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Introduction to the Special Issue

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The Indus and Ganges river basins are among the world's largest and most productive ecosystems (see Figure 1).[1] Home to three quarters of a billion people; the combined basin area extends over 2.25 million km^2 from the mouth of the Ganges to that of the Indus, covering large areas of Bangladesh, India, Nepal and Pakistan. Given the diversity of agroclimatic, social, and economic conditions in the four riparian countries, the basin is a study of contrasts and opportunities. For analysis purposes, the Indus-Ganges Basin (IGB) can be classified into three broad agro-ecoregions (Sikka *et al*., 2003): the upper catchments spanning the Hindu Kush-Himalayas, the Western Indus-Ganges plains (Pakistan and Indian Punjab, Haryana, Western Uttar Pradesh [UP], and Western Nepal Terai), and the eastern plains (Eastern UP, Eastern Nepal Terai, Bihar, West Bengal, and Bangladesh).

The basin provides water for the economic base of agriculture, forestry, fisheries, and livestock, as well as the urban and industrial water requirements of about one billion people. More than 90% of total water use is for agriculture, followed by 8% for domestic use (IGB Brochure, 2003). The Indus-Ganges plains form the largest consolidated area of irrigated food production on the globe with a net cropped area of 114 million ha. Groundwater development (i.e. the percentage of annual net draft to annual available groundwater resources), has been very rapid in the last two decades with development reaching 77.7% in the Indus and 33.5% in the Ganges part of the combined basin area (Sikka and Gichuki, 2006). Rural population accounts for 80% of total population in Bangladesh, 75% in India, 86% in Nepal, and 68% in Pakistan. High population growth rates in all IGB countries remain a cause for concern in terms of water and food security, poverty alleviation, and resource conservation. Per capita annual water availability in the Indian portion of the IGB is expected to fall in the classification of 'water-stressed' by 2025 with per capita availability declining to below 1700 m^3 (Bhatia, 1999; Falkenmark *et al*., 1989). The IGB also has the world's greatest concentration of poverty. In certain pockets, including the upland areas, 55% of the people live below the poverty line, and overall, 30% of the basin population, or 200 million people, are below the poverty line.

The IGB, in general, exhibits high potential for food and agricultural growth but currently only has low-to-medium actual primary productivity of agriculture, forestry, fisheries, and livestock. Alluvial soils, adequate-to-abundant water availability, and favorable climate on the resource side, coupled with good input supply, transportation networks, and marketing arrangements on the demand side, could establish a high-potential production regime for the major crops, fish, and livestock production systems. The basin thus can be described as a 'low-productivity-high potential' region where – with appropriate and adequate technological support/backstopping – agricultural productivity could be significantly improved enabling people to benefit from the region's fertile alluvial soils and generous water endowment.

While agricultural technologies and the harnessing of water have proceeded apace, land and water degradation are taking an increasing toll on the basin economy. Future food security in this area, which is the key breadbasket for South Asia, is threatened by a combination of land and water degradation, stagnating productivity, reduced harvested area, and rapidly increasing populations and, concomitantly, food demand. Linked to increased demand for food, irrigated rice and wheat have been intensively cropped for years, increasingly drawing on slowly dwindling and increasingly polluted groundwater tables. Much of the groundwater use in the basin area is not sustainable. While past development of tubewell irrigation was an important factor in increasing food production and reducing poverty, the basin is now being confronted with major groundwater management challenges: over-exploitation of groundwater and declining water tables in the drier Indus and western Ganges part of the basin, waterlogging and secondary salinization in high intensity irrigation command areas, and rapidly growing pollution of water resources. Climate change will likely further adversely impact

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[1]For the purpose of this Special Issue, the Indo-Gangetic Basin is considered as a contiguous basin area.

Figure 1 Extent of the combined Indus and Ganges basin areas.

food production in the basin. According to Ortiz *et al*. (2008) as a result of climate change approximately half of the entire Indo-Gangetic Plains area, which is currently classified as part of a favorable, high potential, irrigated, low rainfall environment, might be reclassified as a heat stressed, irrigated, short-season production environment. This shift could lead to a significant reduction in wheat yields, unless appropriate cultivars and crop management practices were offered to and adopted by South Asian farmers.

Governance is another area of concern. Poor interactions between state and national government and local communities have often impeded technological advancements that could help cope with problems related to water quality, climate fluctuation and extreme weather patterns, or help address groundwater degradation (ADB, 2007). Better coordination and dialogue are therefore needed between government agencies and farmer organizations. As conditions in the IGB are extremely heterogeneous; the problems and challenges vary in the upper catchments, western Indo-Gangetic plains, and eastern Gangetic plains, as shown in Figure 2 (Sikka *et al*., 2003).

Major opportunities exist, however, to substantially improve land and water productivity. In the lower Ganges, groundwater resources are under-used, not over-exploited, for example. And a new wave of resource conserving technologies such as zero tillage is already being adopted by farmers. Successful interventions will have an immediate and large impact – enabling people to benefit from the region's fertile alluvial soils and generous water endowments. Continued research is needed to further develop the high potential of this basin. From the perspective of people living in this region, the top priority is to raise income and food security. For this to occur, research and development must focus on improving land and water productivity throughout the basin. The CGIAR Challenge Program on Water and Food (www.waterandfood.org) has identified several key focus areas where combined water-and-food research can make a difference in the Indo-Gangetic basin:

- overexploitation of groundwater and declining water tables
- inefficient use and low productivity of surface and rainwater resources
- waterlogging and secondary salinization in irrigation command areas
- pollution/contamination of water resources
- weak and inadequate institutions for water governance and management
- inadequate integration of crops, fisheries and other production sectors
- continuing degradation of land, water and biotic resources

One activity under this initiative was a workshop seminar held during World Water Week at Stockholm in 2004 that brought together policymakers, experts, and researchers working on the Indus and Ganges basins to address some of these challenges. This Special Issues reports on the papers presented during this seminar. Papers range from salinization of irrigation commands in the Indus basin to the management of fisheries in flooded ecosystems in the lower basin area.

The first paper in the Special Issue focuses on the limited success of controlling soil salinity and waterlogging in the Indus part of the IGB. Lack of coordination among federal and provincial governments, research institutes, and national and international organizations; conventional farming and irrigation methods used by farmers; limited attention to reclamation and saline agricultural approaches; and lack of resources are identified as some of the reasons for the low success rate. The paper advocates for

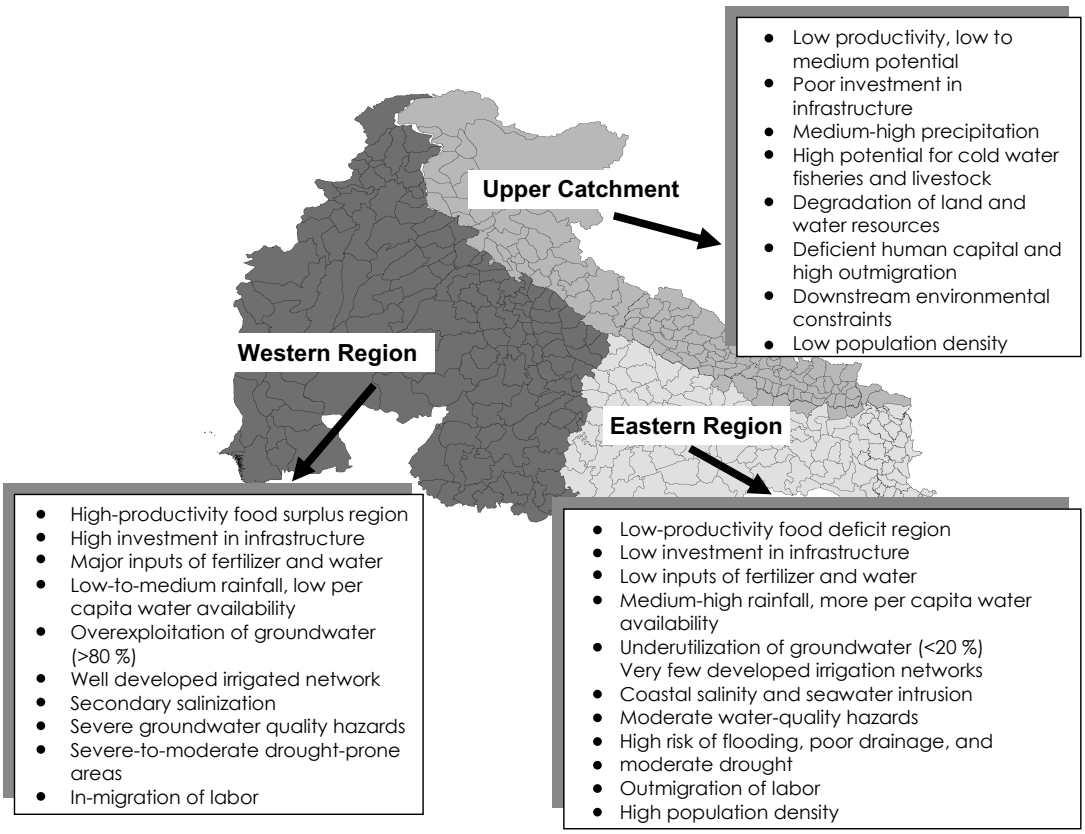

Figure 2 IGB problems and challenges.

a more concerted effort for enhanced salinity and waterlogging control that includes a greater focus on saline agriculture, capacity building of farmers, and promotion of local interventions to improve self-reliance. A sustainable solution would also require coordination among different provinces and strengthening of federal and provincial government agencies.

The next two papers focus on groundwater development, which is highly variable in the basin area and in India, in particular. While 85–90% of available groundwater resources have been developed in Haryana and Punjab, development has only reached one third of the potential in Bihar and West Bengal (Sikka and Bhatnagar, 2006). Coal-rich eastern India is the primary source of electrical power generation, yet the benefits are being captured outside this region. Dynamic, groundwater-led agricultural growth, including positioning the eastern IGB to become a major rice exporter could make important contributions to poverty alleviation in the region. To achieve this, according to the authors, the energy-water nexus must be flipped from west to east. However, this may only take place when western IGB farmers find that water and financial constraints – especially those exerted through the power sector – make rice-wheat cropping unviable, causing them to diversify cropping patterns.

Groundwater governance is examined in the third contribution focusing on minor irrigation policy in North Bengal, India. North Bengal has huge ground and surface water potential and a drainage system that includes numerous large and small rivers. The region has a high concentration of rural poor who depend on smallholder farming and farm labor for their livelihoods. The issue central to water governance is how best to design instruments of public support to stimulate smallholder (minor) irrigation and harness the abundant groundwater resource to improve conditions for the region's rural poor. Subsidy support for minor irrigation investments has remained crucial. This paper addresses three distinct sets of questions regarding the subsidy policy: What is the rationale for minor irrigation subsidies? Does the subsidy policy achieve its minor irrigation objectives in an efficient, sustainable, and livelihood-intensive manner? And is there scope for designing minor irrigation subsidy policies for better impact?

In addition to wheat and rice, fisheries are crucial for food security in the IGB. The Lower Indo-Gangetic Plains and the Brahmaputra and Meghna Basin, located in central Bangladesh, are the major sources of open water fisheries in Bangladesh. The paper in this Special Issue focuses on sustainable management of fisheries resources, livelihood implications for the fisher communities, and researchable issues for further development. Approaches discussed include changing traditional attitudes toward fisheries management, observing closed fishing seasons, developing fish sanctuaries (area closed to fishing), controlling and removing destructive fishing gears that capture juvenile fish, empowering communities to manage their own resources, promoting community-based approaches to fisheries management, harvesting of small indigenous species, and increasing fish abundance and biodiversity by reducing levels of exploitation during critical periods of the year.

The fifth paper in the Special Issue addresses the role of participatory approaches in water management in the IGB. The author classifies water resources and irrigation systems as

"sociotechnical," that is, society has a large role to play in shaping technologies. Water management is a complex process, and depends on a number of factors like the awareness level and socioeconomic conditions of users, frequent dialogue and linkages among stakeholders, and a strong local will for improvement. Participatory water management is a way to move beyond participatory irrigation management: it is a more holistic approach in the efficient utilization and management of water, including, as it does, conjunctive and multiple uses of canal, ground, and rain water.

The last two papers take a broader approach. Upali *et al*. examine some of the key assumptions underlying India's highly ambitious and highly contentious National River Linking Project (NRLP). If fully implemented the NRLP would be the largest ever water transfer project implemented in the world, transferring water from relatively water-rich basins to those basins where demand has already outstripped supply. The paper concludes that based on the most recent trends of key drivers affecting irrigation water demand the NRLP as originally envisioned might not be an adequate solution to India's water problems. Despite, this, interventions are required to avoid severe regional water crises, particularly in Northern India. The solutions advocated by the authors include the promotion of crop diversification to increase the benefits from every drop of consumptive water use, and an increased focus on sustainable groundwater expansion to reap the benefits of changing cropping patterns.

The final paper examines alternative scenarios for water supply and food security in the IGB given increasing concerns about the sustainability of the irrigated production systems in the IGB. An integrated water-food modeling framework, IMPACT-WATER, is used to show that under both "business as usual" and other scenarios, demand for water will likely increase while supply will decrease over the next 25 years. To counteract the resulting likelihood of irrigation water shortages, agricultural research investments should be increased, and investments and policy reforms, including the elimination of power subsidies for pumping, should be implemented to increase basin efficiency and encourage diversification out of irrigated cereals.

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