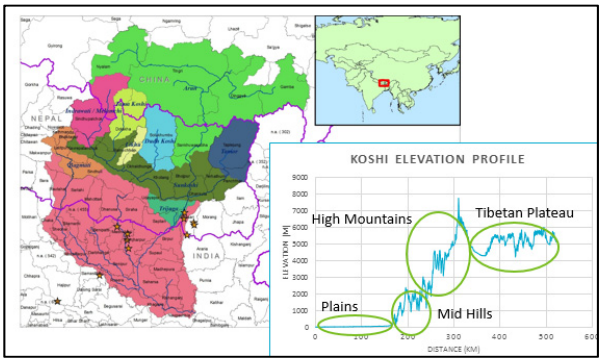
Connecting flow and ecology in Nepal: current state of knowledge for the Koshi Basin

Nepal's plentiful water resources require careful management to ensure equitable use across the many competing facets of water consumers. However, freshwater ecosystems in the Basin are increasingly vulnerable to anthropogenic and climate changes. It is critical to understand the ecological water requirements of aquatic ecosystems in order to manage water resources and protect the ecosystems.

Koshi River Basin

Freshwater within the Koshi River Basin is an important ecosystem, and its interface with other ecosystems is crucial to manage ecosystem services. The Basin has high potential for future hydropower and irrigation in downstream locations, both of which can make a significant contribution to the economic development of the region. However, freshwater ecosystems in the country are increasingly vulnerable to such anthropogenic and climate changes, which will increasingly threaten future water availability if not managed appropriately.



Linking river flow and ecology

A systematic approach is required to capture our current understanding of the links between river flow and the freshwater ecosystems supported by these water resources. A recent published report, summarised within, focuses on the relationship between river flow and ecology to increase our understanding of how future hydrological changes in the Koshi Basin (and beyond the Basin) might impact different ecological components of the ecosystem.

This fact sheet summarises the findings of a study conducted in 2015-16 by Nepali and Australian scientists.

The study report was launched at the Australian Embassy in Kathmandu in June 2016, and can be downloaded from http://research.csiro.au/sdip

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Report co-authors were from the International Centre for Integrated Mountain Development (ICIMOD), Bird Conservation Nepal (BCN), Zoological Society of London, World Wildlife Fund (WWF), Ministry of Forests & Soil Conservation, National Animal Science Research Institute, Department of Hydrology & Meteorology, the Himalaya, IUCN, and Tribhuvan and Kathmandu Universities.

Summary of the quantitative* and qualitative* flow ecology relationships

Wild Water Buffalo

Water Buffalo are a species on the brink of extinction in Nepal, yet there is little known in relation to its key habitat and water requirements.

Quantitative

- a requirement for alluvial tall grassland composed of 80% *Saccharum spp* for grazing
- a requirement to wallow 6-8 hours a day to cool themselves

Qualitative

- require mixed riverine forest in order to have shade and to exfoliate after wallowing.

Fish

Quantitative

- a requirement (in general) of a dissolved oxygen threshold of between 5–7 mg/L
- a maximum water temperature of 28.16 (±0.19) °C and minimum water depth of 3.0-3.6 m are unfavourable for most fishes
- Snow Trout (*Schizothorax spp*) need to migrate upstream to spawn in March–June at water temperatures between 14–21°C. They also require clear water of depths 30–60 cm to lay eggs in gravel along stream banks
- Common and Grass carp (*Cyprinus carpio, Ctenopharyngodon idella*) require a water temperature between 10-25°C for reproduction

Qualitative

- high longitudinal river connectivity; oxygenated, unpolluted freshwater; and minimal macrophyte area enhance fish and fishery viability.

Birds

Many bird species are listed as threatened.

Quantitative

Water birds

- Lesser Adjutant Stork (*Leptoptilos javanicus*) nests in trees greater than 30 m tall

Grassland birds

- Swamp francolin (*Francolinus gularis*) prefers high density grass 2–3 m tall
- Bengal florican (*Houbaropsis bengalensis*) males prefer moist, short, pure grassland 15–35 cm tall
- Bengal florican (Houbaropsis bengalensis) females prefer moist grassland taller than 110 cm

Qualitative

- many species access water-dependent food sources such as fish, snails, reptiles, insects and tubers, while other species nest along river banks or in water dependent grassland.

***Quantitative** data express specific thresholds to flow change, which once exceeded cause a change (generally a decline) in native species populations; **qualitative** data refer to knowledge which comes from observation but which hasn't been scientifically tested to determine a specific threshold to flow change

Ganges River Dolphin

The future of the Ganges River Dolphin is also highly threatened and their national population is low. The population in the Koshi Basin is the only one in eastern Nepal.

Quantitative

- a water depth requirement for adult/calf pairs of less than 2.2–2.4 m depth, sub-adults require >3.8 m depth and adults require >5 m
- gillnets that go to 4.5 m depth are a threat to dolphin life as dolphins swim primarily in that depth range and cannot get under nets
- a requirement for channels with a cross-sectional area of >700 m^2 to ensure foraging opportunities

Qualitative

- high lateral and longitudinal connectivity
- flow to be maintained where streams converge to create eddy counter currents
- move both ways through barrages.

Crocodile

The Gharial is extinct in the Basin, with only Mugger crocodiles present.

Quantitative

- a requirement for substrate for basking which is composed of 62% sand/sand bar and 37% rocky substrate
- require shade by 14:00 in winter to manage thermoregulation
- different water depth requirements depending on size. Juveniles require 1-3 m depth, if 120-180 cm long, require 2-3 m but will use >4 m water depth if available, adults require water depth >4 m

Qualitative

- Muggers require basking substrate which is close to deep water and good habitat for camouflage. This includes good riparian vegetation, suitable water depth and river banks which are suitable for burrowing
- require an ability to travel both upstream and downstream. Can currently only travel downstream due to barrage installation.

Macroinvertebrates

Macroinvertebrates are little studied in Nepal but are known key indicators of flow in other regions of the world.

Qualitative

- taxon richness is maintained in areas with little or no flow alteration.

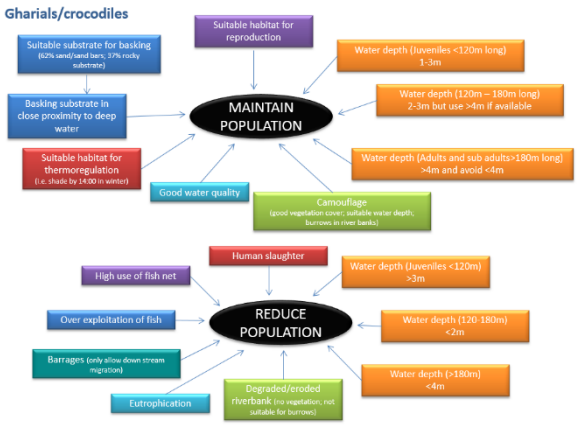
Flora and Biodiversity

The flow-ecology relationships for flora were difficult to identify in the literature, however a comprehensive understanding of the biodiversity values of both flora and fauna exists, from one of the most diverse regions of the world.

For each ecological component (e.g. fish, birds, buffalo) we developed **conceptual models.** These provided a means to:

- consolidate current research and increase understanding of how river flow and ecology interact
- highlight important flow thresholds required to maintain ecological condition
- incorporate the relationships between river flow, ecology and livelihoods
- identify knowledge gaps.

Using expert knowledge, workshops and literature reviews, conceptual models were created for wild water buffalo, fish, crocodiles/gharials, invertebrates, flora and the freshwater Ganges River Dolphin.



Additional information was collated to provide context around the current understanding of threats to aquatic ecosystems in relation to flow change; water regimes and environmental water requirements; and the importance of biodiversity to support livelihoods in the Basin. Overall, there is a paucity of published studies which investigate the water requirements of the selected ecological components in the Koshi Basin and Nepal in general.

For the first time in Nepal and the Koshi River Basin, qualitative and quantitative flow-ecology relationships have been collated: **quantitative** data express specific thresholds to flow change, which once exceeded cause a change (generally a decline) in native species populations; **qualitative** data refer to knowledge which comes from observation but which hasn't been scientifically tested to determine a specific threshold to flow change. Many knowledge gaps exist which will be the focus of future research.

Knowledge gaps

- lack of floristic and faunal inventory at the Basin Scale
- lack of knowledge to relate connectivity between terrestrial, riparian and aquatic systems
- importance of hydrological connectivity upstream and downstream
- quantitative and qualitative relationships for all ecological components especially river birds and macroinvertebrates.

Next steps

SDIP2 is a four-year programme, funded through the Australian Government's Department of Foreign Affairs and Trade, with the goal of increased water, food and energy security in South Asia to support climate resilient livelihoods and economic growth, benefiting the poor and vulnerable, particularly women and girls.

CSIRO is a key partner in SDIP2 and its ecology programme in Nepal includes activities to build the knowledge base on water-ecology-livelihood relationships that are necessary to conduct integrated assessment of changes in flow regimes. We are working to align these activities with other key knowledge players in the region, especially universities.

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