Wetlands of Hindu Kush Himalayas - Ecosystem Functions, Services and Implications of Climate Change

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The Hindu Kush Himalayas is replete with wetlands distributed throughout the region at different latitudes, longitudes and altitudes. Fed primarily by melting glaciers, these wetlands play an enormous role in ecological and economic security of the region through their wide range of ecosystem services, including supporting local livelihoods, regulation of hydrological regimes, carbon sequestration and support to biodiversity. Despite their significant role, these wetlands are under threat due to degradation of catchments, water diversions, unsustainable tourism and other pressures. Climate change has severe implications for these wetlands through changes in hydrological regimes, biodiversity and unmanaged mitigation and adaptation responses. Integration of wetland restoration and sustainable management in adaptation strategies would enhance effectiveness of regional response to climate change. The present paper provides an overview of distribution and extent of wetlands of Hindu Kush Himalayan region, their functions and ecosystems services and implication of climate change. It also provides an outline for their integration into climate change adaptation strategies.

Wetland Extent and Distribution

The Hindu Kush Himalayas, which form a part of the Greater Himalayan Region includes the mountain territories of Afghanistan, Bangladesh, Bhutan, China, India, Nepal and Pakistan. The region is bound by the highly fertile Gangetic plains to the south and Tarim Basin in the north. To its east is the continental scarp that extends from Khingan Range in the northeastern China through Taihang Mountains to the eastern edge of the Yunnan-Guinzhou plateau dividing the low lying areas of China from the Quinghai-Tibetan Plateau. Extremes of altitudes, relief, climate, geology and geomorphology provide conducive environment for presence of a complex mosaic of landscapes. The region is replete with wetlands being present in diverse forms including rivers and floodplain marshes, peatlands, glaciated lakes, hot springs, seasonal waterlogged areas and manmade wetlands (Map 1). The altitudes above 3000 m amsl has glaciated lakes which have probably originated during the third Himalayan glaciations period. They are fringed by alpine wetlands found between 2000 – 2,500 m amsl altitudes. The third series is that of the valley lakes which are found at lower altitudes and mainly occur along river courses. Assessments based on the global lakes and wetlands database (Lehner and Doll, 2004) indicate the overall wetland extent to be 17% of the total area (Trisal and Kumar, 2008). However, these figures are subject to the accuracy of the datasets used and interpretation.

Wetlands within the Hindu Kush Himalayan region in China are mainly dispersed in the north, south and southeast part of the Qing-Tibetan Plateau. The alpine climate favours creation of a vast frozen soil layer which is conducive to formation of wetlands in the form of lakes, marshes and swampy meadows. Known as "simsar" in Nepal (meaning perennial sources of water), 16 glacial and 8 tectonic lakes have been identified of which Panch Pokhari, Dig Tsho, Tonju, Gosain Kund, Bhairav Kund, Tilicho, Phoksundo and Rara are most famous. Rara is the largest and deepest of the high altitude wetlands of Nepal followed by Phoksundo. Wetlands of Bhutan are found located within three clusters : (i))several lakes in the northwestern part of Jigme Dorji Wildlife Sanctuary (ii) eleven small lakes in western Bhutan and (iii) a cluster of six small lakes in eastern Bhutan (IUCN, 1989) . All the major rivers of the country viz the Drangme Chhu; the Puna Tsang Chhu; the Wang Chhu; and the Amo Chhu originate from wetlands. Within India, the wetlands are mostly located within the Leh and Ladakh regions in Jammu and Kashmir, parts of states of Uttaranchal, Himachal Pradesh, and seven northeastern states. Pangong Tso, Chushul Marshes, Hanle River Marshes, Tso Morari, Tso Kar, Wular, Loktak and parts of Mehao Sanctuary are wetlands of India falling within the Hindu Kush region. Tarbela and Mangla in Pakistan and Ab-e-Istadeh-ye-Moqor and Kajakai are key wetland systems of Pakistan and Afghanistan within the Hindu Kush

Himalayan region. Moyingyi and Indawngy are the major Hindu Kush Himalayan wetlands in Mynamar. All these wetlands are linked to their river basins, the major being Indus, Ganga, Bramhaputra, Irrawady, Salween, Mekong, Yangtze and Yellow.

Wetlands Ecosystem Functions and Services

Wetlands are the critical links between terrestrial and aquatic ecosystems and are characterized by high primary productivity and richest biodiversity on the earth. They store and purify water, recharge ground water aquifers, trap sediments and improvise water quantity and quality. The ecosystem services provided by the wetlands of the Hindu Kush Himalayas need to be understood in terms of their interconnectedness within the river basins and their linkages with biodiversity and socio-economic benefits particularly livelihoods of hill communities.

Located at the basin crests, these wetlands play an important role in capturing and retaining snow / ice melt and wherever possible rainfall, releasing water progressively and therefore act as suppliers and regulators of water for the entire basin. Himalayan glaciers cover approximately 3 million ha, or 17% of the global mountain area. With an area of 35,110 sq km and ice reserve of 3, 735 cu.km, they are the largest bodies of ice outside the polar caps (Dyurgerov and Meier, 2005). Such a high concentration of freshwater and ice has aptly earned the region a designation of 'third pole' of earth. The wetlands, by capturing this glacial melt, form the source of eight large rivers of Asia, basins of which support more than 500 million population (19% of global population) living within India, Bhutan, Afghanistan, Nepal, China, Cambodia, Bangladesh, Pakistan, and Myanmar. With the contribution of snow and glacial melt to the major rivers in the region ranging from less than 5% of the average flow of the Irrawady River to more than 45% of the Indus River, regulation of flow regimes and flow support in the lean seasons becomes critical to sustenance of economic development in the downstream reaches of their associated basins (Jianchu *et al.*, 2007).

The wetlands also play an important role in mitigating climate change by acting as carbon sinks. The peatlands in China are one of the most important stores of carbon in the mountain regions storing 1500-4000 tonnes per ha or up to 8-20 times more than mountain forests and 50-100 times more than mountain grasslands. The peatlands in the plateau store 750 million tonnes of carbon equivalent to 2.7 billion tonnes of CO_2 (equivalent to 7.5 times the annual fossil fuel emissions from the whole transportation sector in China).

The wetlands of the Hindu Kush Himalayas are also associated with high biodiversity values. The relatively young Himalayan mountain ranges have opened up new southward routes of migration and colonization into what had hitherto being an island. A range of high altitude lakes within Himalayas acts as stopover habitats for paelarctic species migratory from West. Similarly on the East species migrating from East/Southeast Asia act as stopover for the migratory birds which later get spread over the entire Indian sub continent constituting Central Asian Flyways (Trisal, 1996). The Rourgei marshes are an important breeding habitat especially for summering and breeding populations of black-necked cranes, *Grus nigricollis*. Tso Morari is an important breeding ground for the bar headed geese (*Anser indicus*) and supports significant population of great crested grebe, Brahminy duck, ruddy shelduck, lesser sand plover, black necked cranes (*Grus nigricollis*) and black necked grebes (*Podiceps nigricollis*) (Mishra and Humbert, 1998; Chandan *et al.*, 2006). In the eastern Himalayas, wetlands situated in Sikkim, Assam, Arunachal Pradesh, Meghalaya, Nagaland and Manipur together with sanctuaries of Brahamputra valley are internationally important for a number of bird species.

Wetlands of Central and Eastern Himalayas support an extremely varied mammalian fauna including several rare and threatened species. Over 40 species listed in schedule – I of Indian Wildlife (Protection) Act, 1972, are found within wetland sanctuaries. *Cervus eldi eldi* is the most endangered species now confined to Keibul Lamjao National Park in the Loktak Lake (Trisal and Manihar, 2004) . The Kaziranga National Park containing 15 species of India's threatened mammals and has the largest population of one horned rhinoceros in the world. The high altitude wetlands are also important from the perspective of fisheries, particularly cold water fisheries. Species of *Schizothorax, Orienus, Schizothorichthys* and *Tor* dominate the high altitude wetlands of Nepal and India (Raina, 1999; Swar, 2002).

Despite being located within mountainous terrains, the wetlands of the Hindu Kush Himalayas are closely linked to culture and livelihoods of several communities, which have traditionally linked their identity and existence to these ecosystems. The Rourgei marshes are home to close to 50,000 nomadic Tibetan herders leading a traditional pastoral lifestyle. High altitude wetlands are centers for cultural and religious identity for several communities. Gosaikund, Damodarkund, Bramhakund, Rinmoksha Daha in Nepal and Sheshnag, Tarsar, Marsar and Gangbal are some examples of high altitude wetlands that are revered by the Hindus for occupying special places within their religion and cultures. Similarly, the Buddhists hold high altitude wetlands as Gosaikund in high reverence as several of their teachers as Padmasambhava and Milerepa are believed to have obtained their spiritual insights within these wetlands. Rich scenic beauty located within pristine environs makes these wetlands centres of touristic attractions.

Climate Change in the Hindu Kush Himalayas

The entire Himalayan region is facing tremendous pressure due to increasing temperatures. The Himalayan region including the Tibetan Plateau has shown consistent trends in warming over the last 100 years. The third assessment report of IPCC predicts warming by 3^0C in the decades of 2050s and about 5^0C in the decades of 2080s over the land area of Asia as a result of future increase in atmospheric concentration of green house gases. The stresses of climate change are likely to disturb the ecology of mountains and highland systems in Asia.

One of the key consequences of rising temperatures is on the overall glacial cover within the Hindu Kush Himalayan region. Glaciers in the Himalaya are receding faster than any other part of the world and if the present rate continues the likelihood of them disappearing by the year 2035 in perhaps is sooner very high and if the earth keeps warming at the current rate. The total area is likely to shrink from the present 500,000 to 100,000 by 2035 (WWF, 2005). An example of the rapid retreat is in the Gangotri Glacier which within the last three decades receded at rates three times that of during the preceding 200 years (Srivastava, 2003).

Glacial melt play an important role in supporting perennial rivers in the Hindu Kush Himalayan region, which in turn are the lifeline of the millions of people of South Asian countries. The Gangetic basin alone is home to 500 million people, about 10% of the total human population. As glaciers melt, river runoff is expected to l initially increase in winter or spring but eventually decrease as a result of loss of ice resources. This drastic reduction has a serious consequence for the downstream developmental activities, particularly agriculture. The current trends of glacial melt suggest that the Ganges, Indus, Bramhaputra, and other rivers criss crossing the Indian plains could likely become seasonal rivers affecting downstream economies, particularly war availability for agriculture and ultimately the food security for the region.

The other important consequence of climate change is on the variability of flows, as the peak flows increase and lean season flows decline. This would then lead to flooding risks in the wet seasons and water shortage and even long dry spells in the dry seasons. This would increase the water stress, which is evidenced in decline in agricultural productivity in many parts of the Asia. The yield of rice has been reported to decrease by 10% for every 1^0C increase in growing – season minimum temperature (Pang et. al, 2004). The gross per capita water availability in India is projected to decline from 1820 cum/year in 2001 to as low as 1140 cum/year in 2050. India will reach a state of water stress before 2025 when the availability falls below 100 cum/capita (CWC, 2001). Intense rain occurring over fewer days implies increase in floods and decrease in ground water rechargeable potential. Expansion of areas under severe water stress will be one of the most pressing environmental topics as number of people living under severe water stress conditions is likely to increase substantially.

Climate change also has severe implications for biodiversity within the region. About 50% of Asia's total biodiversity is at risk due to climate change. Large populations of many species could be extirpated as a result of synergic effects of climate change and habitat fragmentation. Within the Himalayan region, a shift of species to the higher elevations is projected. Species with restricted habitat availability run the risk of habitat fragmentation, loss or even extinctions is they cannot move, particularly after an increase of 2ºC (Dirnbock *et al.*. 2003). As a result of rapid melting of glaciers, glacial runoff and frequency of glacier lake outburst causing mud flows and avalanches have increased (WWF, 2005).

The ultimate impact of these changes would be on the livelihoods of a large population of Asia living below social and economic poverty threshold. In absence of opportunities poverty striking communities are left with no option but utilize even the disaster prone areas, unproductive lands and ecologically fragile areas that have been set for protection purposes with climate change the poor sectors will be most vulnerable and without appropriate measures and will continue to slow down the economic role in developing countries of Asia (Cruz *et al.*., 2007)

Implications of Climate Change for Wetlands and Ecosystem Services

Climate change has several implications for wetlands and their ecosystem services. Though definitive assessments for the wetlands of the region in the context of climate change remain a major research gap, increasing temperatures and associated changes in flow regimes are expected to significantly alter their extent and distribution. For the high altitude wetlands, changes in glacial extent can have tremendous impact on the extent of the wetlands. Due to melting of Himalayan glaciers more than 9000 glacier lakes have been formed many have them the potential with dangerous disasters in the form of Glacier Lake Outburst Floods (GLOFs). An assessment carried by ICIMOD has led to identification of 200 potentially dangerous glacial lakes in the region with a potential to wash off entire livelihoods through creation of catastrophic floods (Bajracharya, 2007). In some parts of the Himalayan region about 30% of the lakes and marches have disappeared during last 30 years due to effects of climate change and over exploitation of wetland resources. Peatlands also are quite vulnerable due to warming and droughts conditions. Within the mid altitudes, the wetlands are very likely to be affected by changes in hydrological cycles, which include increase in glacial runoff and shifting monsoonal patterns.

The other range of impacts on wetlands is likely to emerge from the unsustainably managed and ill-informed climate change mitigation and adaptation strategies. One of the key conclusions of the climate based assessments within Asia is the likelihood of declining productivity of agriculture, and increase in catastrophic events as floods and droughts. Historically, responses to similar situation have been biased towards structural approaches as flow regulation through dams and reservoirs, embankments, channelization and bringing additional areas under food production. All of these responses have a potential to accentuate wetland conversion, changes in hydrological regimes, pollution, and habitat fragmentation.

Wetland ecosystem services and climate change adaptation

Wetlands have a tremendous role in adapting to the impacts of climate change. Through their inherent capacity to regulate flow regimes, wetlands can provide a stable flow of water by storing glacial melt and runoff and gradually releasing them over a period of time. Wetlands also recharge groundwater aquifers during wet seasons thereby maintaining moisture during the drought periods. Peatlands act as carbon stores, thereby preventing their release in atmosphere. Loss of wetlands and their associated ecosystem services would thereby enhance vulnerability of the communities to climate change. An example of this is evidenced in wetlands of Jhelum Basin. Loss of extensive marshes that formed contiguous parts of the high altitude wetlands of River Jhelum is known to have induced a reduction in hydrological regulation capacity of the wetlands leading to increase in frequency of floods and droughts within the Kashmir Valley (Fig 1) (WISA, 2007).

One of the key efforts in integration of wetland ecosystem services into climate change adaptation strategies within the region has been the promotion of ‘Himalayan Wetland Initiative’ envisaging establishment of framework for regional cooperation within the Hindu Kush Himalayan countries under the ambit of Ramsar Convention on Wetlands. The initiative, through regional action, emphasizes to integrate conservation wise use of wetlands into water and other natural resources management and land use planning and contribute to an effective climate change adaptation strategy. Though still waiting formal ratification by all member countries as on date, priority issues for have been identified for enhanced cooperation, improved ecological status and livelihoods of the people specific to Himalayan wetlands. The priority issues identified are: (i) inventory and assessment of HAW services and values; (ii) climate change impacts on wetlands functions and values; (iii) engaging participatory involvement of all stakeholders including private sector; (iv) enhancing improved awareness of wetland values and services at local community and government level; (v) promotion downstream and upstream linkages; (vi) developing effective networking between various stakeholders and (viii) addressing common issues of ecological safety (wetlands – related disasters). The recently concluded workshop on Himalayan Wetlands and Initiative Strategy held in Kathmandu on 1 – 3 September, 2008, recommended following strategic areas:

- Develop database methodologies on Himalayan wetlands
- Develop mechanism and facilities for cooperation, networking and capacity building
- Improve knowledge of climate change impacts and of adaptation responses
- Devise and promote best practices on Himalayan wetlands management
- Develop participatory CEPA programmes
- Develop policy support for implementation of wetland conservation

Considering wetlands as a part of the overall hydrological regime, a key prerequisite for achieving effective conservation and wise use of wetlands of Hindu Kush Himalayas is their integration into river basin management framework. The framework aims at coordinating conservation, management, and development of water and land related resources across sectors within a given basin, in order to maximize the economic and social benefits derived from water resources in an equitable manner and preserving and wherever necessary restoring freshwater ecosystems. Integration of wetlands of the region is therefore a useful framework for achieving conservation and wise use of wetlands and mainstreaming their ecosystem services into wider conservation and development contexts. Despite this recognition, there is a very limited integration of wetlands within river basin management policies, plans and strategies. A review of the water and wetland sector policies and strategies in four countries (Bhutan, China , India and Nepal) by Wetlands International – South Asia indicated a sectoral approach within these two sectors with very limited degree of integration (Trisal and Kumar, 2008). This limits communication between the two sectors often leading to changes in water regimes detrimental to wetland ecosystems. Lack of effective capacity within the region to assess the intersectoral linkages and their integration in water resources planning and management is the key factor limiting harmonization of these sectors. Balancing water use for human needs and ecological purposes is one of the key challenges that remains to be addressed.

There is an urgent need for implementing a capacity building strategy for the the region to ensure integration of wetlands within river basin management. Based on a regional consultation process led by Wetlands International involving government and non government organizations from Bhutan, China, India and Nepal, the following capacity building needs were identified for the region:

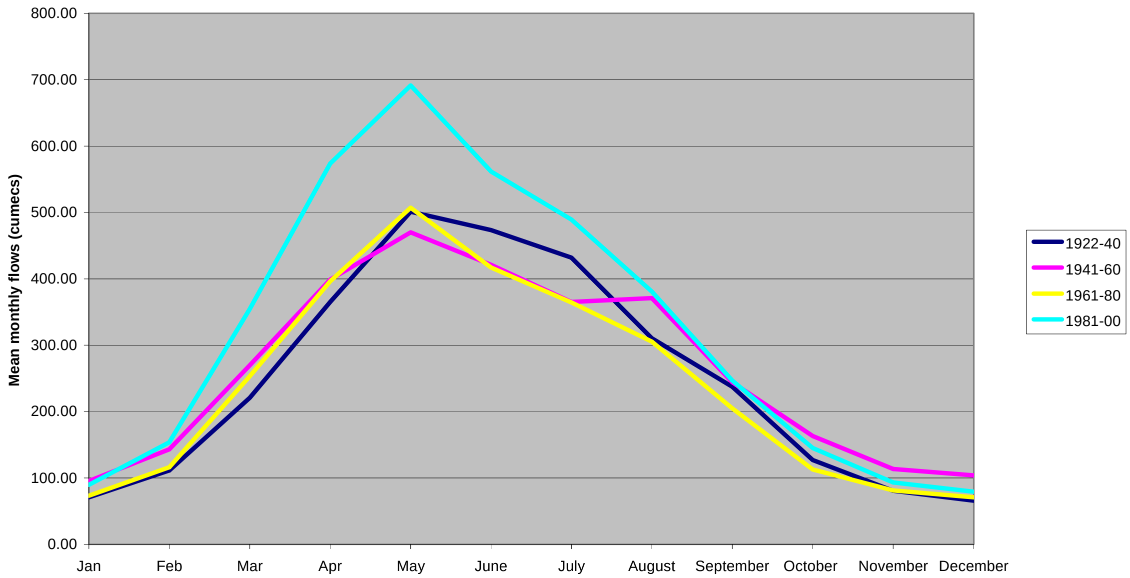
a) IRBM framework for Himalayan Region balancing the socio-political contexts and management planning requirements
b) Needs for methods and tools for inventory and assessment; river basin level management planning; water allocation for human and ecological purposes; valuation of ecosystem services ; incentive systems for balancing conservation and development needs; and modeling impacts of climate change at relevant resolutions
c) Institutional level needs for data access and sharing and multistakeholder and multisectoral communication and cooperation

The capacity building strategy to address the above needs to include (i) creating appropriate institutional mechanisms for imparting training to wetland managers, policy planners, decision makers and other relevant stakeholders; (ii) developing online traning models and training materials ; (iii) developing monitoring and review processes to access the efficiency of capacity building processes and adaptations as may be necessary; (iv) creating network of wetland managers for collaborative research and knowledge base development ; and (v) developing tool kits as a mechanism for information sharing about application of Asian Wetland Inventory , hierarchical information at sub-basin wetland complexes and wetland level to monitor changes in ecological character of the wetlands and its interpretation in terms of upstream – downstream linkages.

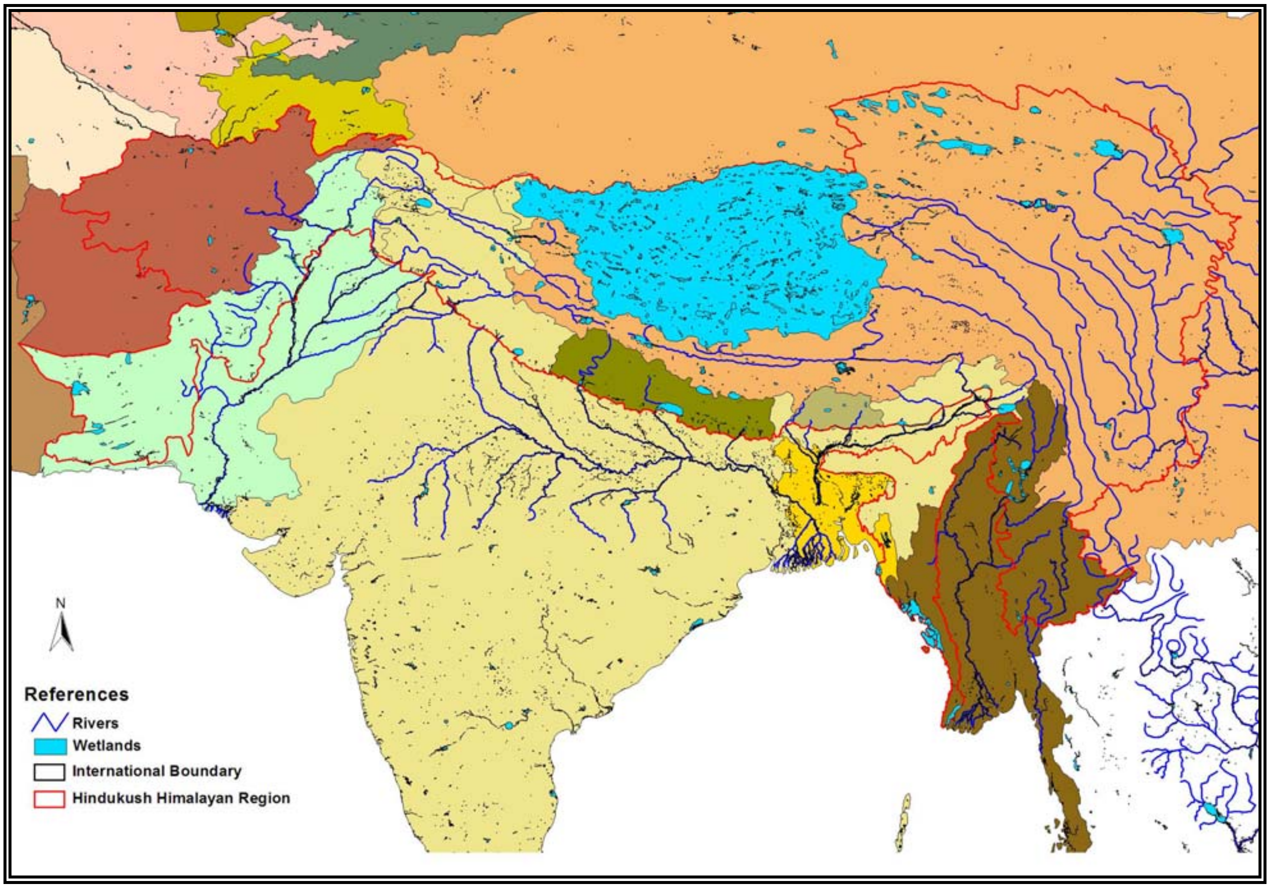
Conclusion

Integration of ecosystem functions and services of wetlands of Hindu Kush Himalayan region is an effective adaptation strategy against the rapidly emerging pressures due to climate change. There is an urgent need for undertaking and promoting cross sectoral and multiscalar regional action for achieving this integration. This should be supported by an intensive capacity building process involving wetland managers, policy planners, decision makers as well as local stakeholders to enable effective wetland management and restoration.

Fig 1: Changes in Mean Monthly Flows of River Jhelum at Baramulla, Kashmir , India



The overall volume of water in River Jhelum passing Baramulla has been increasing steadily over the years. Conspicuous to the flows are the presence of distributed peaks during May – August. These are attributed to the wetlands of the basin, which played a role in absorbing the peak flows and releasing them gradually during lean periods. With destruction of these wetlands, this flow moderation is no longer achieved, leading to floods and droughts.



Map 1: Wetlands of Hindu Kush Himalayas (Source: Drawn based on Lehner and DÖll, 2004 and Jarvis *et al.*., 2008)

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