many constraining factors, a small increase in WP still has a lot of potential to ensure regional food security.

## Spatio-temporal analysis of district level rice water productivity in Bangladesh

A case study employing time series (37 years) of water productivity, both average and marginal, was conducted at a disaggregated (district) level for Bangladesh.

- The analysis found a very high level of inter-district variability in rice productivity, which was explained by hydro-climatic, technological diffusion and agricultural intensification factors.
- Location of the districts in the Ganges basin and the prevailing policy regime also helped in higher productivity.
- Interestingly, the WP has improved historically indicating farmers are producing more rice with the same quantity of water, but still the yields levels are very low.



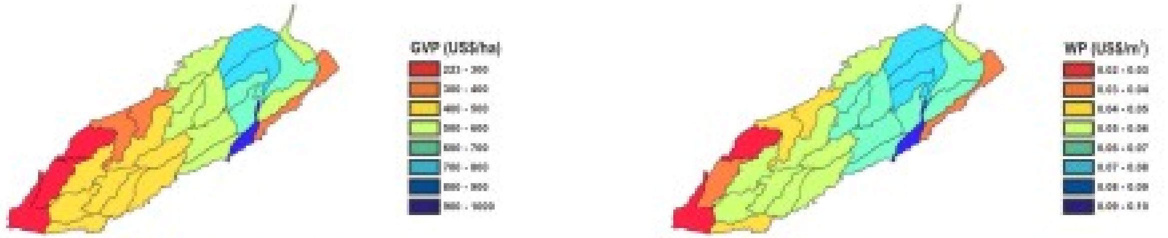

*In current scenario, Bangladesh rice production is more environment - intensive given the high propensity to treat environment (groundwater) as a non-scarce or abundant factor or worse still as a 'free gift' of nature*

- Bangladesh needs to achieve internal water augmentation to enhance and sustain land and water productivity which needs to be supported by both market-based and non-market based and institutional policy support.

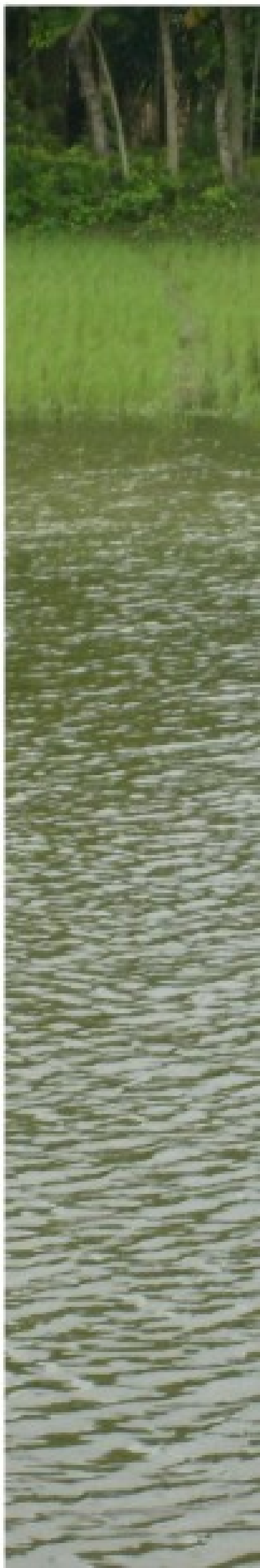
## Water productivity in Rechna-Doab in Pakistan

The performance of Upper Indus Basin Irrigation System was evaluated by the application of surface energy balance techniques using remotely sensed data.

- The water productivity in Rabi is high and relatively less variable than Kharif values across Rechna Doab (due to low evaporative demand in Rabi (winter season) and efficient use of limited canal supplies in marginal to poor groundwater quality areas as well as to the government policy of support price of wheat, which is the major Rabi crop.
- The annual values of sub-divisional water productivity are found to be high in subdivisions with good groundwater quality areas (mostly in upper Rechna) and with adequate and reliable water supplies. The highest water productivity was found in Sikhanwala subdivision, which is attributed to high value fruit, vegetable cultivation, highest cropping (199%) and access to markets in Lahore city.
- The highest annual water consumption is seen in the upper and upper-middle reaches of the Doab, where both surface and ground water supply are plentiful, and rice and sugarcane are grown as summer/annual cash crops.
- Water productivity, in terms of GVP per cubic meter of ETa are found to be generally higher for subdivisions with good quality water, but exceptions are there as in case of Dhular and Sultanpur.
- Although the gross margin for wheat is relatively low, especially compared to rice and sugarcane, the average winter water productivity is high for three reasons: low water consumption, judicious use of groundwater, and expanded areas compared to Kharif, resulting from a combination of the first two factors.




**Spatial variation on subdivision level gross value of production (GVP) and water productivity in Rechna Doab.**



## Publications:


1. Ahmad, Mobin-Ud Din, Nilantha Gamage. 2008. Monitoring Agricultural Water Consumption and Irrigation Performance Using Freely Available Modis Images for a Large Irrigation System in Pakistan. Proceedings 2 International Forum on Water and Food, (Volume-I), Addis Ababa, November 10-14, 2008, CPWF, Colombo. Pp123-126.
2. Ahmad, M.D., H. Turral, A. Nazeer 2009. Diagnosing irrigation performance and water productivity through satellite remote sensing and secondary data in a large irrigation system of Pakistan. Agricultural Water Management 96:551-564.
3. Ahmad, M.D., H. Turral, A. Nazeer, A. Hussain 2009. Satellite based assessment of agricultural water consumption, irrigation performance and water productivity in a large irrigation system of Pakistan. In Thenkabail, P.; Lyon, J.G., Turral, H.; Biradar, C. (Eds.), Remote Sensing of Global Croplands for Food Security. Remote Sensing Applications Series, Taylor and Francis Series in Remote Sensing Applications, CRC Press.
4. Cai, X.L.; B.R. Sharma. 2009. Integrating remote sensing, census and weather data for an assessment of rice yield, water consumption and water productivity in the Indo-Gangetic river basin. Agricultural Water Management (Elsevier). Doi:10.1016/j.agwat.2009.09.021., 8 pages.
5. Cai, X.L., Bharat Sharma.2009. Remote sensing and census based assessment and scope for improvement of rice and wheat water productivity in the Indo-Gangetic basin. Science in China Series E: Technological Sciences( Springer): 52(11):1-9.
6. Xueliang Cai, Bharat R. Sharma, Matin Mir Abdul, Devesh Sharma, Gunasinghe Sarath. 2009. An assessment of agricultural water productivity in the Indo-Gangetic River basin: Current status and scope for improvement. IWMI Research Report (Draft).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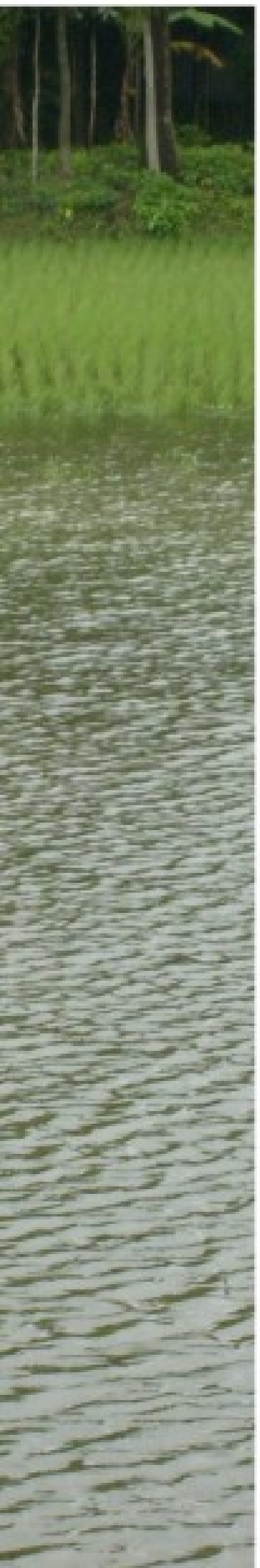


# Policy and Institutions Analysis for the Indus-Gangetic Basin

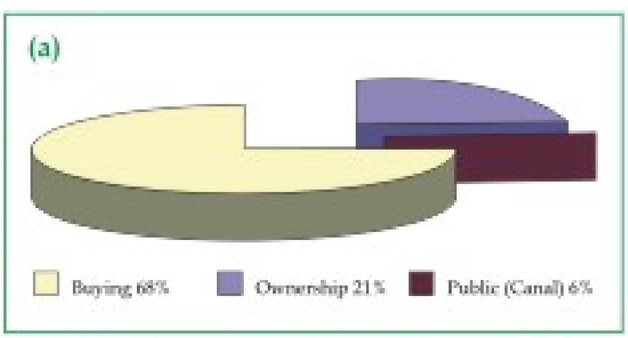
*Water management at the river basin level has undergone several shifts in paradigm over the last several decades, from largely ignoring the hydrological aspects of a river basin and resorting to interbasin transfers on the one hand, to emphasizing the interconnectedness of unique ecological systems and encouraging an integrated approach to planning, on the other. River basin organizations support the integrated physical and technical management of water resources and, if developed adequately, can respond to the growing competition for water among agricultural, industrial, urban and instream uses within basins. However, the Indus-Gangetic basin in South Asia presents very complex management challenges. The geographic and geopolitical challenges of Indian and the neighbouring riparian countries generally do not favour integrated hydrologic perspective. The reasons include a short but intense monsoon season of water availability followed by a long rainless period (instead of steady river flows), and significant decentralized rainwater harvesting in many parts of the basin unrelated to the holistic basin perspective. The basin is also unique in its large-scale dependence on groundwater usage, which is equally seen as seemingly unrelated to the basin perspective. Water resource legislations in the basin countries are also not very effective and conducive to integrated basin management. The more demanding and complex functions related to conservation of water and improvement of water productivity, allocation of water among the competing sectors, integrating environmental and social concerns related to the resources, ensuring equity to access and compensating for losing access or relocating are inadequately addressed.*

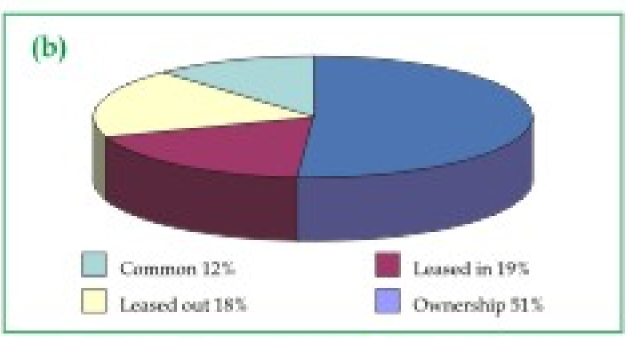
The Basin-Focal Project for the Indus-Gangetic Basin (BBFP-IGB) adopted a broad view of "institutions" to encompass water-related policies, laws and administrative structures but also informal water institutions such as water user organizations, water markets and civil society organizations working in the water resource sector. Both sector specific and basin wide policy and governance analysis were done on some of the relevant themes.

## Water Control and Land-lease Markets in IG basin

Primary surveys conducted at the representative sites in the IG basin indicated that the property rights of the land are quite variable in these countries where farmers own only about 50 to 75% of the holdings and the rest of the land is either 'leased- in' /' leased-out ' or form part of the common property resources. Ownership of land was only 51% in India (Bihar), 79% in Pakistan (Punjab) and 77% in Nepal. About 20 % of the land holding was leased-in by the farmers in all the three countries. Leased-out land was 18% in India and only 0.5% in Pakistan and 1.28% in Nepal. Common property lands were about 12% in India and practically absent in Pakistan and Nepal.

In the eastern Ganges basin, the access to water resources is also very poor and about 68% of the farmers with smallholdings purchased water from the




Water resources property rights (a) and land property rights (b) in Bihar, India (IGB)

neighbouring farmers with tubewell ownership. Situation is quite similar in Ganges part of Bangladesh but much different in the Indus basin where most farmers have the ownership of land and water resources. In Nepal, mainly three forms of tenancy practices were found in the studied area: mortgage, share crop and contract (Hunda in terai). Irrigation is the major determinant in all the studied areas for leasehold in terms of lessee's preference and the rent it commands. Irrigation availability found to be a must incase of contract farming in all the studied areas. Electric operated shallow tubewell irrigated land is preferred by the contractor for lease than the surface and diesel operated shallow tubewell. It shows that both the availability of assured irrigation and cost effectiveness is the first priority of the lessee.

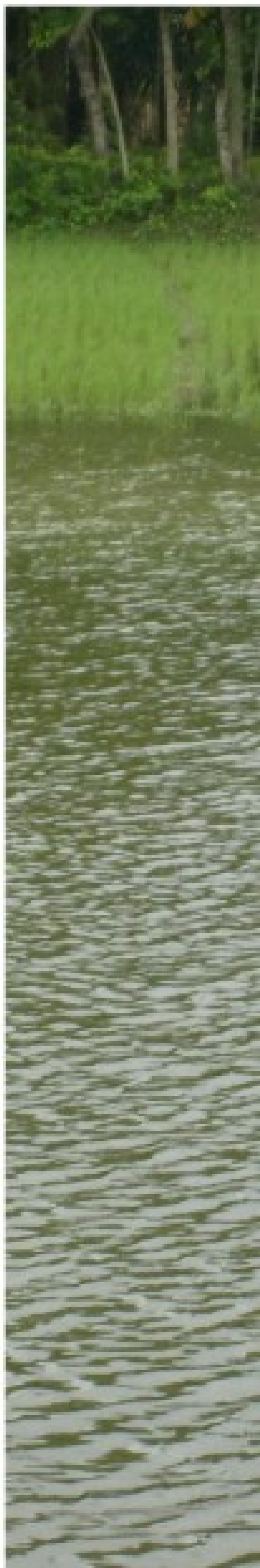
## Evolution of Water Sector Policies and Laws in the Indus-Gangetic Basin – Drivers and Trends

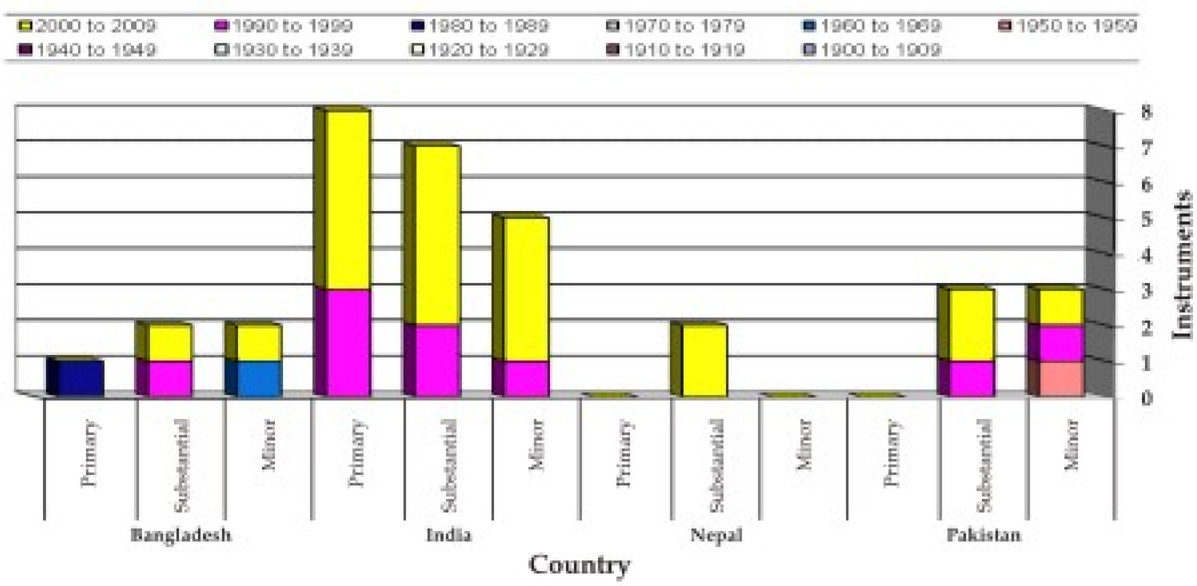
The IG basin countries (India, Pakistan, Nepal and Bangladesh) have witnessed an exponential growth in policymaking and legislation in the recent past, with a significant increase in activity from the 1990s to date. The progression of policy and legal frameworks has witnessed a shift in focus from water development (up to the 1970s) to water management and water governance. There has been change in priorities from hydropower generation to irrigation and drainage and then to integrated water resources management, participatory irrigation management and more recently to groundwater governance and management.

There has been a general increase in attention to groundwater across the IGB since the 1990s; the most evident feature is the rise of groundwater as a key consideration in India both at the federal and the state levels. It is also noteworthy that groundwater featured in 20 of the 25 instruments assessed for India for the 1990-2009 period, with 15 classified as having either a primary or substantial focus on groundwater. But the relevant instruments identified a substantial degree of similarity in content (and language) between several of the more recent instruments, notably the Model Groundwater Bill of several states.

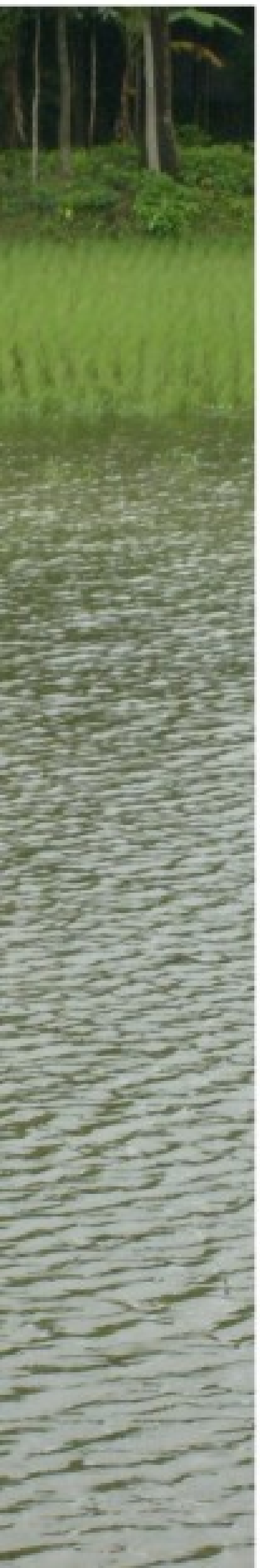
## Governance of Informal Water Economies in the IG Basin

Water governance is the sum total of processes, mechanisms, systems and structures that a State evolves and puts into place in order to shape and direct its water






Dominance of groundwater legislations in India



economy to conform to its near and long term goals. But the core hypothesis is that 'governance capacity' of the state is a scarce resource, which governments ration carefully. Another hypothesis is that all governance of sectoral political economies take the form of three kinds of direct instruments: public production, promotion and regulation, and prices, taxes and subsidies. Under public production, governments build dams and systems/ irrigation services that private entrepreneurs are unwilling or unable to supply or the governments want to control for strategic reasons. Under promotion and regulation of water governance, governments may support public-private partnership in water supply, promote participatory irrigation management and regulate energy and water supplies and abstraction through specific laws and operations. For deriving immediate results and ensure some kind of a financial viability the governments may take the route of imposition of prices, taxes and subsidies. Governments tax private actions deemed undesirable (pollution tax), or subsidize those deemed desirable (power subsidy, diesel subsidy, food price support, irrigation water subsidy), levy a water service fee to finance water services (irrigation revenue); subsidise irrigation if farmers need protection.

All these instruments are still in the evolutionary phase in all the four countries and have not stabilised. Often times the instruments deployed by the states may be in conflict with the advisories of the federal governments and can vary considerably within a country; eg., free electricity supply to farmers in Punjab state versus advanced time-of-day-electronic metering of agricultural power in West Bengal, India.

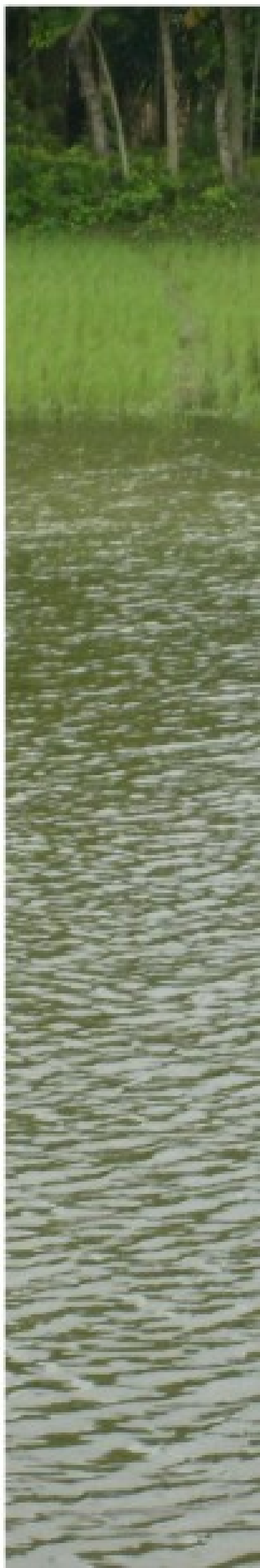
## Economics of Irrigation Water and Coping strategies of Small and Marginal Farmers in the Indus-Gangetic Basin

Global debate on ``water as an economic good'' presumes that irrigation water supply is delivered, controlled, and priced by public institutions; that in the developing world, the price of water is kept so low that water use cost leaves farmers no incentive to use it efficiently. In the eastern Gangetic basin region where irrigation is viewed as an instrument to alleviate agrarian poverty, the dominant emerging trend is the opposite of what the ``water-as-aneconomic good' debate highlights. Public irrigation systems and their pricing policies are losing relevance to the irrigation dynamics of the Indo- Gangetic basin, including in their command areas.

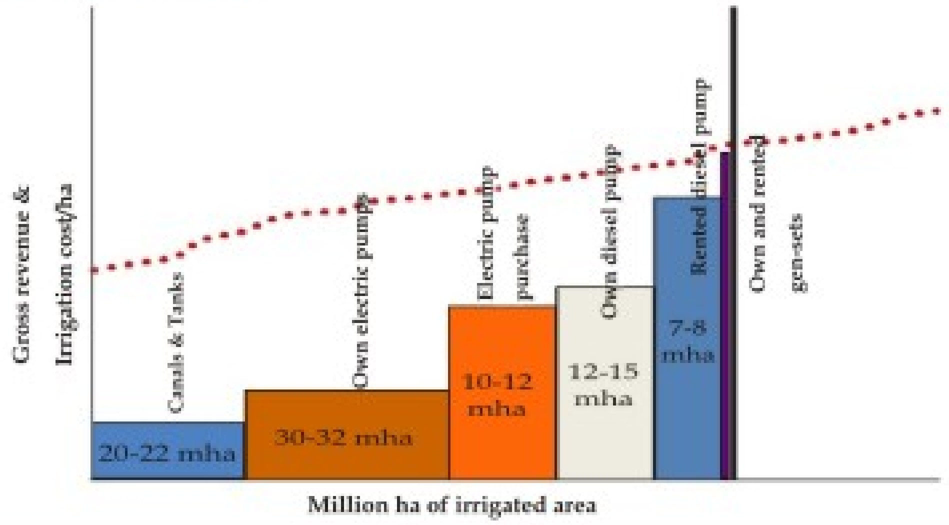
**Thriving groundwater markets in eastern Indus-Gangetic basin**

In the real irrigation economy of the IGB dominated by diesel tube wells and pervasive pump irrigation service markets, the ``surrogate water price'' facing millions of small-holder irrigators has for quite some time been well above the De Fraiture -Perry ``low-threshold,'' and is now crossing the upper threshold beyond which water demand becomes highly responsive to the ``surrogate water price.'' Particularly post-2000, the energy squeeze --and the soaring use cost of groundwater --is inducing smallholders to adapt/respond in myriad ways. At prevailing irrigation water use cost, small-holders fostering efficiency responses, that is, shifting to water-saving crops, water and energysaving irrigation technologies, and improved conveyance efficiency. But the poorest are also forced into distress responses, that is, switching to high-risk crops, reducing irrigated areas, and even getting out of farming itself.

Since the onset of the 1990s, smallholder agriculture in the IGB has been stressed by an overall input cost-price squeeze anyway; but rising diesel prices are proving the last straw on the camel's back. Here, the major challenge is to find ways of bringing down water use cost belowthe ``upper threshold'' beyond which abundantly available water becomes too expensive for the poor to use to maintain livelihoods and food security. Investing in farm electrification and providing rationed electricity at an affordable price -as under Gujarat's new Jyotigram Scheme might provide succour to smallholders in eastern Gangetic basin.



**Classes of Irrigators in India**




## Publications:


1. Shah, T., M.U.Hassan, M Z Khattak, PS Banerjee, OP Singh, SU Rehman. 2008. Is irrigation water free? A reality check in the Indo-Gangetic basin. Water Development, 37(2): 422-434.
2. A. Mukherji, S. De Silva. 2009. Evolution of water sector policies and laws in the Indus- Gangetic Basin – Drivers and Trends. IWMI Research Report ( in progress)
3. Pant, D. 2009. Irrigation and tenancy in Nepali agriculture: A rapid appraisal in three districts. Draft Project Report.
4. Malik, RPS; Shah, T. 2009. Governance of informal water economies: A preliminary framework for study of water governance in the IGB. Draft report (in progress).
5. De Silva, S., A. Mukherji. 2009. An inventory of national, sub-national and trans-boundary water-related legal instruments in the IG basin countries. Project draft report and an electronic version (under development).



This note forms part of the Challenge Program on Water and Food (CPWF) sponsored Basin Focal Project for the Indus-Gangetic Basin (BFP-IGB). For detailed project report, log on to http://bfp-indogangetic.iwmi.org:8080 or write to:



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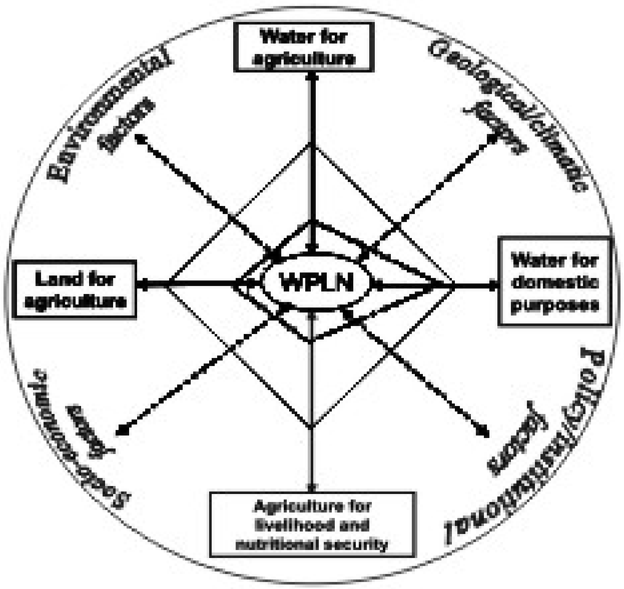
CPWF-IWMI Basin Focal Project for Indus-Gangetic Basin
Research Brief- Series IV

# Water-Land-Poverty Nexus in the Indus-Gangetic Basin

## Water-Land-Poverty Nexus in the Indus-Gangetic Basin

The Indus-Gangetic basin (IGB) is the largest contiguous poverty hot-spot in South Asia (SA). The IGB, which includes parts of India, Pakistan, Bangladesh and Nepal, covers about 45% of the total area of SA and accommodates nearly 46% of the region's population (2000 estimation). Poverty in SA and in particular in the IGB, is largely a rural phenomenon. The rural poverty in Bangladesh, Pakistan and in Nepal are 56, 39 and 35% respectively, which is significantly higher than urban poverty, which represents 36%, 23% and 7% respectively. Rural poverty in the Indian states, Bihar, Jharkhand, Uttar Pradesh, Madhya Pradesh and Chhattisgarh, which cover a major part of the IGB are above 30%. Since a major part of the population in this region live in rural areas, rural poverty dominates the overall poverty. Agriculture is the major source of livelihood for the majority of the rural population in IGB. Thus reducing rural poverty through improving agriculture income is a major pathway for reducing poverty in the IGB. Adequate access to reliable water and quality land resources are crucial for agriculture productivity growth. And there is clear evidence of strong linkages of growth in agriculture productivity and reduction in rural poverty. The water-poverty analysis aimed at mapping sub-national poverty in the IGB and identifying the determinants of poverty, by focusing on water, land and poverty nexus. The project also identifies coping mechanisms of the people living under poor conditions of water and land, and interventions that could alleviate poverty. The analysis applied the following framework for understanding the water-land-poverty nexus.




Framework for understanding and analysis of the water-land-poverty nexus

## Demographic and Poverty Trends

High population pressure and large agriculture dependent livelihoods are key demographic drivers affecting natural resource use in the riparian countries of the IGB. In recent decades, the four riparian countries of the IGB also have some of the highest population growth rates in Asia. High population growth is a significant driver of depleting and degrading the natural resources in the IGB. This increases pressure on natural resources in the IGB, which extensive agriculture has already over exploited.

Low ranking of the Human Development Indicator (HDI) of the four riparian countries (India-128, Pakistan-138, Bangladesh-140, Nepal-142) show the plight of the progress of health, education and economic growth in this region. These countries in IGB also do not also fare well in terms of major indicators in the well known Millennium Development Goals (MDG). However, a bright spot appears to be the access to improved water source for drinking, which is progressing well in India, Pakistan and Nepal. Bangladesh has lagged behind in this aspect, where more than a quarter of the population has no proper access to drinking water supply in 2000, with only a 2% growth in the last decade. Further, the overall Human Poverty Index rankings of the four countries are some of the lowest among the Asian countries.

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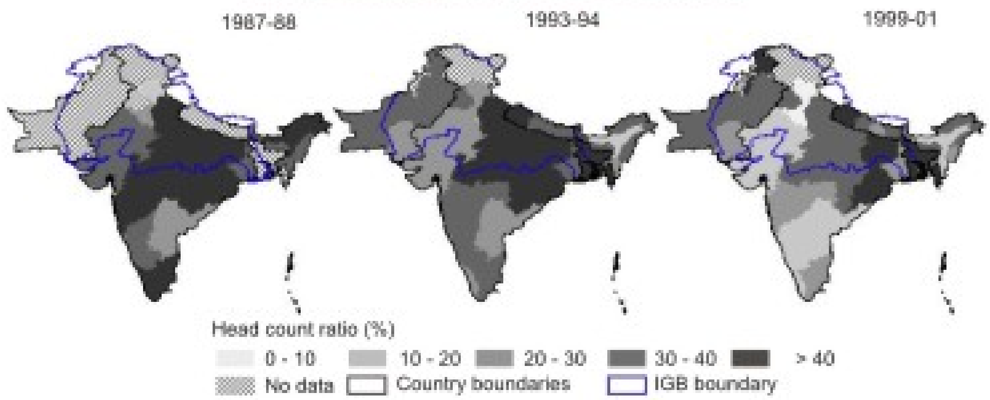
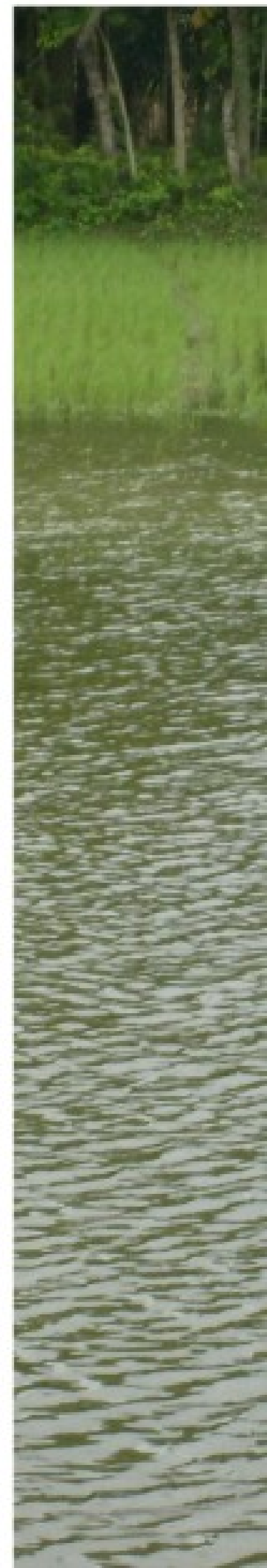
## Head count ratio in IGB countries



### Head Count Ratio, Poverty Gap and Inequality

Head count ratio (the extent of poverty as the proportion of population below a poverty line, HCR) of the riparian countries of IGB has significantly improved lately. In India, income of more than half of the population was below the poverty line before mid 1970s. HCR has decreased since then, to about 36% by 1993, and 26% by 2000. About 21% of the Indian population lived below the poverty line in 2005. About 22% of the population in Pakistan was poor in 2005. In Nepal and Bangladesh, about 31% and 40% of the population were poor in 2003 and 2005, respectively. In spite of these gains, the poverty associated with high rural population is a major concern in all four countries. A major reduction in rural poverty will have a significant impact in reducing the overall poverty in these countries.

Although the spatial resolution is low, the available poverty maps still show large variations of poverty across the IGB. The HCR is relatively lower in north and north-western parts of IGB, which mainly includes northern part of Pakistan Punjab and Indian Punjab, parts of Rajasthan in the Indus basin and Haryana and the western parts of Uttar Pradesh of India, and Kathmandu region in Nepal in the Ganga basin. The low HCR regions in the Indian and Pakistan parts of the IGB are known to have high agriculture productivity and growth.

The HCR is high in the southern and eastern parts of IGB, consisting of states of Bihar, Chattisgarh, Jharkand, and western part of Uttar Pradesh, and Madhya Pradesh in India; southern Punjab, North West Frontier (NWFP), Sindh, and Baluchistan provinces in Pakistan; south-west divisions of Bangladesh; and all NLSS regions except Kathmandu in Nepal.

### Water-Land-Poverty Nexus in the IGB

Agriculture sector contributes to about 20% of the GDP in India, Bangladesh and Pakistan. Yet, due to large population base, livelihoods of many of the rural poor still depend on agriculture. There are still large opportunities for reducing rural poverty in the IGB through agriculture growth. Among others, access to irrigation is a key determinant of reducing rural poverty. A reliable irrigation supply is a key determinant for better inputs use, such as better seed varieties, fertilizer, pesticide etc. They increase productivity and income and reduce poverty. This is clearly the case in Punjab (Indus basin) and Haryana (Ganga basin) where irrigation- mostly through groundwater, covers a large part of croplands. These two states have some of the lowest rural poverty.

Adequate access to quality land is also a major determinant of low rural poverty. In the IGB countries, incidence of rural poverty is evidently high among the landless and marginal farmers. India has the world's largest number of rural poor and largest number of landless people and they are intrinsically linked between each other. Marginal (<1ha) to small (1-2ha) lands, comprising 82% of all operational holdings, is a constraint for poverty alleviation. In Bangladesh, more than 50% of the landless people are poor, and the poverty among the small landholders are three-times higher than the large landholders. Moreover, rural poverty in Bangladesh is high in low-land and high-land areas. In Pakistan, more than half of the landless population, whose livelihood depends on agriculture, is poor. However, in Nepal, more than half the population belonging to landless to small landholders is poor, but poverty among the large land-holders is not strikingly lower either. Lowland productivity is a major factor that

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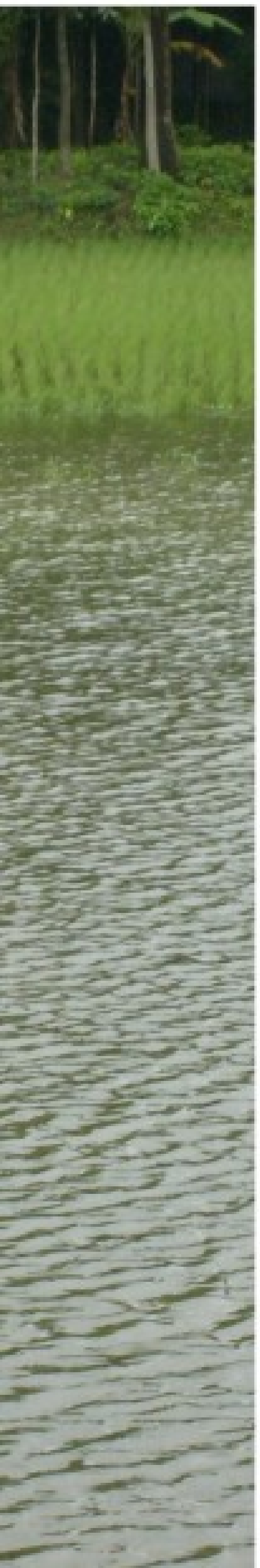

**Contrasting pictures of poverty in the western and eastern regions of IGB**

separates the rural poor from non-poor in Nepal. Access to irrigated land, and associated productivity growth is proved to be a major determinant of decreasing rural poverty. However, intensive irrigation could also contribute to land degradation and threaten the very benefits that irrigation has delivered to the rural people. The linkages of water-logging and salinity with intensive irrigation in the IGB are well known.

## Insights from Case Studies in India, Pakistan and Nepal

Primary surveys were conducted in selected locations in all the four basin countries for a better understanding of the detailed village and household profiles, scattering of the holdings and views of the experts for alleviating the existing conditions. Initial analysis of the data revealed the following trends:

### *i. Water and Property Rights:*

It is surprising to reveal that in Bihar (India) about 2/3 of the respondents buy agricultural water from unofficial trade schemes. In effect, 57% of the sample purchases water from trading mechanisms, 19% 8,5% make conjunctive use of pump and traded water while only about 3%make use of public water (canal irrigation). In the case of Nepal, the pumping practices are quite rare and the canal water is acknowledged as a public property. Therefore, the public use of canal water almost monopolises the water property status while the ownership condition of a tubewell is minimal.

### *ii. Land and Property Rights:*

Only about 50% of the land was directly owned, about 37% was leased-in/leased –out and 13% were the common property sources/ vague titles in the sample villages of Bihar state of India. In Pakistan and Nepal sites, about 80% of the land was directly owned and the rest was leased-in with minimal area as common property.

### *iii. Source of New Knowledge:*

In spite of the huge expenditure and large institutional structures of the agricultural extension; the farm friends, self-experiment, knowledge from the elders and the retail business persons continue to be main source of knowledge in all the three locations. The NGOs and the public institutions consist of the almost last choice of the farmers.

### *iv. Constraints for Improved Farming:*

Farmers in Bihar cited non-availability of credit, inadequate water supply, floods/droughts, poor yielding varieties and poor availability of fertilisers as the main constraints. Farmers in Pakistan cited insufficient supply of water as the major constraint followed by low use of fertilisers, poor yielding varieties and high input pricing. The Nepalese farmers also found water scarcity as the most vital constraint followed by non-availability of credit, poor yielding varieties and small land sizes as the major constraints for improved farming.

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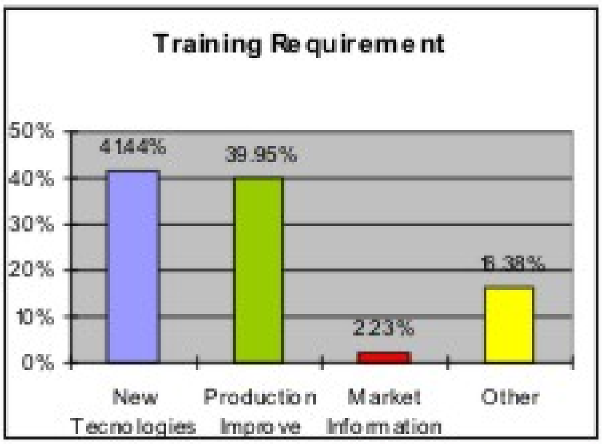
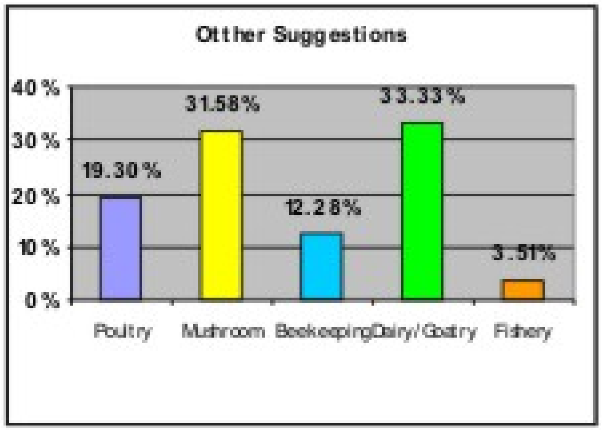
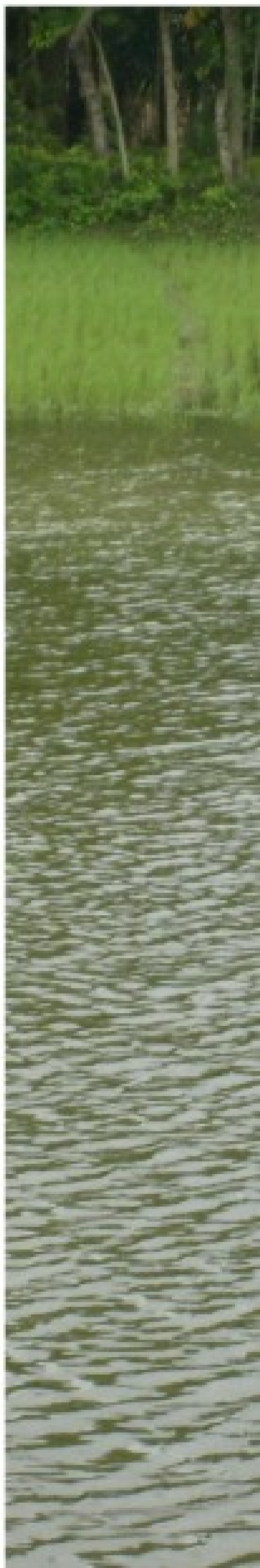



**Options of training requirements in India**



### v. *Farming Challenges:*

Farmers consider the sufficient and regulated supply of water as the most potential intervention for improving the productivity. High input costs, non-availability of the credit and poorly managed canal systems are perceived as the main challenges for farming. Most farmers felt the urgent need for training in new technologies, production improvement and agriculture-related enterprises.

### vi. *Micro-credit Use and Reasoning:*

The farmers felt a severe need for the availability of affordable micro-credit to meet their agriculture and related needs. About 40% of the farmers in India (Bihar), 14% in Pakistan and 50% in Nepal used formal and informal channels for obtaining micro-credits. Only about 52 % of this credit was used for agriculture related activities in Indian case as against about 100 % in Pakistan and Nepal. More than 75% of the farmers made a proper use of this credit.

## Publications:


1. Xenarios, S., U. Amarasinghe. 2009. Nexus of Water, Land and Poverty – Lessons from Case Studies in India, Pakistan and Nepal. IWMI Research Report (Draft)

2. Upali A. Amarasinghe, R. Sirinivasulu , Madar Samad. 2009. Water-Land-Poverty Nexus in the Indo-Gangetic Basin: A Synthesis. Draft Report.

3. Xenarios, S. and Sharma, B. 2009.Welfare and Water Use in Less Developed Regions of Ganges Basin (Bihar). Draft report.



This note forms part of the Challenge Program on Water and Food (CPWF) sponsored Basin Focal Project for the Indus-Gangetic Basin (BFP-IGB). For detailed project report, log on to http://bfp-indogangetic.iwmi.org:8080 or write to:



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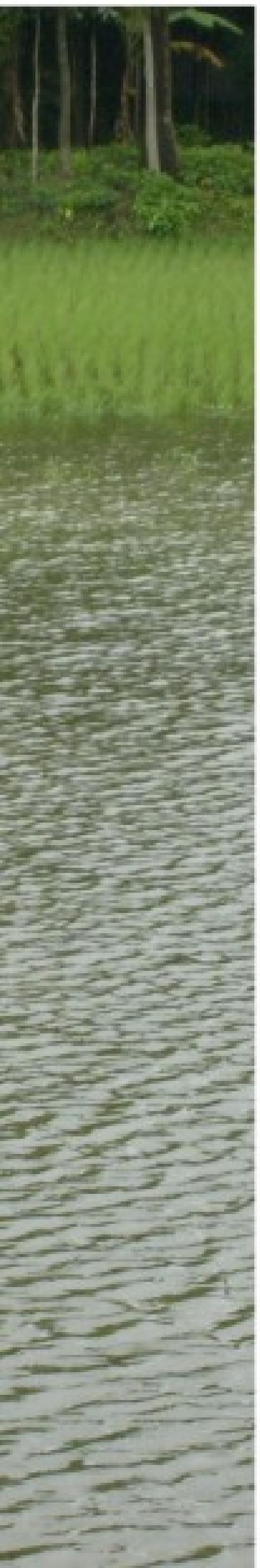


# Investing on Interventions for Water Productivity improvement: A poverty reduction strategy in Indus-Gangetic Basin

*Agriculture remains the main livelihood option for rural population in the Indus-Gangetic basin (IGB) countries. Hence interventions based on improving water productivity in agriculture can help rural poor a way out of poverty. Many interventions have been tried in various parts of the basin to overcome local constraints and provide opportunities for increased production. The project identified specific water-related physical, institutional and policy level options, which have the potential for water productivity improvement in the rice-wheat predominant region of IGB. Detailed matrices were prepared based on their location, coverage, method used, primary purpose, financial aspects, stakeholder linkages and specific impacts. Available water use and yield data from these matrices were used to estimate water productivity (WP) for different interventions and crops.*

## Intervention analysis using Analytic Hierarchy Process (AHP)

AHP was used as the tool for intervention analysis. Questionnaires for different crops were prepared for intervention ranking and sent to experts covering the whole IGB for their opinion. Potential interventions were identified using AHP on expert opinions and the identified interventions were ranked hierarchically for specific crops based on which, crop-wise high potential interventions were identified as below:

- Including sugarcane and mustard in the cropping system could enhance the WP in the IGB.
- Proper irrigation scheduling was found to be the potential intervention for crops like rice, wheat, sugarcane and other major crops.
- For maize and oilseeds, use of hybrid seeds is most critical for productivity improvement.
- For potato, use of quality seeds was identified to be the potential intervention.
- Crop diversification using short duration pulses as summer crop can potentially solve the pulse shortage and nutrition deficiency among the poor.
- Besides irrigation scheduling, two other important interventions in the case of rice are transplanted rice on raised bed (Bed planted system) and selection of short duration (early transplanting) and photoperiod sensitive (delayed transplanting) cultivars.
- Similarly for wheat, the other two important interventions were timeliness in sowing operation-sowing by 3rd week of November and Zero Tillage.

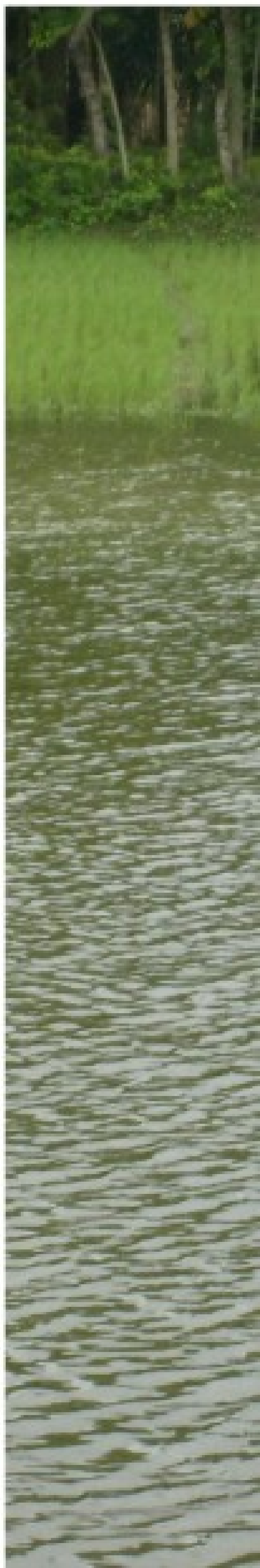
## Potential of Resource Conservation Technologies in saving water and improving water productivity in Indo-Gangetic Basin

Resource Conservation technologies (RCTs) are directed towards productivity gains through efficient utilization of natural resources. Land and crop management practices promoted by such technologies have the potential to improve yields and ensure better returns to farmers through efficient input management. However, it remains still to be investigated whether water in fact is 'really saved' at larger irrigation system or basin scales.

### *Zero Tillage (ZT)*

Zero-tillage is widely adopted in the rice-wheat systems of IGB, to enable timely sowing of wheat after rice crop. Around 3.0 million ha of land are planted using zero till drills as of 2006-07. Irrigation water savings are effected by effective utilization of residual soil moisture (12% more utilization) coupled with the reduction in number of irrigations per season.

- Water savings of around 36% is reported by adopting zero tillage in rice-wheat systems.
- By ZT, the duration of irrigation for wheat is reduced considerably; it saves about 6.4 hours of irrigation per season in wheat, but does not reduce the number of irrigations significantly.



- Reduction in total water application in Punjab and Sindh areas with saline groundwater can bring about 'real water savings' by reducing the amount of water lost to the sink, the saline groundwater aquifer.

### *Laser-assisted Precision Land Levelling (PLL)*

Precision levelling of land by employing laser technology helps in uniform soil moisture distribution and better control of water distribution by reduced topographic variability.

- PLL requires 12–14% lower water application when compared with traditional land leveling in the rice-wheat system of IGB.
- If the whole of western Uttar Pradesh is to adopt laser-levelling technology, it is expected to save an amount of 5.5 BCM of water and would yield a corresponding energy savings equivalent to 675 million INR.
- Farmers reported about 15-20% higher yields under the laser-levelled fields. PLL is now widely practiced in the Indian Punjab.

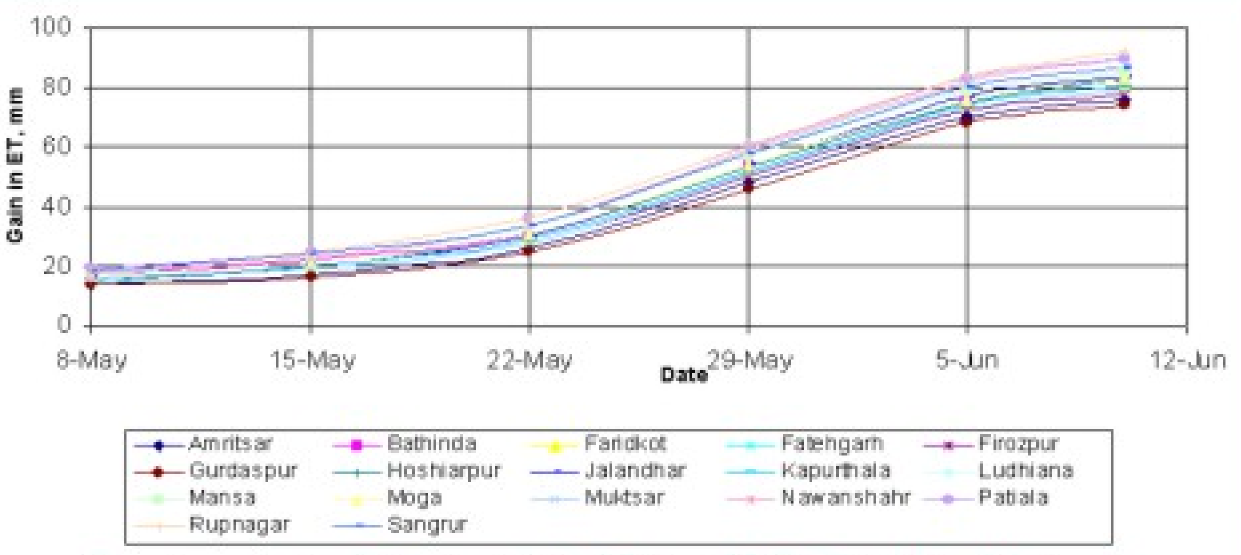
### *Raised Bed Planting*

- Planting in raised bed makes possible yield increase through reduced crop lodging, better weed control and improved fertilizer and irrigation application efficiencies.
- Raised bed planting of rice with furrow irrigation has been reported to have irrigation water saving of upto 40%.
- Better drainage created by raised bed system reduces crop damage by water logging, thus having potential to provide 'real water savings' in the water logged areas of Indian and Pakistan Punjab and Sindh.

### Water Saving Regulation: The Punjab Preservation of Subsoil Water Act

Punjab state in India has promulgated "The Punjab Preservation of Subsoil Water Act" as a regulatory response to its falling groundwater levels. The Act made mandatory for all farmers not to sow paddy before May 10 and not to go for transplanting before June 10.The project investigated the potential of the act in bringing about anticipated real water savings.

- ET gains from 14 mm to 90mm could be obtained for the long duration rice, PR113 by a delaying the transplanting date from May 1 to June 10.
- If the whole rice cropped area of Punjab follow late transplanting by 10th of June, water savings of around 2180 MCM could be achieved.
- Transplanting on10th of June would ensure a




**Evapotranspiration (ET) gains in the districts of Indian Punjab by delaying the transplanting date from May 1st to 10th June**

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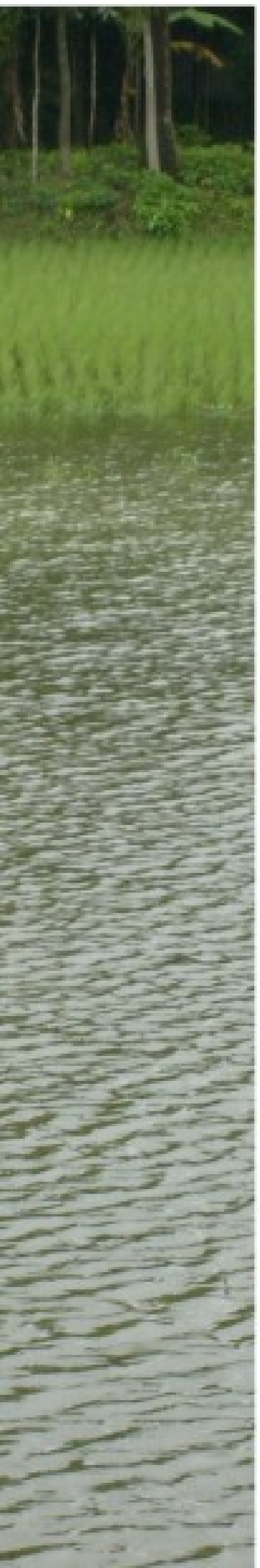


savings of 7% in annual GW draft for irrigation.

- Studies report that decrease in water requirement by 26 to 30 cms, effected by the act would check the water table decline by 60 to 65%.
- Simulation studies report increases in mean water productivity by around 10% and 21% for paddy transplanted on June 1 and June 16 respectively, as compared to that of May 16.
- It is estimated that farmers could save approximately 175 million KWh of electricity by checking real water loss.
- Actual electricity savings of 276 million units for agriculture reported by Punjab State Electricity Board in 2008-09 in spite of an increase in rice area by 1.53% and increase in tubewell connections by 3.7% paddy season has also been attributed to the impact of the act.

## Water saving through Water-course Improvements

Around 45% of the original water diversion to the channels of Indus Basin Irrigation System is lost enroute, which if salvaged, could be profitably used by the farmers. The Government of Pakistan initiated the National Program on Improvement of Watercourses (NPIW) with an objective of controlling excessive seepage from unlined and poorly maintained watercourses, is expected to improve a total of 28000 watercourses in the canal irrigated areas of Punjab, falling under the Indus basin of Pakistan.

- 9% lining and 69% earthen improvement resulted in 6-13% increase in delivery efficiency at various sections of the watercourse.
- Delivery efficiencies were improved in the range of 4-10% for regularly improved watercourses while for accelerated or low cost improved watercourses delivery efficiencies increased in the range of 1-6% at various sections.
- The saving of water due to watercourse improvement had a positive impact on cropping intensities of the command area. Different size farms located at head, middle and tail of the sample watercourse had pre-improvement cropping intensities of 115, 121 and 115%, which were increase to 138, 151 and 132%, respectively after improvement of watercourses.
- 22%, 40% and 19% saving of irrigation time were achieved at head, middle, and tail reaches of the watercourse respectively after improvement of watercourse.

## Micro-irrigation Technologies and Multiple Use Scheme (MUS) in Nepal

The slopy terraces and the insufficient availability of water were not suitable for the development of surface irrigation in the hills of Nepal and this necessitates development of non-conventional form of irrigation including various technologies (drip irrigation, sprinkler irrigation, pond irrigation, treadle pump) and MUS.

The Agricultural Development Bank of Nepal took initiative in 1980s in collaboration with CARE, Nepal in financing and introducing micro irrigation technologies - Tube wells and Treadle Pumps in terai, and hydram, sprinkler, drip irrigation systems in hill region by providing loan and technical support. MUS scheme was

**Improvement in delivery efficiency as a result of watercourse improvement**

| Stage | Delivery efficiency of main water course | | | | Overall delivery efficiency | | | |
|---|---|---|---|---|---|---|---|---|
| | Head | Middle | Tail | Average | Head | Middle | Tail | Average |
| Pre-Improvement | 76 | 71 | 63 | 70 | 66 | 63 | 54 | 61 |
| Post-Improvement | 82 | 81 | 74 | 80 | 79 | 73 | 64 | 72 |

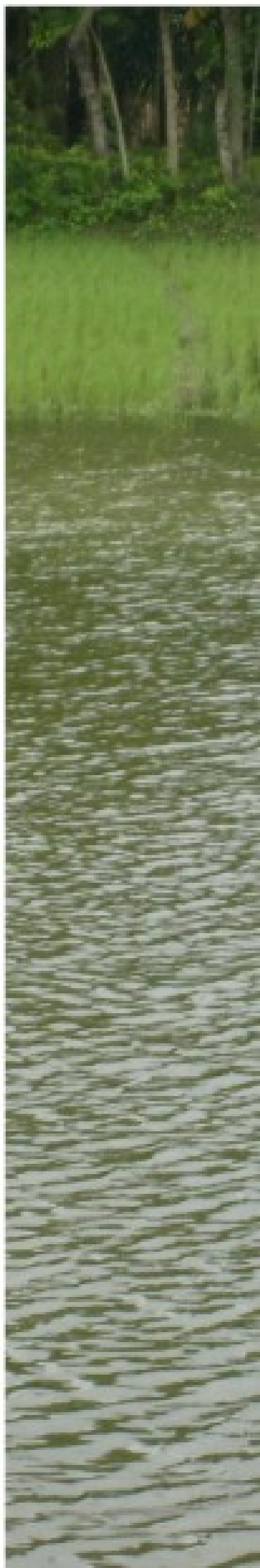
**Major benefits of watercourse improvement**

| Particulars | Extent (%) |
|---|---|
| Savings in irrigation time | 28 |
| Labor saving | 50 |
| Increase in cropping intensity | 23 |
| Increase in crop yields | 16-37 |
| Increase in net farm income | 20 |
| Increase in cropped area | 17 |

implemented in Nepal with an aim to explore ways to improve livelihood of the poor, reduce unpaid workloads, alleviate poverty and enhance gender equity through more productive use of small-scale water supplies in nine hill districts of both the western and far-western regions of Nepal. Within a period of 5 years (2003-2008), the number of MUS has increased to 122. The technology facilitated productive utilization of small water sources. The communities were positive as they could access to water for multiple needs from a single system. It also helped in time saving and reduction in drudgery for women who fetch water for the household.

**Micro irrigation technologies provided beneficial to the small holders mainly through vegetable production.**

**MUS (Thai jar): Meeting both drinking water and irrigation needs in Nepal hills.**



## Publications:


1. Sharma, Bharat R; Cai Xueliang. 2009. Water saving technologies for rice-wheat systems in Indo-Gangetic Basin: New Developments. Invited paper at the 15th Regional Technical Coordination Committee Meeting of the Rice-Wheat Consortium, 2-3 February, 2009; NASC Complex, New Delhi, India.
2. Sharma, Bharat R; U. Amarasinghe; Cai Xueliang. 2009. Assessing and improving water productivity in conservation agriculture systems in the Indus-Gangetic Basin. Lead paper at 4th World Congress on Conservation Agriculture ( Session 1.4: Irrigated Systems), 4-7 February 2009, National Academy of Agricultural Sciences (India), NASC Complex, Pusa, New Delhi, India.
3. Pant, D. 2009. Micro Irrigation technology and its Potential to meet the productive and consumptive water needs for livelihood improvement in Nepal hills. Draft Research Report.
4. Sharma, B.R.; Ambili, G. 2009. The Punjab Preservation of Subsoil Water Act: A regulatory mechanism for saving water ( Draft paper)



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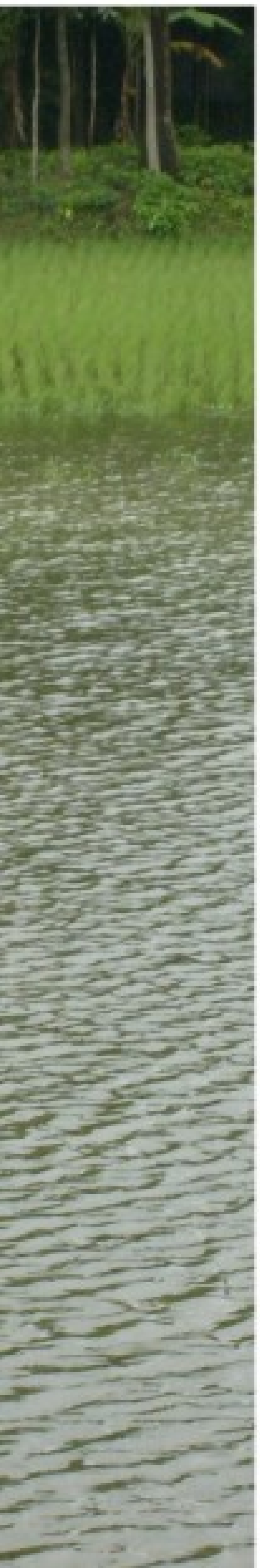


# Fisheries Water Productivity in Eastern Indus-Gangetic Basin: Constraints and Opportunities for Improvement

*The eastern Gangetic basin including the delta portion in India and Bangladesh and Sunderban mangroves have very specific agro-hydrological, socio-economic and livelihood conditions. The region is relatively abundant in water resources and capture and culture fisheries is one of the common economic activity for the small farmers and fishers. Fish and fisheries play an important role in the nutrition, employment and economy of Bangladesh, contributing to about 5 percent of GDP and 6 percent of export earnings. But, the aquatic ecosystem functions that naturally enhance fisheries productivity are not optimized in the Eastern Gangetic Basin, rather the natural and manmade activities put hindrances to optimization of water functions and ecological productivity resulting in lower renewable capacity of the fish stocks and lower level of biodiversity that has gradual deleterious impact in lower overall fish production in the open water systems. The pond aquaculture has developed momentum over the last few decades in order to cope with the nutritional needs, but that has another dimension to look into from the poverty reduction and social dynamics and its complimentary role with other agricultural land use patterns. Presently, about 45% of the ponds found in Bangladesh are underutilized and this huge potential can be harnessed by better utilization and management of these ponds. This has a link with the technological adaptations and institutional developments that has happened in some areas in the EGB, in addition to the sustainable availability and access to water.*

## Temporal and spatial variation of productivity in the Gorai-Madhumati sub-basin

### *Capture fisheries*

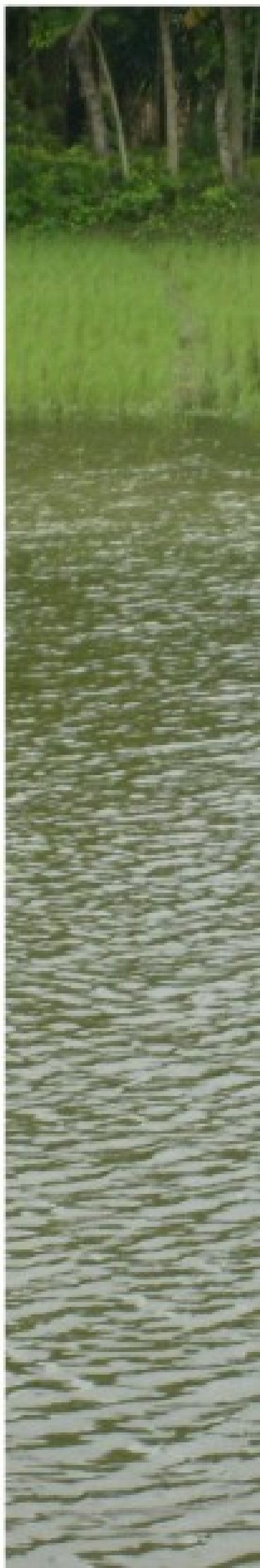
***Beel system :*** Beel fisheries productivity in terms of catch per unit area (CPUA) has a clear peak in the northeastern part of the sub-basin, especially in Faridpur and followed by Rajbari, Madaripur and Gopalganj. The least productive districts are located in the Southeast, coinciding with the lower part of the Sub-basin.

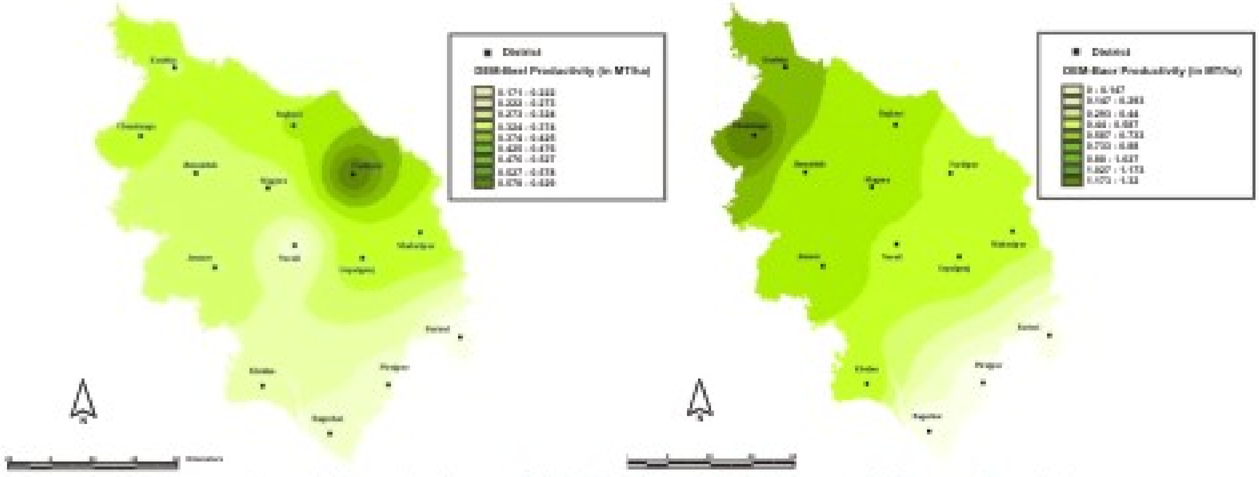
***Baor (bow lake) Ecosystem :*** The intensity of fish production in baors is higher in the northwestern region and gradually decreases towards the south-eastern areas. The highest value is in Chuadanga district, followed by its neighbouring district, Kushtia.

A comparison between productivity of privately managed and government managed baors showed that privately managed baor productivity increased over time at a much higher rate than government managed baors. However, the productivity remains low (<1 t/ha), considering that the productivity in similar water bodies

| Districts | Name of the water body | Water Productivity (kg/ tcm *) | Water Productivity ( BD Tk #/tcm) |
|---|---|---|---|
| Chuadanga | Rais ar Beel | 21 | 1,710 |
| | Mathavanga River | 26 | 2,240 |
| Narail | Dhalna beel | 1.8 | 140 |
| | Guakhola beel | 9.5 | 760 |
| | Nabaganga River | 4.5 | 540 |
| Bagerhat | Badokhali beel | 0.6 | 70 |
| | Kulirjorr River | 144.6 | 17,350 |

**tcm= Thousand cubic metre* *#BD Tk= Bangladeshi Takka; 1USD= BD Tk 69*





**Spatial variation of (a) Beel , and (b) Baor fish productivity in Gorai-Madhumati sub-basin, Bangladesh**

in China and Vietnam are approximately 5 to 10 t/ha. In the study areas, the fish water productivity varied substantially among the locations and systems.

High productivity is in the districts with proximity of the Padma River which ensures good water quality, can cause water flushing, and ensures beels to be mostly perennial, hence allowing production all year round. Further away from the rivers, the productivity in beels decreases. The high Baor productivity hotspot in the north may be as a result of a good management system of the fishery in that area.

### *Aquaculture and Integrated Aquaculture-Agriculture (IAA) System*

***Freshwater Pond Habitats :*** Overall, the western area of the basin is most productive, with Jessore as the productivity hotspot of the study area. The high productivity in the westernmost zone; in Jessore, appeared to be the result of a well-established private hatchery zone and seed dissemination system, facilitating the high production. Additionally, support of research institutions (e.g. BFRI), local government and NGOs in Jessore areas yielded positive benefit to the farmers in knowledge diffusion and production capacity enhancement, and have overall spread of aquaculture activities on small as well as commercial scale. Effort needs to be made to create similar enabling environment in most of the eastern IGB.

***Shrimp Farm Productivity:*** The traditionally established shrimp farming regions of Bagerhat and Khulna have shown a steady and high productivity while there is no visible trend in the other areas of the sub basin. The neighbouring districts, especially Narail, Gopalganj and Jessore, witnessed an increase in productivity since 2002 that has remained steady. Narail had an exceptional increase in production which coincides with the implementation of South West Area Integrated Water Resource Management Project (SWAIWRMP) which facilitated culture fisheries including shrimp farming within the small scale water resources project boundary.

**Pond Harvest**

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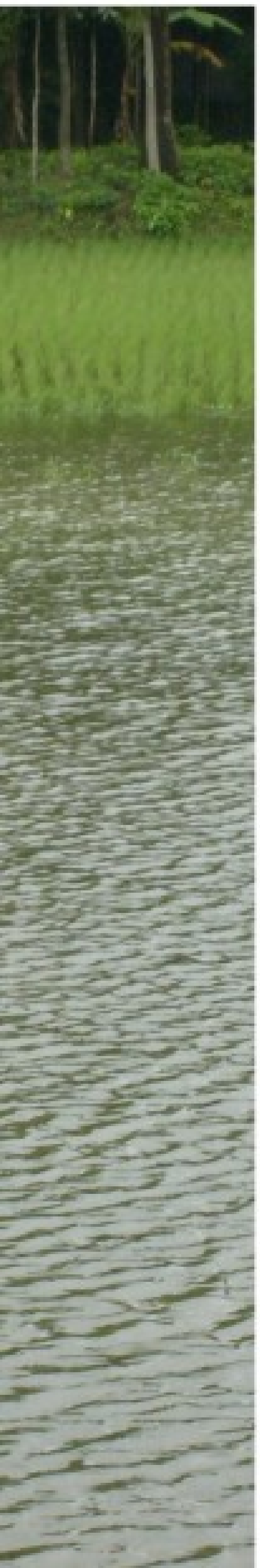
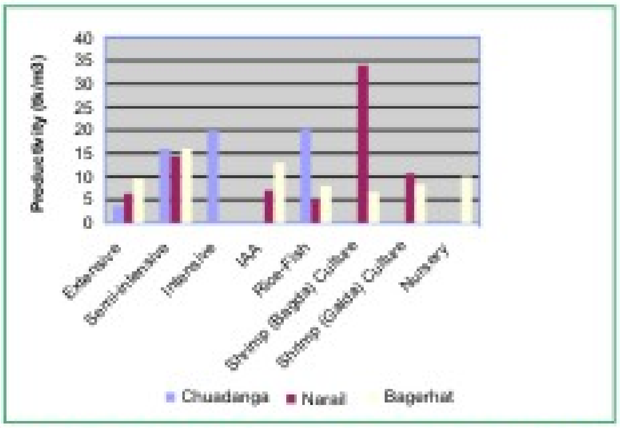





**Variation in culture fisheries productivity**

Based on the agro-hydrological and other enabling conditions, the following are the major hot-spots for different type of fisheries activities in Bangladesh:

- The North-Eastern part of the GM sub-basin is the hotspot for beel systems.
- The North-Western side is concentrated for baor (ox-bow lake) productivity.
- The South-Western side is specifically favourable for pond aquaculture and shrimp farming.
- The coastal zone of the sub basin and its nearby districts has highest productivity for shrimp and prawn cultivation.

## Threats to Fisheries Productivity

The farmers foresee several potential threats, extraneous to the landowners, which may hamper the fisheries productivity in the sub-basin.

- ***Water resource development interventions:*** Several of the water development projects were found to be detrimental to open water fisheries causing a reduction of water area and volume, hampered the migration and spawning of aquatic organisms, increased siltation of beel beds and reducing or eliminating overwintering shelters. These project interventions have also caused delinking of the rivers and together with the draining of beels for irrigation purposes and wetland contamination through agro-chemicals and pesticides.
- ***Climate and land use change:*** The respondents perceive that drought has become severe over the decades and its frequency and duration has been increasing. Fishers of Narail district reported a drought that has prolonged from mid of March to mid of June. This may be due to irrigation to paddy field that resulted in less water available for the fishers to catch fish. Salinity in water is also increasing. Being situated adjacent to the coast, inhabitants told that, during dry season salinity becomes intolerable.
- ***Environmental flow changes :*** Due to enhanced development and upstream land use changes water flow in river measured in terms of water depth has reduced during the last decades, and the situation tends to become worse during the dry season. In case of Chuadanga, participants reported a minimum depth of water in most beels including Raisar Beel. This must have had detrimental effects on the life cycle of some aquatic species, particularly in the overwintering shelter of the spawning fish stock.
- ***Access to water***: Access to water resources was assessed on the basis of leasing method of open water bodies. According to the fishers, earlier it was practiced to lease out the open water bodies to the poor fishers through project based initiatives but the new leasing policies are not pro-poor and their access to water bodies is restricted. Another problem is that currently some influential people in the localities have enlisted themselves as fisher though they are not actually fisher by profession. Poor fishers are the ultimate losers.

## Potential interventions for improving fish water productivity

Based on extensive farm visits, specific group discussion and observation and professional and expert judgement, the following potential interventions have been identified for different systems:

### *Open water bodies*

- Develop more fish sanctuaries followed by habitat restoration, which have wider beneficial impact on fisheries productivity.
- Conservation of natural breeding habitats, and sanctuary development and management.
- Leasing system of public water need to change to enhance productivity and sustainable fisheries.






This is already being attempted to some extent in the new Wetland Policy 2009.

- Move away from standardized training programs to demand oriented ones, which focus on specific systems or community needs.
- Agriculture policy needs be integrated and synchronized with the other natural resource policies e.g. water policy, fisheries policy, environment policy; those that advocate for mechanisms to enhance ecosystem productivity.
- Decentralized fish seed technology extension can minimize input costs for production and improve local community's livelihood.
- Extension services should be strengthened up to union level by increasing sufficient skilled manpower.

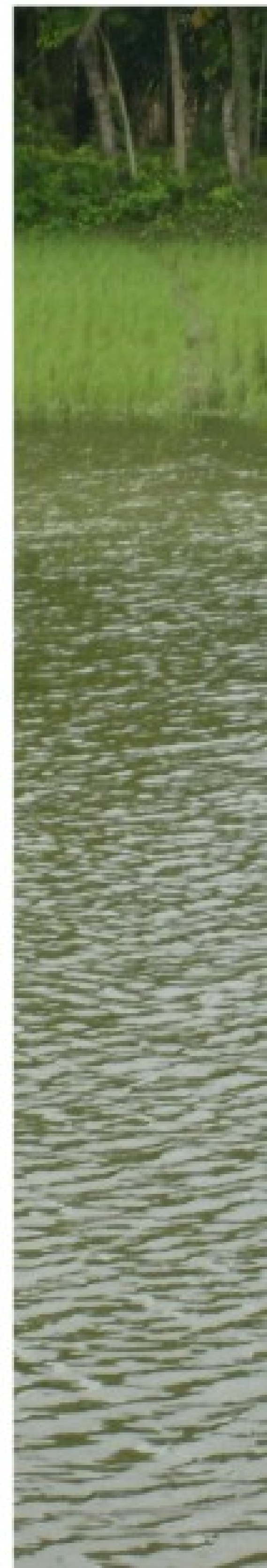
### *Semi-closed and closed (pond) culture system*

- Community based fish culture and management in large open and semi- closed water-bodies.
- Hatchery, nursery and feed mills should be established more evenly throughout the sub-basin, which presently are concentrated in small area. Government has established - but non functional - hatcheries and farms which could help meet the demand.
- Fish-depots and processing plants should also be facilitated more evenly across the sub basin as its demand grows from downstream to upstream, whereas the supply is concentrated down to middle stream.
- Strengthening of marketing linkages would improve the root level producers and at the same time reduce middlemen interception.

**Nursing Pond**

### *Shrimp and coastal aquaculture*

- These culture systems should develop into more sustainable and environmentally friendly technologies.
- Ensure quality of fingerling and post-larvae by guaranteeing the availability of high quality and high yielding variety of brood.
- Due to the industrialized nature of shrimp farming, the facilitation of credit support could benefit those interested in farming.
- Introducing salt tolerant varieties will provide adaptation measures for the coastal regions experiencing salt intrusion, which is predicted to increase with the changing climate. Deep-water rice variety along with fish shall be helpful.
- Introduce shrimp farm registration to avoid management conflicts.
- Development of rural infrastructure and efficient marketing channel.



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