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# Assessment of Water Resources Management & Freshwater Biodiversity in Nepal

## Final Report

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Disclaimer: The views expressed in this document are the views of the authors. They do not necessarily reflect the views of the United States Agency for International Development or the United States Government

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## DEDICATION

This assessment report is dedicated to Jon Breslar for his leadership of USAID/Nepal's engagement on water resources management in Nepal the last time 'round in the mid-1980s. As a junior Foreign Service Officer, Jon was deeply involved in the design and then managed the Irrigation Management Project (IMP) and supported the International Irrigation Management Institute (IIMI – now IWMI, the International Water Management Institute) in their pioneering work on Farmer-Managed Irrigation Systems (FMIS). An anthropologist in a world dominated by engineers, he insisted on careful attention to the social and institutional dimensions of these programs. He was passionate about donor coordination, and developed strong and effective collaboration with both the World Bank and the Asian Development Bank (ADB). Echoes of his work continue to this day. After leaving Nepal, Jon rose rapidly into the senior ranks of USAID management, but he never forgot where he had come from and always had a special place in his heart for his early work with farmers, government counterparts and USAID and other donor colleagues in Nepal. He passed away in 2005 at the much-too-young age of 56.

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## Acronyms

| | |
|---|---|
| ADB | Asian Development Bank |
| AEC | Aquatic Ecology Centre (Kathmandu University) |
| AEPC | Alternative Energy Promotion Centre |
| BFS | Bureau for Food Security |
| BUILD | Biodiversity Understanding in Infrastructure & Landscape Development |
| CA | Constitutional Assembly |
| CBO | Community Based Organization |
| CCD | Climate Compatible Development |
| CGIAR | Consultative Group on International Agricultural Research |
| CHAL | Chitwan-Annapurna Landscape |
| CHARIS | Contribution to High Asia Runoff from Ice & Show |
| CRF | Climate Resilience Framework |
| DDC | District Development Committee |
| DFID | Department for International Development (UK) |
| DHM | Department of Hydrology and Meteorology |
| DoA | Department of Agriculture |
| DoI | Department of Irrigation |
| DOLIDAR | Department of Local Infrastructure Development and Agricultural Roads |
| DNPWC | Department of National Park and Wildlife Conservation |
| DoF | Department of Forest |
| DRRO | Disaster Risk Reduction Office, USAID/Nepal |
| DSCWM | Department of Soil Conservation and Watershed Management |
| DWIDP | Department of Water Induced Disaster Prevention |
| DWSS | Department of Water Supply and Sewerage |
| E3 | Bureau for Economic Growth, Education and Environment |
| EGH | Environment Graduates in the Himalayas (Resources Himalaya) |
| EIA | Environmental Impact Assessment |
| ENV | Environment |
| EU | European Union |
| FAO | Food and Agriculture Organization |
| FECOFUN | Federation of Community Forest Users, Nepal |
| FEDWASUN | Federation of Water and Sanitation Workers in Nepal |
| FMIS | Farmer-Managed Irrigation Systems |
| FNCCI | Federation of Nepalese Chamber of Commerce and Industry |
| FSM | Fecal Sludge Management |
| FWB | Freshwater Biodiversity |
| GESI | Gender Equity & Social Inclusion |
| GLOF | Glacier Lake Outburst Floods |
| GoN | Government of Nepal |
| HiCCDRC | Himalayan Cryosphere, Climate and Disaster Research Center (KU) |
| HighARCS | Highlands Aquatic Resources Conservation & Sustainable Development |
| HIMALI | High Mountain Agribusiness and Livelihood Improvement |
| HIMAWANTI | Himalayan Grassroots Women's Natural Resource Management Association |
| ICCA | Initiative for Climate Change Adaptation |
| ICIMOD | International Centre for Integrated Mountain Development |
| iDE | International Development Enterprises |
| IDRC | International Development Research Center |
| IFC | International Finance Corporation |

| | |
|---|---|
| IFPRI | International Food Policy Research Institute |
| IIMI | International Irrigation Management Institute (now IWMI) |
| IMP | Irrigation Management Project |
| IMTP | Irrigation Management Transfer Project |
| INGO | International Nongovernmental Organization |
| IPCC | Intergovernmental Panel on Climate Change |
| IRMI | Inclusive Resource Management Initiative |
| ISET | Institute for Social and Environmental Transition |
| ISPAN | Irrigation Support for Asia and the Near East |
| IUCN | International Union for the Conservation of Nature |
| IVLP | International Visitors Leadership Program |
| IWMI | International Water Management Institute |
| IWRM | Integrated Water Resource Management |
| JICA | Japan International Cooperation Agency |
| KISAN | Knowledge-based Integrated Sustainable Agriculture and Nutrition Program |
| KU | Kathmandu University |
| LAPA | Local Adaptation Plan for Action |
| LI-BIRD | Local Initiatives for Biodiversity, Research and Development |
| LOE | Level of Effort |
| MCC | Millennium Challenge Corporation |
| MCCICC | Multi-Stakeholder Climate Change Initiatives Coordination Committee |
| MoAC | Ministry of Agriculture and Cooperative |
| MoE | Ministry of Energy |
| MoF | Ministry of Finance |
| MoFALD | Ministry of Federal Affairs and Local Development |
| MoFSC | Ministry of Forest and Soil Conservation |
| MoI | Ministry of Irrigation |
| MoSTE | Ministry of Science, Technology and Environment |
| MoUD | Ministry of Urban Development |
| MoWR | Ministry of Water Resources |
| MUS | Multiple Use Systems |
| NAPA | National Adaptation Program of Action |
| NARA | Nepal Association of Rafting Agencies |
| NARC | Nepal Agricultural Research Council |
| NAST | Nepal Academy of Science and Technology |
| NAVIN | National Association of Village Development Committees in Nepal |
| NEFIN | Nepal Federation of Indigenous Nationalities |
| NCS | National Conservation Strategy |
| NCSA | National Capacity Self Assessment |
| NCSF | National Conservation Strategic Framework |
| NDRI | Nepal Development Research Institute |
| NEA | Nepal Electricity Authority |
| NEC | Nepal Engineering College (Pokhara University) |
| NFIWIAN | National Federation of Irrigation Water Users Association, Nepal |
| NGO | Non-Governmental Organization |
| NPC | National Planning Commission |
| NRM | Natural Resources Management |
| NTNC | National Trust for Nature Conservation |
| NWCF | Nepal Water Conservation Foundation |
| NWP | Nature, Wealth & Power / National Water Plan |

| | |
|---|---|
| ODF | Open Defecation Free Zone |
| PACT | Private Agencies Collaborating Together |
| PAPA | Participating Agency Program Agreement |
| PC | U.S. Peace Corps |
| PIO | Public International Organization |
| PPCR | Pilot Program for Climate Resilience |
| PSS | Philanthropy Support Services Inc. |
| PSHDP | Private Sector Hydropower Development Project |
| Ramsar | Convention on Wetlands of International Importance (signed in Ramsar, Iran) |
| RDMA | Regional Development Mission for Asia (USAID) |
| SaciWATERs | South Asia Consortium for Interdisciplinary Water Resources Studies |
| SAWI | South Asia Water Initiative |
| SEED | Social, Environmental and Economic Development Office, USAID/Nepal |
| SIMI | Smallholder Irrigation Market Initiative |
| SIWI | Stockholm International Water Institute |
| SOW | Statement of Work |
| SPCR | Strategic Program for Climate Resilience |
| TAL | Terai/Tarai Arc Landscape |
| TMI | The Mountain Institute |
| TU | Tribhuvan University |
| UNCCD | United Nations Convention to Combat Desertification |
| UNDP | United Nations Development Program |
| UNFCCC | United Nations Framework Convention on Climate Change |
| USAID | United States Agency for International Development |
| USFS | United States Forest Service |
| USG | United States Government |
| USGS | United States Geological Survey |
| USFWS | United States Fish and Wildlife Service |
| VDC | Village Development Committee |
| WAFED | Water and Energy Users Federation |
| WASH | Water and Sanitation for Health/Hygiene |
| WB | World Bank |
| WECS | Water and Energy Commission Secretariat |
| WLCN | Women Leading for Change in Natural Resources Management Network |
| WM | Watershed Management |
| WOCAN | Women Organizing for Change in Agriculture and Natural Resources Management |
| WRI | World Resources Institute |
| WRM | Water Resources Management |
| WRS | Water Resources Strategy |
| WWF | World Wildlife Fund/Worldwide Fund for Nature |

# Executive Summary

## Assessment Purpose, Background & Objectives

*Purpose:*

To conduct country-level water resources management (WRM) and freshwater biodiversity (FWB) analyses for Nepal in order to inform the design of a new five-year USAID/Nepal Natural Resources Management (NRM) project (2015-2019).

*Background*:

Water is arguably **the** most important of all natural resources; it is essential to life, and in many ways it **is** life. Through the global water cycle, water is literally the connection between the heavens and the earth. From an international development perspective, water is a cross-cutting theme par excellence: it is in one way or another part of virtually all "sectors" (agriculture, health, energy, drinking water & sanitation, environment, governance, the combination of these into economic growth, both urban & rural development, etc.) and linked to many other of the most important cross-cutting themes: gender & social inclusion, community participation, the involvement of both civil society and the private sector. Water is also an important theme in a vertical sense as a key natural resource that is at the center of human and power relations and dynamics between the individual, family and community up through scales to the national level and from the national level up through the regional level (i.e. Nepal's relations with China, India and Bangladesh) to a global level.

On the biological side of the equation, biodiversity is important not just for its own sake, but also in at least three other ways: 1) ecosystem services - biodiversity is directly linked to livelihoods for many Nepalese (disproportionately relevant to women and marginalized groups) and contributes to water quality and economic development, 2) ecosystem health - if we are paying attention, the monitoring of biodiversity can serve an important canary-in-the-coal-mine function to indicate when ecosystem health is failing, and 3) Government of Nepal's international commitments - Nepal is a signatory to all of the key international biodiversity conventions including the Convention on Biodiversity and the Convention on Wetlands of International Importance (RAMSAR). In addition, climate change is having, and will continue to have, huge impacts on biodiversity. Understanding climate change vulnerability, adaptation and building resilience needs to be applied not just to human systems but to natural ecosystems on which these human systems depend.

*Objectives*:

1) To prepare a summary report on the status of fresh water biodiversity and water resources management in Nepal
2) To make recommendations for USAID/Nepal to address the conservation and development challenges associated with the two sectors.

## The Assessment Process

USAID/Nepal requested the assistance of the United States Forest Service (USFS) in conducting this assessment. The USFS hired the Team Leader (George Taylor) through Philanthropy Support Services (PSS) Inc. and provided two USFS experts, a forest hydrologist/watershed planner (Mark Weinhold) and a freshwater ecologist (Susan Adams). USAID hired a local firm –

NDRI – to provide two Nepali technical experts (Nawa Raj Khatiwada and Tara Nidhi Bhattarai) and logistics backup (led by Ms. Sona Shakya).

The Assessment was carried out in June/July 2014. It began with an extensive literature review and meetings for the Team Leader in Washington with USAID and Forest Service staff along with several DC-based groups active in Nepal. It continued with three weeks in Nepal for the Team Leader, conducting many interviews in Kathmandu along with the NDRI members of the Team, and two weeks for the USFS experts. Of those two weeks, six days were spent outside the Kathmandu Valley on field trips to the Indrawati Watershed and on a five day circuit that included Pokhara, Palpa, Butwal, Lumbini and Sauraha/Chitwan. USAID Environment Team staff accompanied the Assessment Team on these field visits. The Kathmandu portion of the Assessment concluded with an Out-Brief on July 25th.

**Recommendations**

Two streams of USAID funding (climate change adaptation and biodiversity conservation) are available for the new NRM project.[2] The Recommended Themes and Program Ideas listed below and presented in detail in Section IV of the report have been developed with these boundaries clearly in mind.

Using inputs from many sources the Assessment team developed a series of nine priority Recommended Themes and Program Ideas for USAID support of water resources management and freshwater biodiversity:

1) Understanding water resources management (WRM) and freshwater biodiversity (FWB): critical knowledge/research gaps
2) Re-invigorating the policy & program framework for water resources management
3) Promoting hydropower sustainability
4) Addressing the impacts of infrastructure development on WRM & FWB
5) Developing watershed management best practices
6) Urban water: harnessing the private sector
7) WASH: linking into the NRM/water resources mainstream
8) Supporting Gender and Social Inclusion in WRM & FWB
9) Incorporating support from across the USG & weaving water into ongoing USAID programs.

Looking back at USAID investments in NRM in Nepal over the past 30 years, coupled with both the challenges & opportunities of the current situation and what other donors are currently supporting, the Assessment Team believes that the highest and most strategic priorities for USAID programming in water are four fold:

1) Add fresh water biodiversity to the conservation & development mix.
2) Support the long-term science needed to: 1) understand climate change (using water as the single most important lens) including predictions to the extent feasible; and 2) monitor the adaptation of social & production systems (i.e. agriculture, transhumant livestock and other forest, grassland and lake & river-based systems) both to climate change and to other key drivers of socio-economic development (i.e. local & regional markets, transportation systems and communications technologies).

[2]The one exception is the WASH component which receives funding from the USAID Water/WASH earmark.

3) Work with the Government of Nepal (GoN), other donors and civil society to promote and re-invigorate a holistic "whole of government" approach to water resources management.
4) Support innovative bottom-up, top-down, and outside-in initiatives that promote inclusive, just and lasting social change.[3]

Two additional program areas that are both high priorities and through which USAID/Nepal can make an important difference are:

- Urban water: harnessing the private sector, and
- WASH: linking WASH programming into the NRM/WRM mainstream.

Four cross-cutting themes deserve careful and concerted attention, and are described in more detail below:

- The regional dimensions of water
- Hydropower sustainability
- The gender and social inclusion dimensions of water, including land and natural resource tenure, and
- A "whole of government" approach to U.S. Government (USG) support for water resources management and freshwater biodiversity in Nepal.

*The regional dimensions of water*:

The regional context of water, water resources management and freshwater biodiversity are central to any comprehensive understanding of water in Nepal.

The Assessment Team is well aware that USAID/Nepal bilateral funds need to be invested in Nepal programs. That said, we encourage the USAID Environment Team to keep the broader South Asia/Hindu-Kush Himalaya context of its work firmly in mind and to proactively explore ways in which USAID/Washington and USAID/Regional Development Mission for Asia (RDMA) support can be used to complement what USAID/Nepal decides to support in the water sector.

*Hydropower sustainability*:

The Assessment Team went into this assignment assuming that "run of the river" hydropower had relatively benign impacts on the environment. Our visits to the Middle Marsyangdi and Kali Gandaki power plants quickly showed that these assumptions were not correct. Even our team members from NDRI were very surprised by what we found. "Run of the river" is a serious misnomer for these two hydro plants. As currently operated, these are not "run of the river" systems, they are hydropower dams (or "dammed river" systems). Although the rivers "run" during the monsoon season, during the dry season <u>all</u> of the water is diverted for power generation – even though GoN regulations and environmental analyses say otherwise. The reason for not meeting the regulations was stated as the need to run the powerhouse in order to maximize the production of power, thereby minimizing the power cuts and "load shedding"

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[3]For example: bottom-up (eg grassroots development), top-down (eg government leadership, policy reform) and outside-in (eg technical assistance, training, farmer-to-farmer visits etc.). For details on this theory of change see Daniel Taylor-Ide and Carl Taylor 2002. *Just and Lasting Change - When Communities Own Their Futures.* Baltimore: John Hopkins Press See also the more recent Daniel C. Taylor, Carl E. Taylor and Jesse O. Taylor. 2011. *Empowerment on an Unstable Planet: From Seeds of Human Energy to a Scale of Global Change.* Oxford University Press.

in the country. During the course of our field visits we discovered an important suite of issues linked to hydropower sustainability. Both the issues and ways to address them are discussed in the report. Among the challenges: developing what has been called "the next frontier of hydropower sustainability" - planning at the river basin and national scales, rather than project by project with scant if any attention to inter-linkages and cumulative impacts. (IDB, 2013)

*The gender and social inclusion dimensions of water, including land and natural resource tenure*:

The central issues for women and marginalized groups related to water and freshwater biodiversity are having access to land and water, having a voice in decision making, and the 'feminization' of rural production systems in light of large-scale emigration of Nepali men to the Gulf. While understanding the importance of these issues, the Assessment Team did not have time to do them justice. Additional work needs to be done to help insure that USAID/Nepal investments in water push these issues in a positive direction.

*A "whole of the U.S. Government (USG)" approach to water resources in Nepal:*

Two key recommendations on the process used to conceptualize and design the new NRM project are "incorporate support from across the USG" and "weave water into ongoing USAID programs". Rather than designing a stand-alone program, we believe that designing a flexible program that (a) builds on the strengths of different parts of the USG - some based in Nepal already (e.g. The State ENV Hub, Peace Corps, Fulbright & the International Visitors Leadership Program (IVLP)), others that work in the region from a base in the U.S. (e.g. MCC, the United States Forest Service - funders of this Assessment, the U.S. Geological Survey and perhaps the U.S. Army Corps of Engineers) and (b) weaves water into ongoing USAID programs, will encourage synergy thereby maximizing results. There would need to be a program framework constructed for this, a framework that would also include new elements that address some of the Recommended Themes and Program Ideas noted above and presented in detail in Section IV.

In closing, there are several recent developments in the water sector in Nepal that are encouraging and deserve to be highlighted:

- A decision by the GoN, announced during the Budget Speech in July, to start work on transforming the Water and Energy Commission Secretariat(WECS) into a high-level Water Resources Commission that can begin to more effectively coordinate actions across the water sector and serve as an honest broker between competing Ministries and interests, and
- Work by Members of Parliament (MP) from the Kathmandu Valley to expand the vision of MP Gagan Thapa in his Kathmandu Sustainability Plan into a valley-wide Unified Kathmandu Valley Development Vision that will begin to systematically address a wide range of pressing water and other issues.
- A recent visit by Professor Khem Raj Sharma, Program Coordinator of the Interdisciplinary Water Resources Management Program at the Nepal Engineering College (NEC), to TERI University in Delhi. TERI University was interested in learning about and emulating this path-breaking interdisciplinary program that has been producing a steady stream of Masters students, many of whom are women. One element that has contributed to this is Nepal's pioneering, globally-important work on Farmer Managed Irrigation Systems (FMIS), work that began with USAID support in the 1980s.

- The NEC example cited above highlights an important piece of the Nepal water resources management scene that is too often either forgotten or overlooked: Nepal has a wealth of highly talented, thoughtful, world-class experts in this arena. One of the pleasant challenges and opportunities for the new USAID NRM program is to find ways to productively engage this talent in moving the water sector forward.
- Nepal is currently working on putting Integrated Water Resources Management (IWRM) principles into practice through: (1) the formulation of an Integrated Water Policy, (2) establishment of knowledge based information system in WECS, and (3) establishment of River Basin Offices in three major river systems of Nepal; Koshi, Narayani and Karnali. These efforts, conducted in collaboration with the Department of Hydrology and Meteorology, are intended to move Nepal forward in river basin planning for sustainable water resources management and development.
- Nepal's Sun Koshi River was named the #1 rafting river in the world by Lonely Planet. This highlights the importance of the multiple uses of Nepal's water wealth to promote broad based economic development while at the same time preserving the stunning natural beauty upon which Nepal's large and dynamic tourism industry is based.

# Section I. Introduction/Setting the Stage

## A. Setting and Context for the Assessment

The overall setting and context for this Assessment is clearly set out in the Statement of Work (SOW) and in the Natural Resources Management Concept Paper from which much of the SOW is drawn.

To recap briefly:

**Purpose:**
To conduct country-level water resources management and freshwater biodiversity analyses for Nepal in order to inform the design of a new five-year USAID/Nepal project (2015-2019). [4]

**Background:**
*"Nepal is often lauded as the second most "Water Rich" country in the world (after Brazil), yet this belies the fragile nature of its water systems and the extreme seasonal variation in its water availability. Poor management of the riverine forests and riverbanks, as well as unregulated riverbed mining have led to increasing levels of sedimentation, blocking dams and in some cases displacing entire rivers.[5]Exacerbating this is municipal and rural, point and non-point source, pollution of waterways. Endemic and rare species make up contribute to the incredible biodiversity of Nepal's rivers and other wetlands, but they are poorly studied and understood, and are likely to be under enormous threat due to those previously mentioned challenges.[6]*

*Despite the clear importance of sustainable water resources management to Nepali development, very little is actually known about water resources management at a large scale, and the status of freshwater biodiversity in the hills and mountains, particularly in the face of climate change. Furthermore, water is managed by approximately 10 different ministries (out of a total of 27) dealing with different aspects of water use. The ministries, and even departments within ministries, do not coordinate sufficiently, and there is very little joint planning.*

*Climate change is a risk multiplier that will put greater pressure on biodiversity preservation, land use planning, forest health and quality, and water resources. Climate change is already greatly affecting water availability, changing the pattern of the monsoon, provoking both droughts and floods, changing water tables, and changing freshwater storage in glaciers. Climatic changes increase the variability and magnitude of natural weather events and increase uncertainty about adequate and appropriate natural*

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[4]The project is currently called the Natural Resources Management (NRM) project. Once the project scope within one or multiple activities is more clearly defined, a new project/program name that resonates in Nepal and in Nepali language will be chosen.
[5]Basistha Raj Adhikari. "Flooding and Inundation in Nepal Terai: Issues and Concerns," HYDRO NEPAL Issue No. 12 January, 2013 ; Arjun Paudel. "Environmental management of the Bagmati River Basin." 2011. UNEP EIA Training Resource Manual. Department of Water Supply and Sewerage. His Majesty's Government of Nepal
[6] Nepal Biodiversity Strategy. Ministry of Forests and Soil Conservation. His Majesty's Government of Nepal. 2002. http://www.cbd.int/doc/world/np/np-nbsap-01-en.pdf

*resource use, protection, and management in a country currently ranked 14th in the world for vulnerability to climate change*."[7]

**Objectives:**

1) To prepare a summary report on the status of fresh water biodiversity and water resources management in Nepal
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**The Assessment Process**

USAID/Nepal requested the assistance of the United States Forest Service (USFS) in conducting this assessment. The USFS hired the Team Leader (George Taylor) through Philanthropy Support Services (PSS) Inc. and provided two USFS experts, a forest hydrologist/watershed planner (Mark Weinhold) and a freshwater ecologist (Susan Adams). USAID hired a local firm – Nepal Development Research Institute (NDRI) – to provide two Nepali technical experts (Nawa Raj Khatiwada and Tara Nidhi Bhattarai) and logistics backup (led by Ms. Sona Shakya). Brief biosketches of the Team members are presented in **Annex** .

The Assessment was carried out in June/July 2014. It began with an extensive literature review and meetings for the Team Leader in Washington with USAID and Forest Service staff along with several DC-based groups active in Nepal. It continued with three weeks in Nepal for the Team Leader, conducting many interviews in Kathmandu along with the NDRI members of the Team, and two weeks for the USFS experts. Of those two weeks, six days were spent outside the Kathmandu Valley on field trips to the Indrawati Watershed and on a five day circuit that included Pokhara, Palpa, Butwal, Lumbini and Sauraha/Chitwan. USAID Environment Team staff accompanied the Assessment Team on these field visits. The Kathmandu portion of the Assessment concluded with an Out-Brief on July 25th. The list of documents consulted is presented in **Annex** .

## B. Water & water resources management in Nepal, the Hindu-Kush Himalaya and South Asia

Water is arguably the most important of all natural resources; it is essential to life, and in many ways it is life. Through the global water cycle, water is literally the connection between the heavens and the earth. From an international development perspective, water is a cross-cutting theme par excellence: it is in one way or another part of virtually all "sectors" (agriculture, health, energy, drinking water & sanitation, environment, governance, the combination of these into economic growth, both urban & rural development, etc.) and linked to many other of the most important cross-cutting themes: gender & social inclusion, community participation, the involvement of both civil society and the private sector. Water is also an important theme in a vertical sense as a key natural resource that is at the center of human and power relations and dynamics between the individual, family and community up through scales to the national level

[7] From the USAID/Nepal Assessment Statement of Work p. 1-2 fn. Maplecroft 2012. http://maplecroft.com/themes/cc/ There are many different rankings . This one ranks Nepal #141 of 183 countries for vulnerability: http://index.gain.org/ranking/vulnerability

and from the national level up through the regional level (i.e. Nepal's relations with both India and Bangladesh) to a global level.

This multi-dimensionality of water was captured well as follows:

"*Water …..wends its way through a multitude of disciplines: geography, geology, hydrology, meteorology, climatology, biology, ecology, agronomy, engineering, economics, history, law, political science, urban planning, and public policy, to name some that spring to mind."*[8]

The regional dimensions of water, water resources management and freshwater biodiversity are central to any comprehensive understanding of water in Nepal. These dimensions are evident at the most basic physical and topographical levels in maps such as these:

**Figure I-1: The Ganges Basin** (Strategic Foresight 2010, p.8)

[8]Stephen Grace. 2012. *Dam Nation: How Water Shaped the West and Will Determine Its Future*, p.vi.

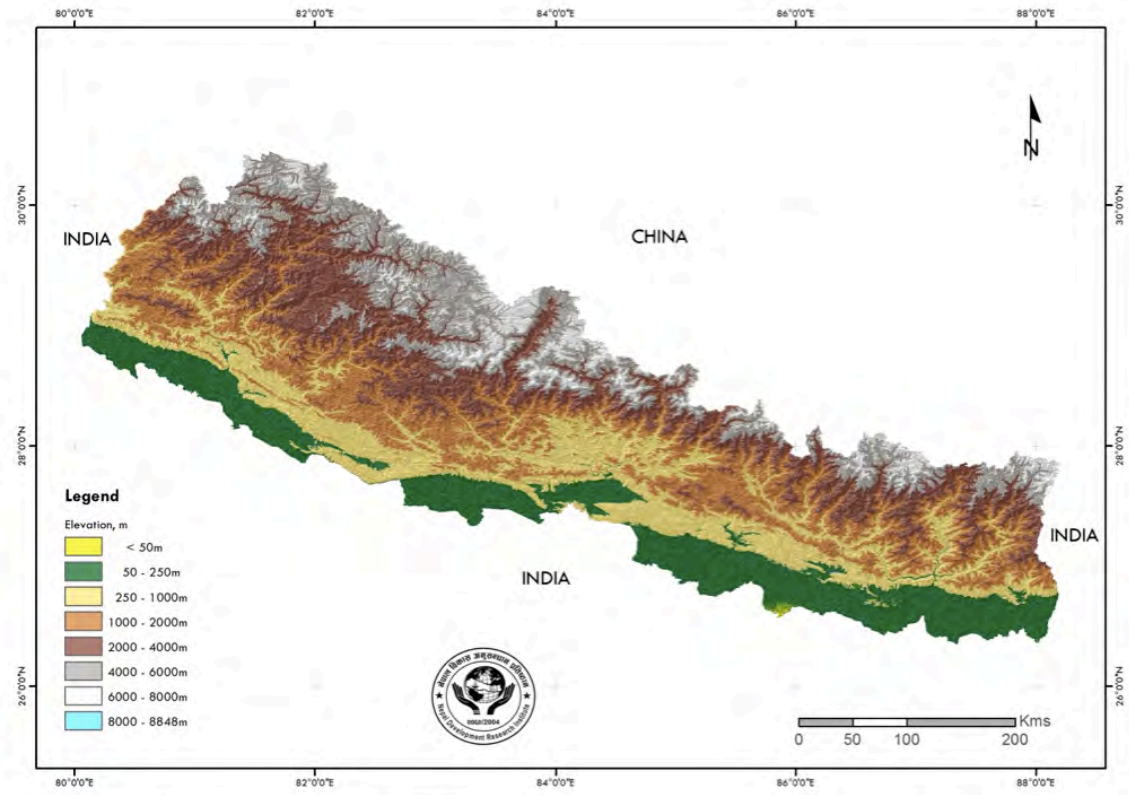


**Figure I-2: Nepal Topography** (NDRI)

The key driver, of course, is that water flows downhill. Beyond this physical dimension there are extensive social, cultural and economic links that bind Nepal with both its upstream and downstream neighbors.[9]

There are two axes to the regional dimensions of water: 1) an east-west axis along the Hindu-Kush Himalaya, important for understanding how communities and states with strong ecological similarities to Nepal have worked on water, WRM and FWB, and 2) a north-south axis where the movement of water from the Himalayas through the Tarai[10] to the Gangetic Plains and on to the Bay of Bengal provides direct connections that link actions upstream to consequences downstream (and, to some extent, in the opposite direction as well). A key element of the north-south axis was captured by Han Suyin as follows: "*The true Himalayas, miles above the sea, are still in the throes of creation. The mountains are young, very young, adolescently dinosaurian, terrible with ruthless youth*."[11]

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[9]"Upstream neighbors" and "Nepal" are not often used in the same sentence. It is important to remember that while the great majority of cases Nepal is the "upstream" neighbor, in the case of the Kosi River, a substantial portion of the upper watershed lies in the Tibet Autonomous Region of China.
[10]Also the anglicized "Terai". We will use the spelling that is closer to the original.
http://www.britannica.com/EBchecked/topic/583312/Tarai
[11]Han Suyin.1958. *The Mountain is Young* quoted in Colopy. 2012. p. 9

A recent book weaves together multiple strands of water resources management in South Asia.[12] Using Kathmandu as a base and travelling across South Asia, the author provides an engaging and informative first person account of someone encountering the many facets and complexities of water, water use and water management in South Asia. Many of the themes covered in this Assessment are touched on in the book in chapters with titles like "Dirty, Sacred Rivers", "The Real Poop, How Rivers Become Sewers", "Melting Ice Rivers", "The Shrinking Third Pole", "Melamchi River Blues", "The Koshi's Revenge", "The Engineers", "Poisoned Blessings" [13], and "Beyond Barrages and Boundaries".

A provocative and instructive title to a recent news article earlier this year was What Nepal Doesn't Know About Water.[14]It notes: "*Nepal's hydrologists, water experts, meteorologists and climate scientists all call for better management of water. But a vital element of water management – quality scientific data – is still missing."* Although much is known about water in Nepal, there is still much to be learned. This assessment identifies a number of critical knowledge gaps.

## C. USAID/Nepal support for water resources management & biodiversity conservation

USAID/Nepal has a long history of working on natural resource management (NRM) and biodiversity conservation.[15] Much of the NRM work has been, and continues to be, focused on community forestry. Support for both water resources management and related investments in energy were initiated in the 1980s and continued, in the case of work on private hydropower, into the 2000s. The key investments in WRM were the Irrigation Management Project (IMP) followed by the Irrigation Management Transfer Project (IMTP) and support to the International Irrigation Management Institute (IIMI – now IWMI) for work on farmer-managed irrigation systems followed by the Nepal Smallholder Irrigation Market Initiative (SIMI) which has led in more recent years to the Initiative for Climate Change Adaptation (ICCA). These programs were supplemented with important support from two regional programs: Irrigation Support for Asia and the Near East (ISPAN) and the Water Management Synthesis Project. On the energy side of the equation, the key investments were Phases 1 and 2 of the Private Sector Hydropower Development Project (PSHDP) aimed at "increased private sector participation and investment in environmentally and socially sound hydropower".

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[12]Cheryl Colopy .2012. *Dirty, Sacred Rivers: Confronting South Asia's Water Crisis.* Oxford University Press, New York

[13]About arsenic contamination in Bangladesh. This is also an issue on some parts of the Nepal Tarai as well as in a few areas of the mid-Hills. See http://filtersforfamilies.org/

[14]http://www.ipsnews.net/2014/04/nepal-doesnt-know-water/

[15]The 50 year retrospective on USAID/Nepal (Skerry, 1991) and CDIE evaluations of forestry & ENV:
F. Sowers, M. Rechlin et.al. 1994. *Forestry and the Environment: Nepal Case Study*. CDIE Working Paper No. 201 http://pdf.usaid.gov/pdf_docs/PNABU995.pdf
P. Church and J.Laarman 1996. *An Assessment of USAID Support for Forest Stewardship*. USAID/CDIE Assessment Report No.14 http://pdf.usaid.gov/pdf_docs/PNABY210.pdf
There has not yet been a systematic retrospective of USAID/Nepal investment in environment & natural resources, including energy and NRM-linked investments in agricultural development. Initial plans for this report included an Annex with a synopsis of earlier USAID investments in water resources management. LOE limitations have not allowed adequate time for its preparation. The Assessment Team encourages USAID to consider investing either in such a synopsis or, better yet, in a full retrospective of USAID investments in NRM including water resources management, environment, energy and related rural and urban development programs. One model for this would be Thomas M. Catterson 2000. *Retrospective Study of USAID Support to the Development of the Environment Sector in Bolivia* .http://pdf.usaid.gov/pdf_docs/PNACH843.pdf

USAID/Nepal has provided extensive support for biodiversity conservation, working over the past three decades with a wide range of US, Nepali and international groups including the Smithsonian Institution, WWF/Nepal, The Mountain Institute (TMI), the King Mahendra Trust (now the Nepal Trust) for Nature Conservation (NTNC), the Department of National Parks and Wildlife Conservation (DNPWC) and the International Union for the Conservation of Nature (IUCN), to name a few. While some of this work has been at the policy level (e.g., support for the Nepal National Conservation Strategy in the late 1980s), virtually all of the field-level investments have been in terrestrial biodiversity. The Assessment Team commends USAID/Nepal for starting to focus some much needed attention on freshwater biodiversity. This Assessment is the first step in redressing an important imbalance.

The Assessment Team is well aware that USAID/Nepal bilateral funds need to be invested in Nepal programs. That said, we encourage both the Environment Team and the USAID Mission to keep the broader South Asia/Hindu-Kush Himalaya context of its work firmly in mind and to proactively explore ways in which USAID/Washington and Regional Development Mission for Asia (RDMA) regional programming can be used to complement what USAID/Nepal decides to do in the water sector.[16]

## D. Lenses for thinking about water resources management and freshwater biodiversity

The many perspectives on and potential lenses through which to view water are captured in the following list:

*"Water …..wends its way through a multitude of disciplines: geography, geology, hydrology, meteorology, climatology, biology, ecology, agronomy, engineering, economics, history, law, political science, urban planning, and public policy, to name some that spring to mind."*[17]

As such, water and water resources management are complex subjects, composed of many strands. These can be presented graphically in different ways, for example, through a sectoral lens:

[16]Programs like the long-running South Asia Regional Initiative (SARI)-Energy program

[17]From Hariyo Ban CHAL Biodiversity Assessment quoting Stephen Grace 2012 *Dam Nation: How Water Shaped the West and Will Determine Its Future.*

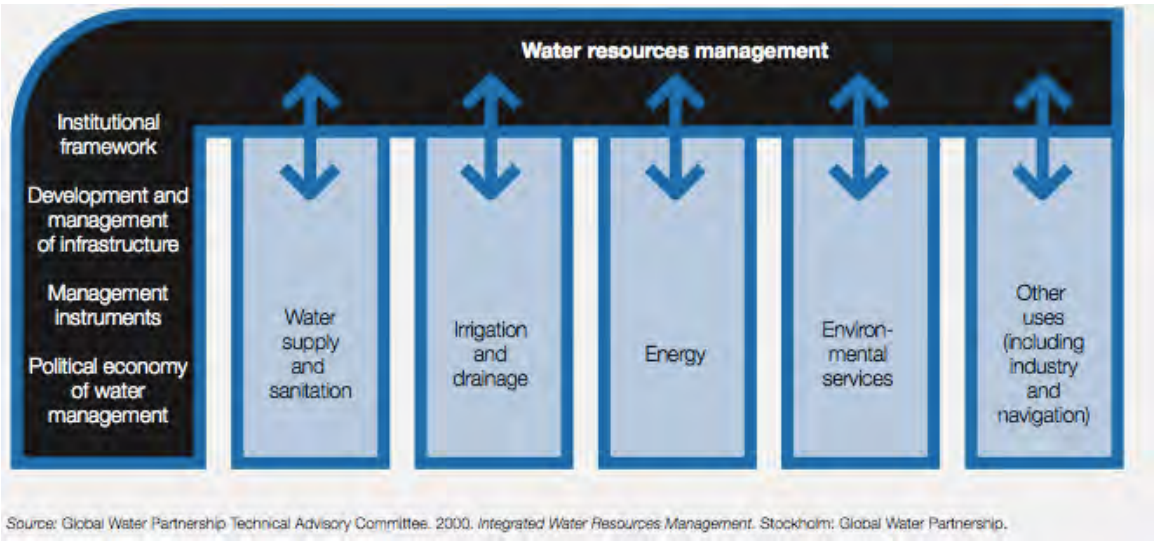


**Figure I-3: Water resources management: a sectoral lens** (Global Water Partnership 2000) **or through an Integrated Water Resources Management (IWRM) lens**

[18]

**Figure I-4: Integrated Water Resources Management (IWRM): cross sectoral integration** (Global Water Partnership)

Other lenses that are sometimes used include: Multiple Use Services of Water (MUS)[19], Blue/Green water[20], Blue/Green/Gray water,[21] Water-energy-food-nexus[22], Water-energy-food-climate nexus[23], Water security[24], Water poverty[25], Water rights & tenure[26] and Gender &

[18]Global Water Partnership http://www.gwp.org/ToolBox/ABOUT/IWRM-Plans/
[19]Mary Renwick (Ed.) 2014. *A Guide to SolutionMUS Putting multiple-use water services into Action*. Winrock International, Washington DC.
[20]University of Nebraska–Lincoln Office of Research and Economic Development 2013. *Blue Water, Green Water and the Future of Agriculture* - Proceedings of the 2012 Water for Food Conference Lincoln, Nebraska – May 30-June 1, 2012. Lincoln, NE: Water for Food/Robert B. Daugherty Institute.

water[27]. Each of these can be useful in thinking about and formulating the Theory of Change that is now required for all USAID biodiversity programs, and should be required for all of USAID's other programs as well.[28] The Government of Nepal used the Integrated Water Resources Management (IWRM) lens as a central piece of the National Water Resources Strategy (2002) and the National Water Plan (2005).

The most important lens for the purposes of this assessment is climate change adaptation.[29] Water resources management and climate change adaptation are inextricably linked together. Two quotes that characterize this link well are:

***"Climate change will express itself through water"***
*Dipak Gyawali, Former Minister of Water Resources, Nepal*

***"If mitigation is about CARBON, then Adaptation is about WATER"-***
John Slater, MLA, Parliament Secretary of Water Supply and Allocation to the Minister of Environment, Province of British Columbia

A productive way to think about water resources and climate change is the Climate Resilience Framework (CRF) developed by Institute for Social and Environmental Transition (ISET) with important input from ISET-Nepal.[30] The CRF starts with a critique of IWRM:

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[21]Caroline Schneider October 2013. *Three Shades of Water Increasing Water Security with Blue, Green, and Gray Water* .CSA Newshttps://www.specmeters.com/assets/1/7/20131108_-_Three_Shades_of_Water_-_CSA_News,_Oct_2013.pdf
Blue Water: Found in lakes, rivers and reservoirs. Used for many purposes including drinking water, water for homes and businesses, and irrigation for agriculture.
Green Water: Available in the soil for plants and soil microbes. It is absorbed by roots, used by plants, and released back to the atmosphere through transpiration.
Gray Water: Water that has been previously used and may contain some impurities. It is wastewater that is usually treated, discharged, and used by cities, households and industries.
[22]Golam Rasul. 2014. *Food, Water and Energy Security in South Asia: a Nexus Perspective from the Hindu Kush Himalayan Region*. Environmental Science & Policy Vol.39, p.35-48 and ICIMOD 2012. 48.http://www.sciencedirect.com/science/article/pii/S1462901114000239 and Nexus knowledge platform: http://www.water-energy-food.org/en/knowledge/regions/view__himalayas.html
[23]http://www.weforum.org/reports/water-security-water-energy-food-climate-nexus
[24]Lankford et.al. 2013. *Water Security: Principles, Perspectives and Practices*. Routledge, London.
[25]For a somewhat dated map see http://www.grida.no/graphicslib/detail/water-poverty-index-by-country-in-2002_d6db Also Caroline Sullivan, et al., 2006. *Mapping the Links between Water, Poverty and Food Security*. and WWF Nepal 2012. *Water Poverty of Indrawati Basin, Analysis and Mapping*.
[26]see FAO 2012. *Voluntary Guidelines on the Responsible Governance of Tenure*, and Sultana and Loftus. 2011.*The Right to Water.*
[27]see, for example, ADB & IWMI, Women, Water and Leadership Asia Pacific Workshop February, 2014 http://www.adb.org/themes/gender/activities/women-water-and-leadership
[28] USAID's Biodiversity Code includes 4 key elements two of which require a Theory of Change: 1) The program must have an explicit biodiversity objective; it isn't enough to have biodiversity conservation result as a positive externality from another program; 2) Activities must be identified based on an analysis of drivers and threats to biodiversity and *a corresponding theory of change*; 3) Site-based programs must have the intent to positively impact biodiversity in biologically significant areas; and 4) The program must monitor indicators *associated with a stated theory of change* for biodiversity conservation results. See: http://www.usaid.gov/biodiversity/impact/requirements
[29] It is important to note that this is a USAID-centric view linked to the sources of earmarked funding available for the new NRM project. USAID's current Water and Development Strategy 2013-2018 and Water and Development Strategy Implementation Field Guide (March 2014) are narrowly conceived documents designed to respond to the funding earmarks imposed on USAID by the US Congress. Funding under this strategy is only available for the WASH component of the new NRM project.

*"While the importance of integrated understanding in managing any complex system is fully acknowledged, we found that attempts to integrate numerous and often fundamentally different considerations into a single overview perspective often obscured key factors…, most applied [IWRM] work focuses on high-level basin management agencies attempting to address competing needs within a river basin. In comparison to prior sector-focused approaches to water management this represented a major advance. In practice, however, IWRM was often framed as a command and control strategy for optimal allocation of available supplies that ignored the diverse array of actors, institutions, and often very localised system characteristics that determine water use and allocation. It involved attempts to reduce variability in ways that ultimately increased system rigidity and the consequences of failure – what Holling and Meffe (1996, 328) call "the pathology of natural resource management"[31]. Furthermore, our field research often identified emergent water outcomes that could not be planned based on high-level analysis. They reflected interactions between a wide array of actors and system components and were often full of surprises and unanticipated interactions at local levels and across scales."[32]*

The CRF is presented graphically as two inter-linked circles:

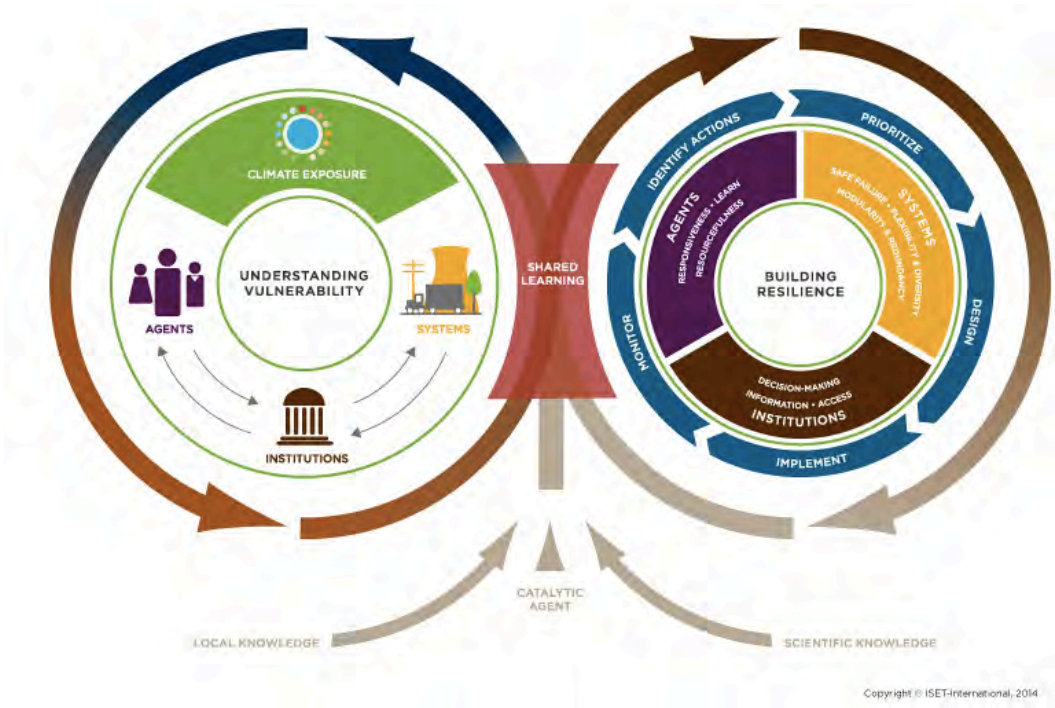


**Figure I-5: Climate Resilience Framework (**Moench 2014)[33]

CRF is both an analytical framework and an iterative planning process where shared learning builds understanding and encourages adaptive responses. It builds on IWRM but it is different in several important ways:

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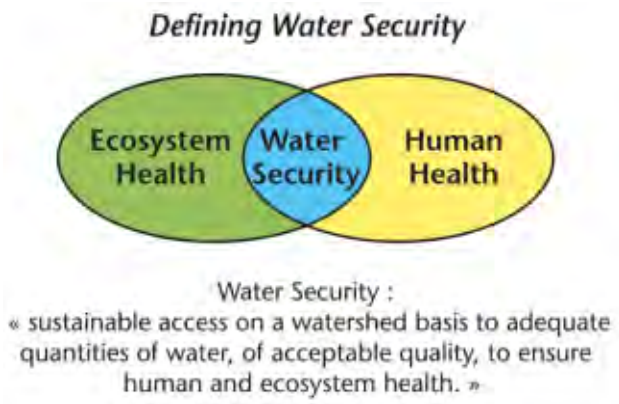
[30] Marcus Moench 2014. "Experiences applying the climate resilience framework: linking theory with practice" *Development in Practice,* 24:4, 447-464, DOI: 10.1080/09614524.2014.909385 Three key limitations to the CRF approach are spelled out on p.462

[31] Holling, C. S., and G. K. Meffe. 1996. "Command and Control and the Pathology of Natural Resource Management." Conservation Biology 10 (2): 328–337.doi: 10.1046/j.1523-1739.1996.10020328.x.

[32] Moench 2014

[33] see http://i-s-e-t.org/projects/crf.html

*"Rather than integration, the goal is to support ownership, recognition, and response as conditions evolve and knowledge grows. It is designed for emergent needs rather than integrated prediction and response.*
*The two circles represent an iterative flow of shared learning through analysis and action to build resilience. The left side describes a vulnerability diagnostic phase, while the right side focuses on the steps that can be taken. The process involves analysis followed by identification of context-specific actions, prioritization, design, implementation, and monitoring before returning to the basic diagnosis. It was structured to respond to the needs of planning organizations and could be changed for other uses…iterative processes for building understanding, engaging different groups of agents, and adapting approaches are central to resilience and are fundamental to the CRF."*[34]




In addition to the Climate Resilience Framework, three other lenses may be useful to USAID/Nepal as it designs the new NRM project. The Water Security and Water Poverty lenses may be relevant in framing project goals and the Blue/Green/Gray Water lens may be helpful in defining objectives and project components.

**Figure I-6: Water Security Lens** (Program on Water Governance, Canada)

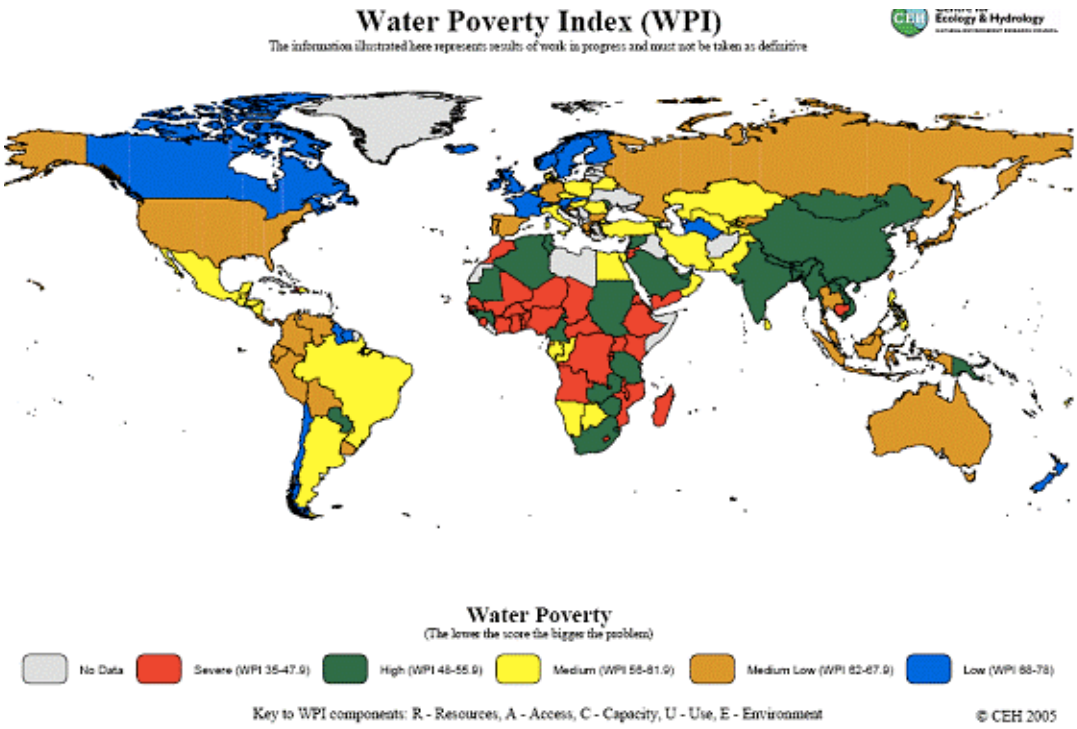
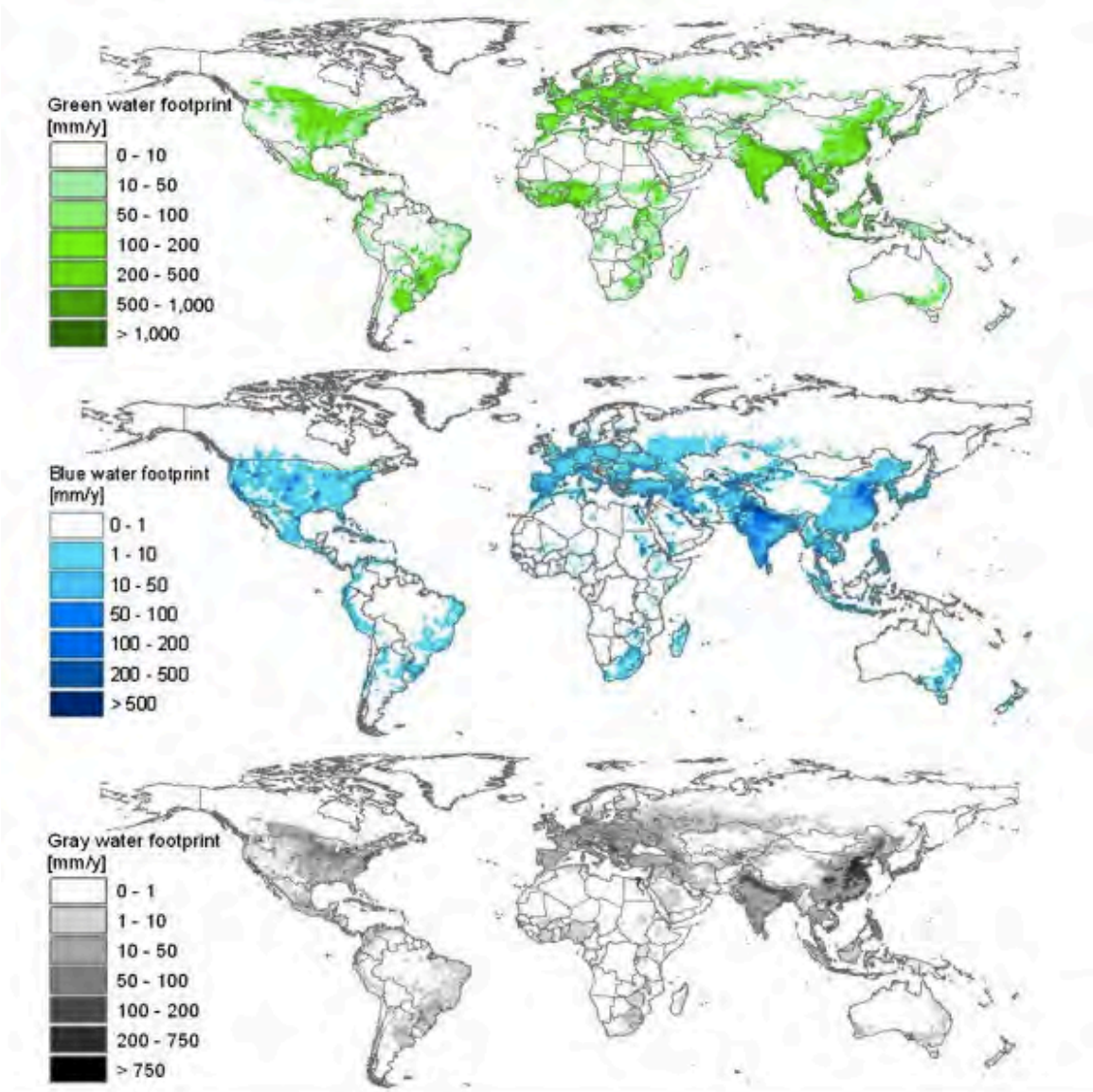



**Figure I-7: Water Poverty Lens/ Water Poverty Index** (Centre for Ecology & Hydrology 2005)

[34]Moench 2014




The green, blue, and gray water footprints within nations in the period 1996-2005. (c)PNAS, doi:10.1073/pnas.1109936109

**Figure I-8: Blue/Green/Gray Water lens** [35]

On the biological side of the equation, biodiversity is important not just for its own sake, but also in at least three other ways: 1) ecosystem services - biodiversity is directly linked to livelihoods for many Nepalese (disproportionately relevant to women and marginalized groups) and contributes to water quality and economic development, 2) ecosystem health - if we are

[35] http://phys.org/news/2012-02-duo-worldwide-footprint-high-spatial.html

paying attention, the monitoring of biodiversity can serve an important canary-in-the-coal-mine function to indicate when ecosystem health is failing, and 3) Government of Nepal's international commitments - Nepal is a signatory to all of the key international biodiversity conventions including the Convention on Biodiversity and the Convention on Wetlands of International Importance (RAMSAR). In addition, climate change is having, and will continue to have, huge impacts for biodiversity. Understanding climate change vulnerability, adaptation and building resilience needs to be applied not just to human systems but to natural ecosystems on which these human systems depend.

As a final lens for thinking about water in Nepal, the Assessment Team recommends that the USAID/Nepal ENV Team familiarize themselves with the Nature, Wealth and Power Framework (NWP). NWP has been used by a number of USAID Missions to frame their NRM and rural development programs.[36]

## E. Boundaries/ limitations of the assessment

**Boundaries**

Water resources management and freshwater biodiversity are both broad areas for investigation and analysis. Taken together, the scope of this Assessment was very broad.

The boundaries of the assessment were of three types:

- USAID funding sources
  Two streams of funding (climate change adaptation and biodiversity conservation) are available for the new NRM project.[37] The Recommended Themes and Program Ideas presented in Section IV have been developed with these boundaries clearly in mind.
- USAID/Nepal program priorities
  The Mission suggested that the Team not explore energy/hydropower given the recent decision by the Millennium Challenge Corporation (MCC) to develop a Threshold Program in Nepal. While we have steered well clear of hydropower "development" *per se,* including the kind of work supported by USAID in the late 1990s and early 2000s under the Private Sector Hydropower Development Project (PSHDP) Phases I & II, we have focused considerable attention on promoting hydropower sustainability and its direct links both to freshwater biodiversity and to water resources management writ large.
- Assessment Team decisions
  The Team put no further boundaries on its work until the time came to decide on the priority themes and program ideas to be presented at the Out-Brief. Given the importance of presenting our "final cut" at the Out-Brief so that this input could be fed into the NRM project design process that was getting underway almost immediately after we left Nepal at the end of July, and in light of (i) the USAID funding boundaries described above and (ii) our decision to make "weaving water into ongoing USAID programs" a key recommendation, it was decided not to include either agriculture/irrigation or drinking water as distinct themes or program ideas. Both of these elements of water resources management are already being supported to some extent by USAID's Feed the Future/KISAN project, by the Multiple Use Systems (MUS)

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[36]USAID. 2013. *Nature, Wealth and Power 2.0: Leveraging Natural and Social Capital for Resilient Development* http://rmportal.net/library/content/nwp-2.0

[37]The one exception is the WASH component which receives funding from the Water/WASH earmark.

and solar pumping components of the Initiative for Climate Change Adaptation (ICCA project, and (indirectly) the WASH program. The Team has proposed a study of the National Federation of Irrigation Water Users Association, Nepal (NFIWIAN) with a view to seeing if NFIWIAN can be transformed and redirected along the path pioneered by Community Forestry Users Groups through the Federation of Community Forestry Users, Nepal (FECOFUN). If so, nurturing and supporting such a transformation would be a very high priority.

**Limitations**

The principal limitations of the Assessment were its timing (during the monsoon season which impacted options for field visits and meant that a number of key contacts were on vacation out of the country) and the short amount of time allotted for the Assessment, and especially the Nepal visit, in relation to the scope of the Assessment. That said, the Team worked efficiently and effectively together to make maximum use of the time available.

## F. Key Findings and Recommendations

Two streams of USAID funding (climate change adaptation and biodiversity conservation) are available for the new NRM project.[38] The Recommended Themes and Program Ideas listed below and presented in detail in Section IV of the report have been developed with these boundaries clearly in mind.

Using inputs from many sources (meetings with USAID and others in Washington, document review, discussions with knowledgeable individuals in Nepal and around the globe, two weeks of interviews in and near Kathmandu and field visits outside of the Kathmandu Valley in the Central and Western Development Regions), the Assessment team developed a series of nine priority Recommended Themes and Program Ideas for USAID support of water resources management and freshwater biodiversity:

1) Understanding water resources management (WRM) and freshwater biodiversity (FWB): critical knowledge/research gaps
2) Re-invigorating the policy & program framework for water resources management
3) Promoting hydropower sustainability
4) Addressing the impacts of infrastructure development on WRM & FWB
5) Developing watershed management best practices
6) Urban water: harnessing the private sector
7) WASH: linking into the NRM/water resources mainstream
8) Supporting Gender and Social Inclusion in WRM & FWB
9) Incorporating support from across the USG & weaving water into ongoing USAID programs.

Looking back at USAID investments in NRM in Nepal over the past 30 years, coupled with both the challenges & opportunities of the current situation and what other donors are currently supporting, the Assessment Team believes that the highest and most strategic priorities for USAID programming in water are 4 fold:

1) Add freshwater biodiversity to the conservation & development mix.

[38] The one exception is the WASH component which receives funding from the USAID Water/WASH earmark.

2) Support the long-term science needed to: 1) understand climate change (using water as the single most important lens) including predictions to the extent feasible; and 2) monitor the adaptation of social & production systems (i.e. agriculture, transhumant livestock and other forest, grassland and lake & river-based systems) both to climate change and to other key drivers of socio-economic development (i.e. local & regional markets, transportation systems and communications technologies).
3) Work with the Government of Nepal (GoN), other donors and civil society to promote and re-invigorate a holistic "whole of government" approach to water resources management.
4) Support innovative bottom-up, top-down, and outside-in initiatives that promote inclusive, just and lasting social change.[39]

Two additional program areas that are both high priorities and through which USAID/Nepal can make an important difference are:

- Urban water: harnessing the private sector, and
- WASH: linking WASH programming into the NRM/WRM mainstream.

Four cross-cutting themes deserve careful and concerted attention, and are described in more detail below:

- The regional dimensions of water
- Hydropower sustainability
- The gender and social inclusion dimensions of water, including land and natural resource tenure, and
- A "whole of government" approach to U.S. Government (USG) support for water resources management and freshwater biodiversity in Nepal.

***The regional dimensions of water*:**

The regional context of water, water resources management and freshwater biodiversity are central to any comprehensive understanding of water in Nepal (see, for example, Box I-1 below along with Sadoff and Rao 2011, SAWI 2014, SaciWATERs 2014, Strategic Foresight Group 2010 & 2011, Colopy 2012, McCauley and Shaikh 2001, Moog et.al. 2008, Rasul 2012 & 2014, and Rogers et. al.1989).

The Assessment Team is well aware that USAID/Nepal bilateral funds need to be invested in Nepal programs. That said, we encourage the USAID Environment Team to keep the broader South Asia/Hindu-Kush Himalaya context of its work firmly in mind and to proactively explore ways in which USAID/Washington and USAID/Regional Development Mission for Asia (RDMA) support can be used to complement what USAID/Nepal decides to support in the water sector.

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[39]For example: bottom-up (eg grassroots development), top-down (e.g. government leadership, policy reform) and outside-in (e.g. technical assistance, training, farmer-to-farmer visits etc.). For details on this theory of change see Daniel Taylor-Ide and Carl Taylor 2002. *Just and Lasting Change - When Communities Own Their Futures.* Baltimore: John Hopkins Press See also the more recent Daniel C. Taylor, Carl E. Taylor and Jesse O. Taylor. 2011. *Empowerment on an Unstable Planet: From Seeds of Human Energy to a Scale of Global Change.* Oxford University Press. See also Ned Breslin. 2010. *Rethinking Hydro-Philanthropy*. Water for People. Denver, Colorado http://tap.waterforpeople.org/usercontent/1/1/109810001/81/Breslin-Rethinking-hydrophilanthropy-040110.pdf

**BOX I-1: Regional Water Programs & Information Sources**

1. South Asia Water Initiative (SAWI) – coordinated by the World Bank with support from the United Kingdom, Australia and Norway. https://www.southasiawaterinitiative.org/
2. Highland Aquatic Resource Conservation and Sustainable Development (High ARCS) – supported by the European Commission http://www.higharcs.org/project_overview.php
3. Himalayan Adaptation, Water and Resilience (HI-AWARE) – recently launched by ICIMOD and partners in India, Pakistan and Bangladesh with support from IDRC and DFID. http://www.icimod.org/?q=13156
4. Outputs from and followup to the South Asia Consortium for Interdisciplinary Water Resources Studies SaciWatersprogram (2002-2012) http://www.saciwaters.org/
5. International Water Management Institute (IWMI) http://southasia.iwmi.cgiar.org/
   Including the IWMI-Sir Ratan Tata Trust program on water policy research
   http://www.indiawaterportal.org/articles/highlights-10-year-water-policy-research-programme-international-water-management-institute
6. South Asia Network on Dams, Rivers and People http://sandrp.wordpress.com/
7. India Water Portal http://www.indiawaterportal.org

***Hydropower sustainability*:**

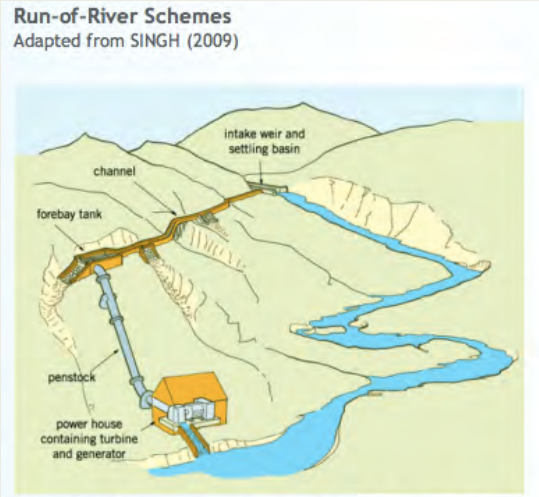
The Assessment Team started this assignment assuming that "run of the river" hydropower had relatively benign impacts on the environment. Our visits to the Middle Marsyangdi and Kali Gandaki power plants quickly showed that these assumptions were not correct. Even the engineer team members from NDRI were very surprised by what we found. "Run of the river" is a serious misnomer for these two hydro plants. As currently operated, these are not "run of the river" systems, they are hydropower dams (or "dammed river" systems). Although the rivers "run" during the monsoon season, during the dry season all of the water is diverted for power generation – even though GoN regulations and environmental analyses stipulate otherwise. The reason for not meeting the regulations was stated as the need to run the powerhouse in order to maximize the production of power, thereby minimizing the power cuts and "load shedding" in the country. During the course of our field visits we discovered an important suite of issues linked to hydropower sustainability.[40] Both the issues and ways to address them are discussed later in the report. Among the challenges: developing what has been called "the next frontier of hydropower sustainability" - planning at the river basin and national scales, rather than project by project with scant if any attention to inter-linkages and cumulative

[40]These issues are echoed in the literature. For example: *Hydropower Sustainability Assessment Protocol* (HSAP) 2010-2014, Skinner and Haas 2014, Rajashekariah et.al. 2012, Meng et.al. 2011, Meng et.al. 2014.

impacts (IDB, 2013), and finding ways to balance construction with "natural" or "green" infrastructure (Aspen Institute 2012, Gartner et.al. 2013, Gleason et.al. 2012, Reid 2014 and WBCSD nd)

**BOX I-2: Run-of-the- River (ROR) Hydropower: Theory vs Praxis**

Run-of-the-River (or Run-of-River ROR) hydropower is often presented as the temporary use of a limited amount of water having little or no impact on the river. This impression is supported by graphics such as:




*Typical run-of-river scheme. Source: PRACTICAL ACTION (n.y.)*

http://www.sswm.info/category/implementation-tools/water-use/hardware/water-energy/hydropower-small-scale

Robert Goodland has described the problem(s) with this presentation and the impression it leaves as follows:

*"Strictly speaking RoR means little or no storage; what water enters, flows out without being retained behind a dam, either through the turbines or the spillway or whatever.* ***RoR should be used to mean: "a water supply taken directly from a river with no significant attempt to store water or regulate flow".*** *No storage or no reservoir means low impact because no land is impounded for storage, no resettlement, no habitat loss, no impediment to fish, no decrease in the nature of river flows, and no GHG emissions.* ***Because RoR has erroneously become associated with "Good Dams" it has become meaningless.***

*RoR has been misused at least since 1994 when RoR was applied to massive storage dams over 60 m high on the Mekong River (MRC 1994). More recently China labeled one of the world's biggest dams -- Zangmu -- as RoR. Sierra Leone's 400 MW Bumbuna dam -- 88 m in height -- is called RoR. RoR is now misused to imply that after the reservoir is full, what water enters will eventually flow out, with no additional storage, no out-stream diversion, and only brief (days or weeks rather than months or years) retention time."* (Goodland, 2013 Annex 1 Emphasis added.)

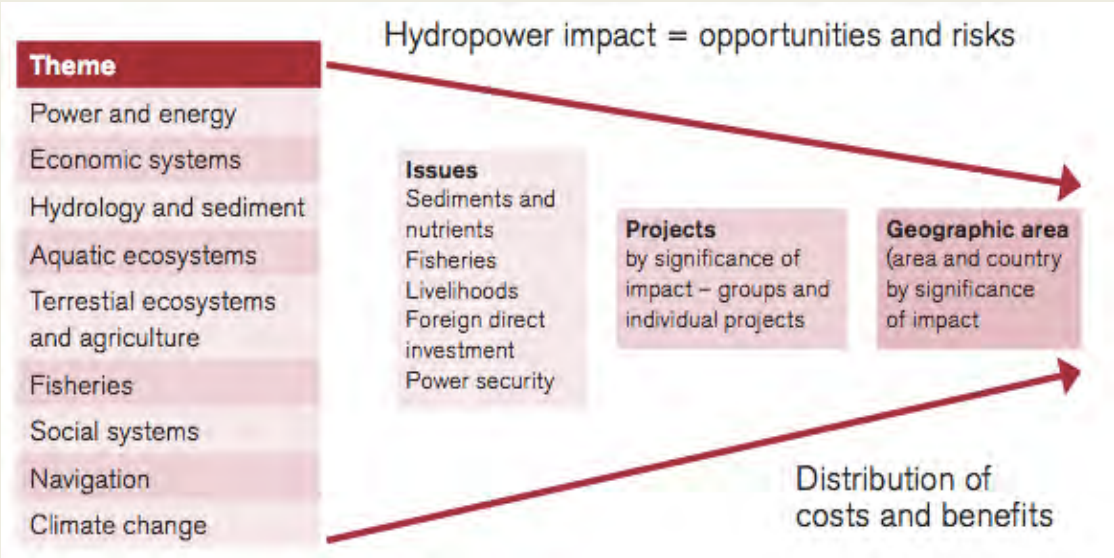
One proposal for more accurate terminology is to divide Run-of-the-River projects into three types:

**1. Pure run-of-river**: schemes without any flow regulation at all, where the water is turbined as it comes.

**2. Pondage run-of-river**: schemes where water is released to maximise generation during the electricity peak demand hours, which requires some storage behind a dam to provide the daily and/or weekly regulation.

**3. Diversion run-of-river**: schemes where a portion of the river is diverted by intakes upstream of the dam to surface or underground tunnels that run to a powerhouse downstream, with the water returned to the river at that point. The diversion may be anything from a few hundred meters to tens of kilometres and is often around a river bend with a significant gradient. (Skinner and Haas, 2014)

The environmental and social impacts of large ROR hydropower schemes need to include consideration of the following elements:




(Skinner and Haas, 2014, p.62)

***The gender and social inclusion dimensions of water, including land and natural resource tenure*:**

The central issues for women and marginalized groups related to water and freshwater biodiversity are having access to land and water, having a voice in decision making, and the 'feminization' of rural production systems in light of large-scale emigration of Nepali men to the Gulf.[41] While understanding the importance of these issues, the Assessment Team did not have

[41]See, for example, Sugden 2014, Khadka and Verma 2012, Ahmed 2005 &2014, ICIMOD & GIZ 2012, Bikash Sharma et.al. 2005, S. Shrestha 2013, Udas 2014, Zwarteveen 2014.

time to do them justice. Additional work needs to be done to help insure that USAID/Nepal investments in water push these issues in a positive direction.

**Figure I-9: What's wrong with this picture? Gender (im) balance in water resources management.** (GON/MoUD, 2013)

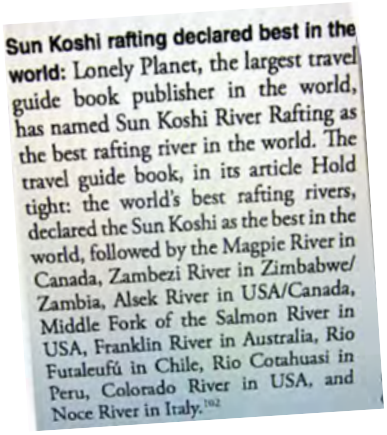
*A "whole of the U.S. Government (USG)" approach to water resources in Nepal:*

Two key recommendations on the process used to conceptualize and design the new NRM project are "incorporate support from across the USG" and "weave water into ongoing USAID programs". Rather than designing a stand-alone program, we believe that designing a flexible program that (a) builds on the strengths of different parts of the USG - some based in Nepal already (e.g. The State ENV Hub, Peace Corps, Fulbright & the International Visitors Leadership Program (IVLP)), others that work in the region from a base in the U.S. (e.g. MCC, the United States Forest Service - funders of this Assessment, the U.S. Geological Survey and perhaps the U.S. Army Corps of Engineers) and that (b) weaves water into ongoing USAID programs, will encourage synergy thereby maximizing results. There would need to be a program framework constructed for this, a framework that would also include new elements that address some of the Recommended Themes and Program Ideas noted above and presented in detail in Section IV.

In closing, there are several recent developments in the water sector in Nepal that are encouraging and deserve to be highlighted:

- A decision by the GoN, announced during the Budget Speech in July, to start work on transforming WECS into a high-level Water Resources Commission that can begin to more effectively coordinate actions across the water sector and serve as an honest broker between competing Ministries and interests, and
- Work by Members of Parliament (MP) from the Kathmandu Valley to expand the vision of MP Gagan Thapa in his Kathmandu Sustainability Plan into a valley-wide Unified Kathmandu Valley Development Vision that will begin to systematically address a wide range of pressing water and other issues.(Gagan Thapa, 2013)

- A recent visit by Professor Khem Raj Sharma, Program Coordinator of the Interdisciplinary Water Resources Management Program at the Nepal Engineering College (NEC), to TERI University in Delhi. TERI University was interested in learning about and emulating this path-breaking interdisciplinary program that has been producing a steady stream of Masters students, many of whom are women. One element that has contributed to this is Nepal's pioneering, globally-important work on Farmer Managed Irrigation Systems (FMIS), work that began with USAID support in the 1980s.
- The NEC example cited above highlights an important piece of the Nepal water resources management scene that is too often either forgotten or overlooked: Nepal has a wealth of highly talented, thoughtful, world-class experts in this arena. One of the pleasant challenges and opportunities for the new USAID NRM program is to find ways to productively engage this talent in moving the water sector forward.
- Nepal is currently working on putting Integrated Water Resources Management (IWRM) principles into practice through: (1) the formulation of an Integrated Water Policy, (2) establishment of knowledge based information system in WECS, and (3) establishment of River Basin Offices in three major river systems of Nepal; Koshi, Narayani and Karnali. These efforts, conducted in collaboration with the Department of Hydrology and Meteorology, are intended to move Nepal forward in river basin planning for sustainable water resources management and development.
- Nepal's Sun Koshi River was named the #1 rafting river in the world by Lonely Planet.[42] This highlights the importance of the multiple uses of Nepal's water wealth to promote broad based economic development while at the same time preserving the stunning natural beauty upon which Nepal's large and dynamic tourism industry is based.[43]


**Sun Koshi rafting declared best in the world:** Lonely Planet, the largest travel guide book publisher in the world, has named Sun Koshi River Rafting as the best rafting river in the world. The travel guide book, in its article Hold tight: the world's best rafting rivers, declared the Sun Koshi as the best in the world, followed by the Magpie River in Canada, Zambezi River in Zimbabwe/ Zambia, Alsek River in USA/Canada, Middle Fork of the Salmon River in USA, Franklin River in Australia, Rio Futaleufú in Chile, Rio Cotahuasi in Peru, Colorado River in USA, and Noce River in Italy.[162]

On a more sobering note, a massive landslide occurred in Sun Koshi River on August 2, 2014 which blocked the river for about 12 hours creating a lake of some 7 million cubic meters of water. More than 150 people lost their lives and a 3 km road section of the Araniko Highway from Kathmandu to the Tibet/China border was submerged under the water.[44] It took nearly one month to resume temporary traffic on the highway. The disruption created and the slow post-disaster response from the government authorities clearly indicated that much remains to be done to strengthen disaster response systems and to manage such water-induced disasters.

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[42] http://www.ekantipur.com/2014/03/05/business/sun-koshi-named-best-for-rafting/386261.html

[43] see http://www.nepal-himalaya.com/nepal/nepal-rafting.html and Nepal Association of Rafting Agencies (NARA) http://www.raftingassociation.org.np/

[44] *Eye on the Sun Koshi Landslide: Monitoring and Infrastructure Planning Key to Minimizing Scale of Disasters*, http://www.icimod.org/?q=14356

# Section II. Water Resources Management

## A. Status Overview

Nepal is considered a water rich country, and this water is one of the principle natural resources supporting the economy of the country. Effectively developing, managing, and protecting this resource is critical to the country's economic future (National Water Plan (NWP) 2005).

The greatest influence on Nepal's climate, and the availability of water resources, is the South Asian Monsoon. The average annual precipitation in Nepal is close to 1500 mm, of which 90 percent occurs in the monsoon months between June and August. Flooding is common in parts of the country, particularly the Tarai. Figure II-1 shows annual measured stream flows in the Kali Gandaki River, and demonstrates this concentration of precipitation in the short monsoon season. This feast or famine scenario of water supply has made realizing the strategic outputs of the NWP difficult. Consequently there is considerable emphasis on responsibly developing water resources as the flood/drought cycle intensifies with climate change.

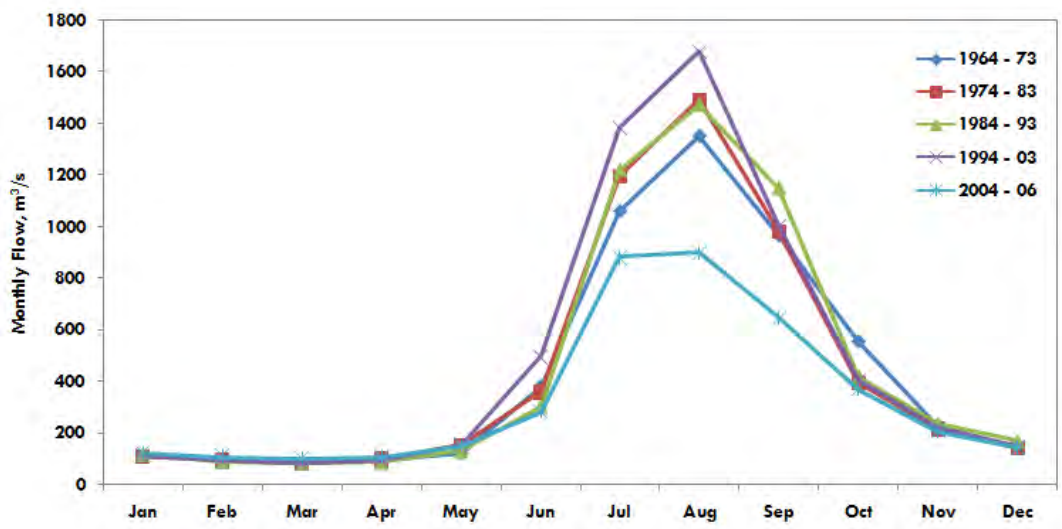



**Figure II-1: The annual hydrograph of the Kali Gandaki River showing the majority of stream flow occurring during the relatively short monsoon season in mid-summer.** (NDRI using DHM data)

Nepal faces a number of physical and human challenges in recognizing the benefits associated with water resources development and management. The rugged topography, young mountains, and monsoon climate all combine to produce high rates of runoff, erosion and sedimentation. On the other hand, human activities have resulted in impacts to forests, soils and terrestrial and aquatic species and habitats. Increasing population pressure and demand for agricultural land often conflict with plans for protection of the natural environment. In urban areas, waste water, solid waste and air pollution have seriously degraded living conditions (Thapa 2013). Poverty and environmental degradation are closely related in Nepal. Figure II-2 shows an example of development and food production being displaced to steep hillsides as population and the need for agricultural land increase.

The current focus of development programming in Nepal is toward low income, rural areas. However Nepal, like most other developing countries, is rapidly urbanizing and are large percentage of the population has migrated to urban centers. According to the World Bank,

**Figure II-2: Population increases and the need for agricultural land can move development to steep and potentially unstable slopes.** (M. Weinhold)

Nepal is the fastest urbanizing country in South Asia, and Kathmandu is the most rapidly growing metro region in South Asia. The rate of urbanization out paces the cities' ability to provide adequate sanitation and clean water. Issues related to water supply in urban areas are discussed in more detail below.

To address these challenges, the Government of Nepal (GoN) recognized the need for a focused strategy and comprehensive national water plan. This was addressed through the adoption of key legislation such as National Water Resources Strategy (2002), the National Water Plan (2005) and the National Water Resources Policy (2011), which are discussed below. While these plans and policies have provided sound guidance to date, conditions are changing in Nepal that may require a review. These changing circumstances include:

- The new political landscape that will be created by Nepal's new Constitution,
- A new economic landscape with many elements including large-scale migration to the Gulf and other regions and signs of long-awaited forward movement in negotiations with India on water and power,
- The emergence of climate change adaptation as an overarching theme of GoN programs, and,
- The recent decision to move towards creation of a National Water Resources Commission to develop and coordinate water programs across multiple Ministries, civil society, and the private sector.

There are numerous ongoing activities that are tied to implementation of the NWP, which are supported and funded by the GoN and a number of donor countries. Examples of these activities are listed in Annex B. Many activities involve active local participation.

## B. Institutional Framework

The institutional framework for water resources management in Nepal consists of a web of government ministries, commissions, and departments; legislation in the form of acts, rules, and regulations; policies; strategies; and plans and programs. A summary of these water resource management-related elements is given in Annex A.

Of primary importance to water resources management in Nepal are the Water Resources Strategy (NWS 2002), the National Water Plan (NWP 2005), and the National Water Resources Policy (NWRP 2011). The Water Resources Strategy was developed in 2002, and the National Water Plan was approved in 2005 to implement the WRS. The general principle of the NWP plan was to integrate the objectives of social development, economic development, and environmental sustainability with an emphasis on decentralization and local participation. These objectives were carried forward into the National Water Resources Policy of 2011, and are represented as the following underlying principles:

- Water resources shall be developed and managed in a comprehensive and planned way, adopting principles of integrated water resources management as the underlying premises.
- Water shall be used in a sustainable manner for the conservation of water resources and environment. Every river basin shall be managed in a comprehensive way.
- Water services shall be decentralized to autonomous and responsible agencies (like: public, private, community and users-based organizations).
- Economic benefits and social equity shall be considered as fundamental premises during the development and management of water resources.
- Development and management of water resources shall be done in consultation and participation of stakeholders at all level.
- Benefits of water resources shall be mutually distributed among the coastal countries for the mutual benefits.
- Institutional and legal frameworks shall be put in place for ensuring coordination and transparency in water resources management.
- Institutional coordination shall be made effective for ensuring maximum use of best prevailing technologies and practices and also for using new researches and technologies.

The Water Resources Strategy tiers to the national goal that "living conditions of Nepali people are significantly improved in a sustainable manner". To move toward this goal, ten strategic outputs are listed in the strategy that fall under the general headings of Security, Use, and Mechanisms. These outputs, which are echoed in the National Water Plan and the National Water Resources Policy, are as follows:

1) Security
    a. Water Induced Disasters
    b. Environmental Action Plan on Management of Watersheds and Aquatic Ecosystems
2) Use
    c. Water Supply, Sanitation and Hygiene
    d. Irrigation for Agriculture
    e. Hydropower Development
    f. Industries, Tourism, Fisheries and Navigational Uses
3) Mechanisms
    g. Water-related Information Systems (Decision Support System for River Basin Planning and Management)
    h. Regional Cooperation Frameworks
    i. Legal Frameworks
    j. Institutional Mechanisms

For reasons discussed in Section I.E, this Assessment has focused on a sub-set of the outputs listed above. Aquatic ecosystems are covered in Section III; Water, Sanitation and Hygiene

(WASH) are covered in Section IV. In the following section we turn our attention to hydropower sustainability, watershed management, and an element of water resources management not highlighted in the National Water Plan: urban water supply.

## C. Priority Areas for USAID Support

### 1. Hydropower Sustainability

Of these strategic outputs in the NWP, much attention is currently focused on hydropower development. In 2001 the Ministry of Water Resources' Hydropower Development Policy was approved. This document charted the path forward to invest in the nation's hydropower potential to meet domestic needs, support economic development through supplying electricity to rural areas, and export power to foreign energy markets, particularly in India.

Nepal's current hydropower generation capacity is considerably lower than the demand, particularly during the dry season. Daily power cuts (load shedding) in cities like Kathmandu can occur up to 18 hours per day in the fall, winter and spring. Consequently there is an immediate push for hydroelectric power development.

While hydropower is considered a clean and renewable energy resource, experience in Nepal and other countries has highlighted potential issues to consider in order to maximize the sustainability of the hydropower development program. In broad terms, these issues center on basin planning that maximizes power production while minimizing impacts to marginalized river communities and aquatic species biodiversity; designing mitigation measures that ensure environmental flows in downstream reaches and provide for fish passage past the dams; and investing in watershed management programs to minimize anthropogenic sediment sources (particularly road-related landslides) that halt power generation due to excessive equipment wear.

Assessment of the viability of a hydropower project depends not only on the cost-benefit ratio of construction and operation, but also on the impacts on the services provided by free-flowing rivers. Intact freshwater ecosystems provide some of the largest ecosystem contributions to biodiversity and human welfare through provision of natural capital and ecosystem services, including commercially valuable fisheries (Millennium Ecosystem Assessment 2003; TEEB 2013). This recognition led experts at the World Bank and World Wildlife Fund to present a few general rules for hydropower development at the World Water Week 2014 conference in Stockholm that are directly applicable to hydropower planning in Nepal:

- Often, a few (maybe large), well-operated dams do less damage than multiple (sometimes hundreds) small dams scattered all over the basin.
- A sound mix of heavily utilized, single tributaries and remaining free-flowing river sections may balance the trade-offs between energy production requirements and conservation needs.
- The best solution, from an environmental perspective, is likely to include an undammed main stem connected with a number of the most valuable tributaries.
- In already impacted basins, refurbishment and modernization of existing dams and hydropower stations can increase their lifetimes and improve their performance, thus reducing the need to extend infrastructure into the untouched parts of the basin. It also often constitutes an opportunity for rectifying social and environmental problems associated with the original design and/or operation mode.

An example of the comparison between intense versus minimal hydropower development is currently observable on the Teesta River in Gangtok, India compared to the nearby Tamor

River in Nepal (Kanak Dixit 2014). These two sites provide an excellent opportunity to contrast effects to freshwater biodiversity and river-dependent economies from two very different hydroelectric development scenarios.

While large-scale dams will have inevitable effects on aquatic species, river morphology, and river-dependent communities and economies, these impacts can be lessened with appropriate dam location, design criteria and mitigation measures. Of primary concern is the design and implementation of environmental flows below dams. Environmental flows are intended to provide an appropriate amount of water in the downstream river channel to sustain river morphology, aquatic species, and river-dependent communities in that reach. In many cases in Nepal, all water is diverted through power generation tunnels and the downstream reach is dry until the next tributary junction brings water back into the river. While the environmental assessments for the projects speak to providing minimal environmental flows, they are not always implemented in practice due to the high demand for power.

The current language in Section 6.1 of The Hydropower Development Policy requires that '*provisions shall be made to release such a quantum of water which is higher of either at least ten percent of the minimum monthly average discharge of the river/stream or the minimum required quantum as identified in the environmental impact assessment study report*'. The ten percent criterion was adopted from a publication by the World Bank and has been used as a one-size-fits-all approach in the absence of site-specific information. In practice, each location has a unique physical setting, stream channel dimensions, and hydrologic regime. A single environmental flow value, considered to be universally applicable, may be acceptable in some locations, but will certainly be inadequate in others.

To add to this complexity, there is a gap in knowledge regarding the type and abundance of aquatic species in the rivers, and how local communities use those resources for their livelihoods. Even less is known about the species' essential migratory patterns required to sustain their populations.

**Figure II-3: Current dam design with either limited or no provisions for upstream of downstream aquatic species.** (M. Weinhold)

This data gap would suggest an immediate effort to validate aquatic biodiversity above and below potential projects, and determine design criteria for key migratory species so that engineers can appropriately design fish passage facilities at dams. Figure II-3 shows the Middle Marsyangdi hydroelectric plant, which lacks facilities to provide adequate upstream and downstream fish passage.

Watershed management, particularly related to sedimentation, is emerging as a critical issue for operation and maintenance of some of the existing hydroelectric plants. When sediment concentration thresholds in the river are exceeded, wear and tear on the mechanical equipment can cause the cost of operation to exceed the value of the power generated by a factor of 10 (WECS 2011). Consequently, poorly located plants may never realize their design potential for power production if they are unable to operate when river flow rates are otherwise optimal. Data collected at Middle Marsyangdi power plant have shown a steadily increasing trend in the concentration of suspended sediment. Anecdotal accounts suggest a link to increased road construction in the upstream watershed. Indeed, observations throughout the Mid-Hills between Kathmandu and Pokhara show miles of new, poorly constructed roads with massive amounts of surface erosion and associated landslides.

An example of road-related sediment from road construction is shown in Figure II-4. Consequently, improving road design and construction techniques is likely to play a larger and larger role in watershed management in drainages upstream of hydroelectric plants.

**Figure II-3: Erosion from poorly constructed roads on steep slopes can be a significant source of sedimentation affecting operation of hydroelectric projects.** (M. Weinhold)

## 2. Watershed Management

Because of diminishing water supplies and poor water quality for downstream users, one aspect of water resources management that has been receiving increased focus and attention is integrated, participatory watershed management (WM). The institutional development of watershed management in Nepal started with the inception of the Division of Soil Conservation and Watershed Management (DSCWM) in the Ministry of Forestry and Soil Conservation (MoFSC). The Department has gradually expanded with the establishment of District Soil Conservation Offices (DSCOs), which mobilize user groups to take the initiative in planning and implementing WM interventions (Singh et al. 2004).

In keeping with the decentralization and local control themes of the 2005 National Water Plan, there are many ongoing activities with a broad range of donor involvement that are implementing participatory watershed management and integrated water resource management programs at the VDC level. Much work is occurring through the Department of Soil Conservation and Watershed Management in activities ranging from erosion control and prevention, maintaining soil productivity, to slowing runoff to encourage ground water recharge. An example is the joint effort by WECS and WWF-Nepal in the Indrawati sub-basin (a tributary of Koshi River) which targets local livelihood enhancement and resilience through small-scale water storage, distribution, and groundwater recharge projects. Similarly, the Department of Agriculture is working with ICIMOD & LI-BIRD on the High Mountain Agribusiness and Livelihood Improvement (HIMALI) project (ICIMOD 2012).

**Figure II-4: An example from the Indrawati sub-basin of local, small-scale water storage to support growing of high-valued vegetables by a coalition of local families.** (M. Weinhold)

Watershed management plans are being developed that are driven by a livelihood improvement goal, rather than the more traditional soil conservation and water management focus of DSCWM programs. Other examples are described in detail in Annex B.

Watershed management activities are occurring across the country and are often not well coordinated among project proponents. The only country-wide assessment of watershed condition was completed in 1983 by the Department of Soil Conservation and Watershed Management (DSCWM 1983). This evaluation is still used as a prioritization mechanism even though ranking parameters such as population and land use have changed significantly. Also, the final map product in Figure II-6 was based on district political boundaries, as opposed to delineated watersheds. In 2012 the International Water Management Institute (IWMI) completed climate change and vulnerability mapping for the middle and high mountains of Nepal (Siddiqui et al. 2012). Other groups have done condition/vulnerability assessments, but often only for a specific river basin. Independent of the scale analyzed, there is a clear need to account for new data, including climate change predictions, and provide a mechanism to coordinate actions in the watershed.

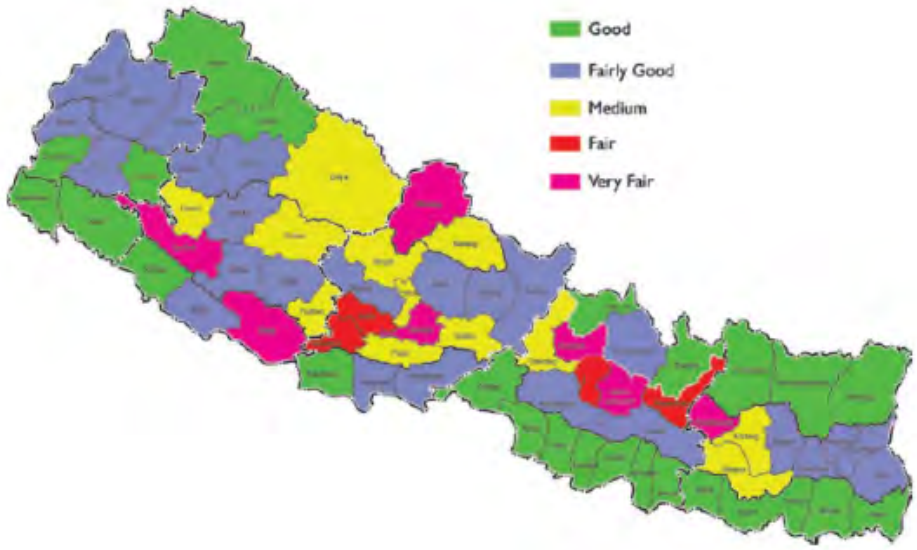



**Figure II-5: Results of a 1983 assessment of watershed conditions conducted by the DSCWM, which continues to be used to prioritize areas of focus.** (DSCWM, 1983)

Sustainable management of upland natural resources is a critical issue in steep, mountainous countries such as Nepal. As discussed previously, an emerging watershed management issue that has yet to receive adequate attention is the proliferation of poorly constructed local roads. The erosion and sedimentation, irretrievable loss of topsoil, and rapid routing of water off the landscape can quickly offset the gains made by many other ongoing watershed management activities. Finding a way to engage engineers and train road building contractors in methods to design/build stable and sustainable roads will be a key challenge in the coming years. Similarly for higher volume public roads, planning of the traffic volumes and demand for transport services, accounting for the long-term operation and maintenance as well as the internal rate of return (IRR) are other crucial factors to be considered while planning and constructing such roads.

### 3. Urban Water

Nepal is undergoing what the World Bank has called "two momentous transformations": from a rural to an urbanizing economy and from a unitary to a federal state (Muzzini and Aparacio 2013). Nepal is the fastest urbanizing country in South Asia and Kathmandu is the most rapidly metro region in South Asia with growth rates up to 7 percent. In addition, air quality issues are extreme in cities like Kathmandu. The pace of this urbanization out paces the cities' ability to provide adequate sanitation and clean water. These issues were mirrored in the other urban areas and secondary cities visited during the Assessment Team field trip through Pokhara, Butwal, Bhairawa and Bharatpur.

As noted earlier, urban water has not been highlighted as a distinct theme in the National Water Plan or in the GoN policies and strategies. Given Nepal's very rapid urbanization, coupled with significant differences in both the technical options and scale of urban and rural water supply systems, we believe the time has come to devote urgent attention to urban water.

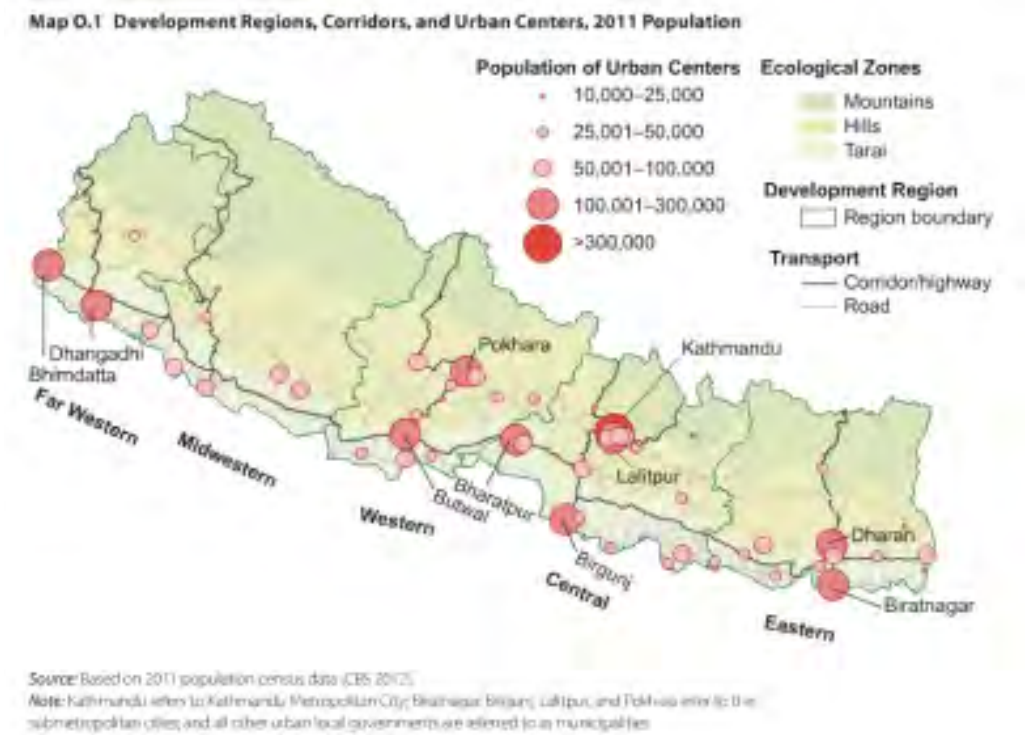



**Figure II-6: Urban Centers in Nepal.** (World Bank/Muzzini and Aparacio 2013)

The South Asia Urban and Water Unit at the World Bank is supporting Nepal's urban sector with the Emerging Towns Project and a program of Technical Assistance for the Kathmandu Valley focusing on metropolitan planning and management and the urban regeneration of the historic city cores in the valley. At the same time, Members of Parliament (MP) from the Kathmandu Valley are working with the Kathmandu Municipality to expand the vision of the Kathmandu Sustainable Development Working Action Plan (Thapa 2013) into a valley-wide Unified Kathmandu Valley Development Vision that will begin to systematically address a wide range of pressing water and other issues. Topics covered include restoring air quality, sustainable urban mobility, urban energy security, public lands/parks, women's space & safety, water & food security, energy and carbon-efficient built environment, infrastructure codes, urban slums, waste management, bipartisan action and public participation and implementation & financing.

The private sector has been moving to address these issues in the Kathmandu Valley and beyond by providing services that include rainwater harvesting and groundwater recharge at private homes and high end hotels, trucking water to tanks at private residences, and fecal sludge management.

## D. Knowledge Gaps and Associated Research Agenda

The amount of information in Nepal for water resources availability, use, and management is not extensive, but it is increasing. Collection of much of the available information has been facilitated by donor countries working in the region. According to Poudel (2005), Nepal's watersheds have not been properly evaluated according to their resource endowment and degree of fragility, and the Nepalese government does not have a zoning system that delineates land by the most appropriate use. Watershed-based data are often only available by administrative unit, and these

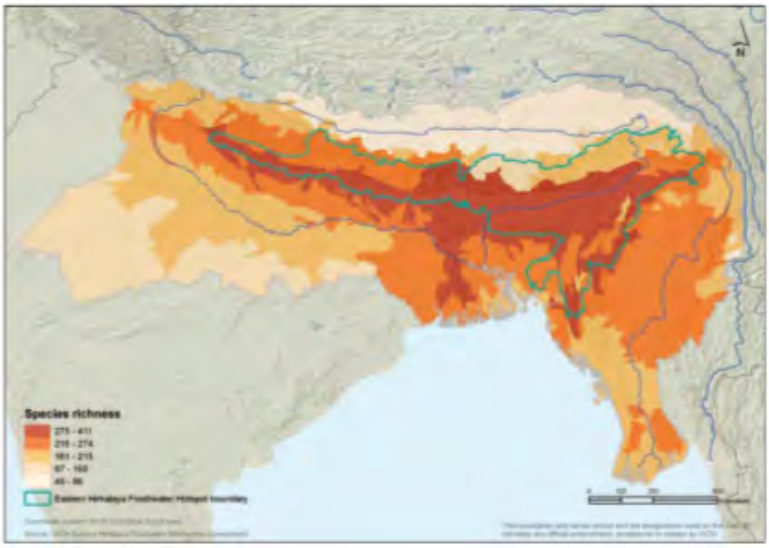
units don't often coincide with physical boundaries. Time series data for human-induced impacts on water resources are lacking, and most studies have failed to separate out natural and human causes.

Updated data and information are needed as population size and distribution changes, and as water availability shifts with observed extremes in precipitation related to climate change. As discussed in the Strategic Program for Climate Resilience (SPCR), climate change is expected to cause greater water scarcity in the High Mountain Region, affect water quality and availability in the Middle Mountains, and cause more water-related disasters (flooding, landslides, sedimentation, water-borne disease) in the Churia/Tarai Region. The SPCR focuses on three key elements for building resilient communities, the first of which is to enhance the resilience of natural water systems, which are considered essential for sustained social and economic development. Consequently, acquiring information on the magnitude, frequency, and spatial extent of these expected changes will be an important aspect of any adaptation strategy.

Additionally, development in the hydropower and irrigation sectors is considered a key factor in developing resilience of water systems within the context of Nepal's economic development framework, and within the context of the predicted drier dry seasons and wetter wet seasons. These types of infrastructure development, which involve water storage and diversion from both large and small rivers, will have unavoidable effects on nearby river-dependent communities and freshwater aquatic biodiversity. Consequently, the detailed discussion of knowledge gaps and the associated research agenda in Section IV of this report contains a mixture of research needs across a broad spectrum of water resource and freshwater biodiversity issues.

# Section III. Freshwater Biodiversity

## A. Status Overview




Nepal is globally important in terms of freshwater biodiversity. The country contains large numbers of freshwater species (Figure III-1), including endemics (those that occur nowhere else), and has a remarkable turnover in species over short distances (beta diversity).The most unique feature of Nepal's freshwater diversity is the transition from alpine to tropical ecosystems over very short distances.

**Figure III-1:Species distributions of freshwater fishes, dragonflies and damselflies, and aquatic mollusks in the Eastern Himalaya IUCN project area, based on known and inferred species presence, mapped to river sub-catchments. The boundary of the Eastern Himalaya Hotspot region is shown in green.** (From Allen et al. 2010a)

This phenomenally rapid change in aquatic systems makes Nepal a globally important laboratory for freshwater biodiversity (Gurung 2012).

Nepal's freshwater ecosystems are diverse in myriad other ways. Almost as dramatic as the elevational relief is the extreme temporal variation in precipitation and character of freshwater ecosystems between the monsoon and dry seasons (Dudgeon 2000b; Rasul 2014). While Nepal is often cited as one of the world's most water-rich nations, in fact, water scarcity is a large and growing issue during the dry season, and many springs and rivers dry seasonally (Rasul 2014). Along another axis of variation, the climate becomes significantly wetter from West to East, driving associated changes in freshwater ecosystems. Finally, Nepal's estimated 819,277 ha of freshwater habitats encompass many types, both natural (glaciers and glacial lakes, small to large perennial and intermittent rivers, lakes, springs, swamps, and wetlands) and man-made (reservoirs, ponds, irrigated rice paddies)(Rai 2011; MoFSC 2014). Relatively unexplored in terms of aquatic biodiversity in the country are deep canyons, caves, and hyporheic zones (Dudgeon 2000b; S. Sharma, pers. comm. KU 15 July 2014).

Despite its global and local significance, freshwater biodiversity in Nepal, as throughout much of Asia, has received much less attention than terrestrial biodiversity (Dudgeon 2000b). By all accounts, the following biodiversity summary is based on an incomplete taxonomic accounting of species in nearly every floral and faunal group.

Estimates of the number of fish species in Nepal range from 185 to 230 (Sharma 2008; Rai 2011; Gurung 2012; MoFSC 2014), and more species remain to be described, especially in the western regions. In the Ganges River basin, species number is highest in the low elevations and decreases with increasing elevation (Figure III-2)(Dudgeon 2000b;Vishwanath et al. 2010; Sarkar et al. 2012), with fish occurring up to about 3,000 m elevation (Sarkar et al. 2012) or possibly much higher (S. Sharma, pers. comm. KU 15 July 2014). Of these, nine species are endemic, including three from Rara Lake (Sharma 2008). Other fishes, including the Indian Mottled Eel (*Anguilla bengalensis*; local name Rajabam) and Gonch (*Bagarius yarrellii*), have large ranges and undertake long migrations between the Bay of Bengal and the high mountains. Nepal's fishes vary from small, short-lived species (e.g., *Danio rerio* that reaches 26 mm) to some of the world's largest freshwater fishes (e.g., Gonch that can attain 80 kg) (Sharma 2008).

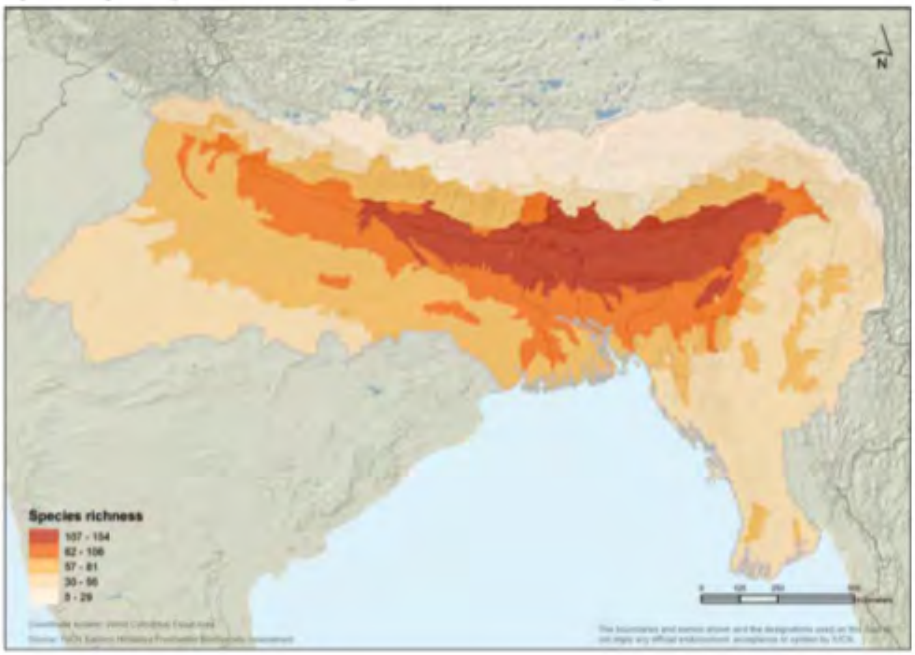
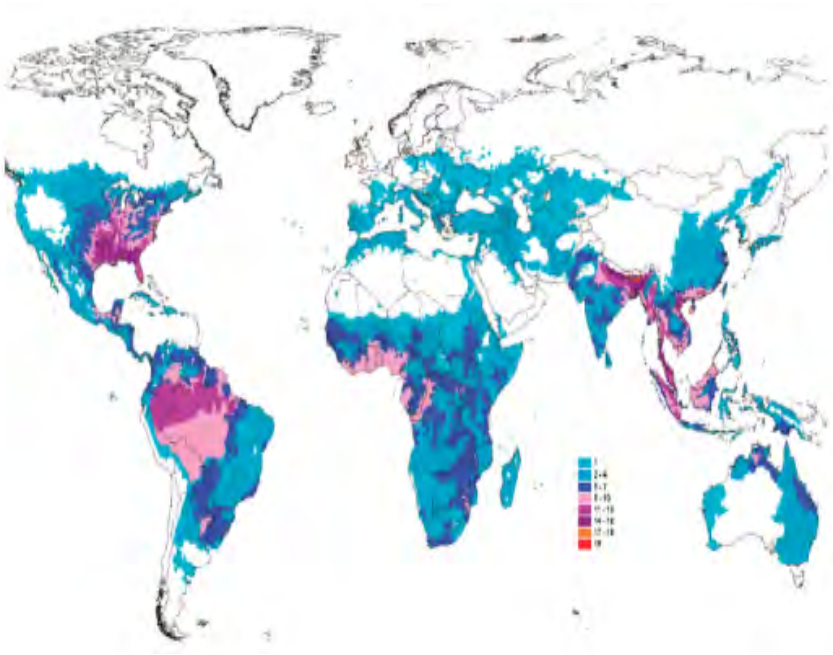
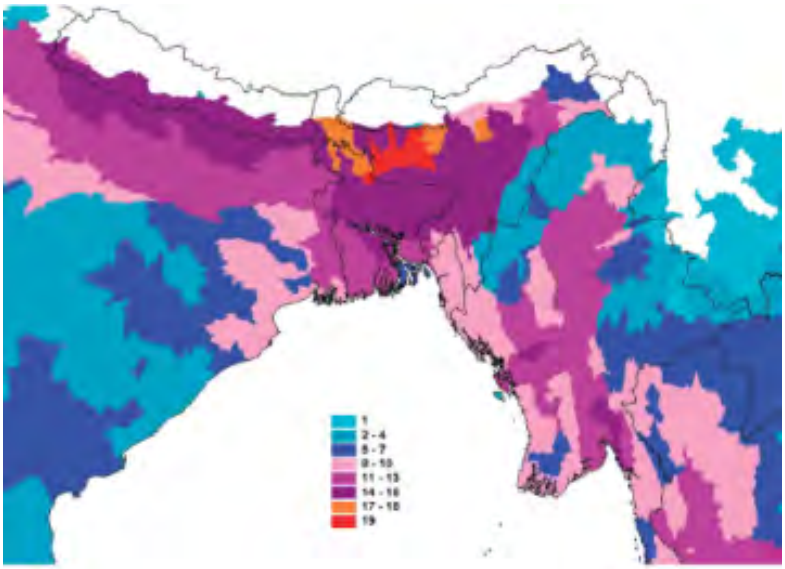



**Figure III-2: Map showing overall freshwater fish species richness in the Eastern Himalaya region.** (From Vishwanath et al. 2010)



Reptile and amphibian species are globally significant in Nepal, with 10 endemic species (IUCN 2004). The Lower Gangetic Plains Moist Deciduous Forest Ecoregion, including part of the Tarai, has the third-highest species richness of turtles on earth and is one of Buhlmann et al.'s(2009) three proposed Turtle Priority Areas, where globally high turtle species richness coincides with minimal existing conservation protection (Figures III-3 and III-4).

**Figure III-3: Global patterns of species richness based on projected ranges in hydrologic unit compartments of all 305 species of tortoises (45) and freshwater turtles (260) included in this analysis. Scale of color codes indicates number of species for each area.** (From Buhlmann et al. 2009)



The Gharial and Marsh Crocodile are found in the Tarai, as well as numerous snakes, frog, and toad species. Despite the diversity of amphibians in the country, during our many meetings regarding freshwater biodiversity in Nepal, no one mentioned amphibians.

**Figure III-4: The world's greatest turtle species richness area, based on the co-occurrence of species in hydrologic unit compartments in the Ganges–Brahmaputra river basin drainages of India and Bangladesh in South Asia." Color codes as in previous figure.** (From Buhlmann et al. 2009)

Much remains to be discovered about the freshwater invertebrates of Nepal (and Asia in general; Dudgeon 2000b), but several groups, including mollusks (snails, bivalves, etc.), crustaceans (freshwater crabs and shrimps), odonates (dragonflies and damselflies), and some other insect families have been fairly well documented. The Kali Gandaki gorge (by one measure the deepest on earth) contains over 1,375 species of water beetles (S. Sharma, pers. comm. KU 15 July 2014).

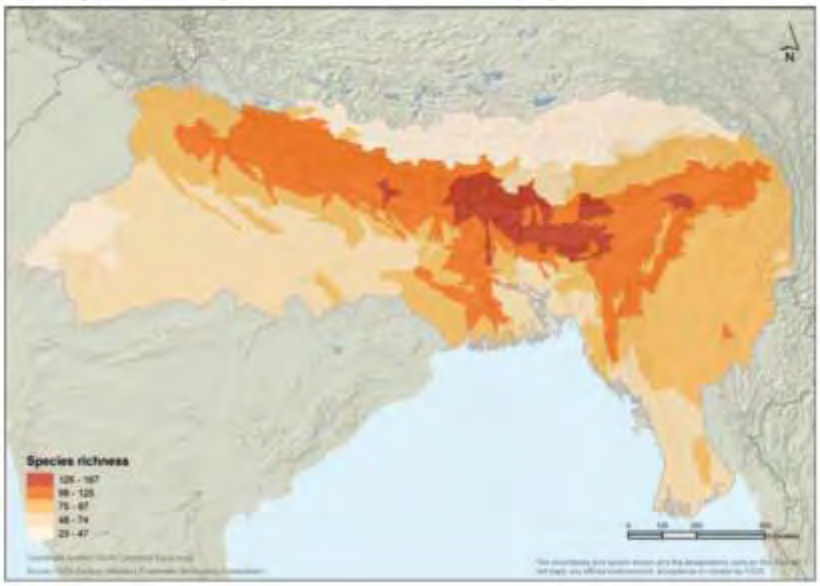



**Figure III-5: Species richness of dragonflies and damselflies in the Eastern Himalaya region."** (From Mitra et al. 2010)

The remaining species groups discussed (mammals, birds, and plants) include species that are predominantly or entirely associated with freshwater as well as those that are generally considered terrestrial but that depend heavily and directly on freshwater habitats. Of the freshwater mammals, the most notable is the Ganges River Dolphin, the sole remaining representative of the family Platanistidae and one of several freshwater dolphin species, all of which are endangered or extinct. The one remaining dolphin population in Nepal that is thought to be viable occurs in the Karnali River (Smith and Braulik 2012). Other predominantly aquatic mammals include: Fishing Cat, several species of deer and otter, shrews, and the Indian Water Buffalo. The Indian Rhinoceros is an example of the many charismatic megafauna often considered terrestrial but that depend heavily on freshwater habitats (Dudgeon 2000a, b). The IUCN Red List includes 307 bird species that use freshwater habitats in Nepal. An estimated 25% of Nepal's vascular plant species are at least partially dependent on wetlands (IUCN 2004). IUCN Red List assessments have been conducted for 284 freshwater plants that occur in Nepal, and only three species (1%) were assessed as at-risk.

## At-risk Species

Of the freshwater animal species in Nepal evaluated with the IUCN criteria, 11 percent were found to be of conservation concern, with percentages by group varying from 90% of freshwater mammal species to 0% of mollusk species assessed (Table 3.1). However, 7% (range 0-16 %) of the species were assessed as Data Deficient, indicating that insufficient information existed to assess the species status(Table 3.1).Of the freshwater species evaluated by the IUCN Eastern Himalaya assessment, the highest numbers of at-risk species in Nepal occurred in the mid-hills

regions (Figure III-6). Species at risk include charismatic mega fauna such as the Indian Rhinoceros, Gharial, Marsh Crocodile, and Ganges River Dolphin; the most endangered populations of the latter may be in Nepal (WWF Nepal 2006). "The Gharial is especially at risk from flow regulation because it prefers fast-flowing river habitats, which are prime sites for dams" (Dudgeon 2000a). Such species tend to garner attention, funding, and conservation efforts. However, many of the remaining at-risk species are relatively unknown except perhaps to those whose livelihoods bring them in contact with the species.

**Table III-1: IUCN Red List search results for native animal species that use freshwater habitats in Nepal. Number "at risk" includes species assessed as Critically Endangered, Endangered, Vulnerable, or Near Threatened. Data Deficient indicates insufficient data to apply the IUCN assessment criteria; this may also reflect taxonomic uncertainty. Not all species in each group have been assessed. Search conducted 19 August 2014. http://www.iucnredlist.org/search**

| Group(s) | Number of freshwater species assessed | Number at risk (%) | Number Data Deficient (%) |
|---|---|---|---|
| Mammals | 10 | 9 (90) | 0 |
| Reptiles/amphibians | 59 | 14 (24) | 5 (8) |
| Birds | 307 | 39 (13) | 0 |
| Fish | 152 | 18 (12) | 13 (9) |
| Odonates | 159 | 4 (3) | 26 (16) |
| Mollusks | 65 | 1 (2) | 8 (12) |
| Decapod crustaceans | 7 | 0 | 1 (14) |
| **Total** | **759** | **85 (11)** | **53 (7)** |

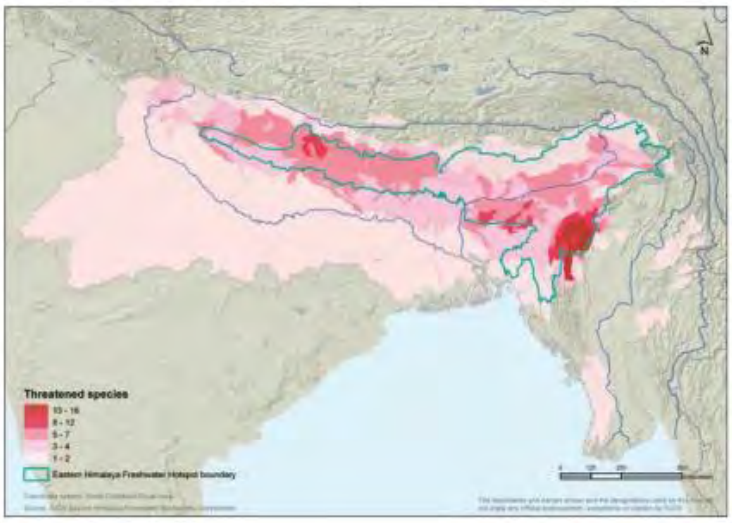



**Figure III-6: The distribution of threatened (CR, EN, and VU Categories) species of dragonflies and damselflies, freshwater fish, and aquatic mollusks in the Eastern Himalaya project area, based on known and inferred species presence, mapped to river sub-catchments. The boundary of the Eastern Himalaya Hotspot region is shown in green."** (From Allen et al. 2010a)

The IUCN Red List assessments consider the global ranges and populations of species. Additional species may be at risk of extirpation within Nepal but are not necessarily at risk globally. Furthermore, global extinction of some at-risk species would represent a greater loss

of biodiversity than would others. Extinction of a frog from a speciose genus represents less of a biodiversity loss than extinction of a dolphin that is the last remaining species in its family.

## Genetic Diversity

Genetic, or population-level diversity, is another important aspect of biodiversity. Genetic diversity provides the foundation for speciation and local adaptation, and is especially critical in providing the variation essential for adaptation to habitat alterations and climate change. For many freshwater plants and animals in the region, considerable genetic diversity is to be expected between major river basins (e.g., Brahmaputra, Ganges, and Indus), but is also likely present among rivers that drain south into the Ganges as well as between north- and south flowing tributaries of the Ganges, as well as among lakes. Such diversity has received little attention in Nepal. However, the existence of some endemic species in lakes (e.g., Rara Lake) suggests that genetic diversity within species among habitats also is present.

## Ecological Processes and Ecosystem Services

Conservation of freshwater biodiversity requires consideration of spatial and temporal habitat linkages and variation. Freshwater habitats typically have clearly evident upstream and downstream linkages. Less obvious may be the lateral (floodplain and riparian) and vertical (hyporheic, karst) linkages and temporal fluctuations. Nepal's freshwater flora and fauna evolved in these variable ecosystems, and thus, many depend on the three-dimensional linkages and temporal fluctuations (Dudgeon 2000b).

The most obvious example of the need for upstream-downstream linkages are the long, riverine migrations of many species, including fishes, dolphins, and shrimps, epitomized by the historic migrations of the Indian Mottled Eel from the Bay of Bengal to the Kagbeni section of Kali Gandaki River near Muktinath (Trans-Himalayan zone, Mustang district). Upstream-downstream linkages are also needed in Nepal for terrestrial biodiversity (Allendorf et al. 2012). Similarly, many species, from catfishes to rhinos, rely on seasonal inundation of floodplains for feeding, spawning, and creation of appropriate habitats. Vertical linkages between surface and groundwater help to dampen seasonal fluctuations in water temperature and discharge, provide habitat for hyporheic species and refuge during floods for some riverine species, and may play an important role in water quality.

Freshwater species provide many ecosystem services, undoubtedly including many that have yet to be documented. The most obvious ecosystem service is providing resources directly to humans (Rajashekariah et.al. 2012). Resources provided by wetlands include food (fish, mammals, snails, shrimps, birds, turtles, etc.), forage for livestock, wood, and shelter (plant materials for building and thatching)(WWF Nepal 2005; MoFSC year unknown). Some wetlands and associated species are important for labor (e.g., water buffalo), spiritual practices, or enjoyment (including tourism)(WWF Nepal 2005; MoFSC year unknown). Research in other regions has shown that species diversity (of both plants and animals) is important to maintenance of water quality and control of some diseases. For example, freshwater species composition and abundance can have a profound effect on mosquito populations. Some freshwater species, such as crocodiles, rhinos, and birds can be an important basis for ecotourism. Yet without a robust community of freshwater invertebrates and fishes, the more charismatic freshwater fauna will disappear.

## Value/Economics of Biodiversity

Little effort has been made to put economic valuation on Nepal's freshwater biodiversity and wetlands (IUCN 2004), especially components that are not directly exploited. IUCN (2004) referenced a study indicating that a Sri Lankan marsh produced 725 million Sri Lankan Rupees

worth of goods and services annually. With little economic analysis of wetlands, a precautionary approach is advised in which we acknowledge that we do not know the full economic costs of losing pieces of wetland ecosystems.

Fish provide an increasingly important source of protein and income for many rural people (Rai 2011). Rai (2011) lists more than 10 indigenous groups that rely primarily on fishing and cites a 2006 figure that 762,000 people benefitted from capture fisheries, with an additional 87,000 people employed in aquaculture. IUCN (2004) lists 13 ethnic groups, including 2.5 million people that depend on wetlands, and (MoFSC date unknown) lists 22 wetland dependent groups. These include many of the poorest and most marginalized groups in the country (IUCN 2004). Several examples of positive economic results from aquaculture are based on non-native species, such as exotic carps and rainbow trout, but no research on impacts to native biodiversity have been conducted (Sharma 2008). Both fish production and fish consumption have been increasing in recent years (Sharma 2008; Rai 2011), and more women than men now participate in capture fisheries (Rai 2011).

The Assessment Team visited the Rupa Lake Conservation and Fisheries Cooperative, a community based organization that illustrated the tremendous potential for economic benefits from fisheries initiatives (Figure III-7). A group of 744 local farmers participate in the cooperative, rearing primarily introduced, but also some indigenous, fish species in Rupa Lake. The annual revenue generated was reported to be 7 million Nepali rupees. The community has been so well organized that payments for ecosystem services and community development have extended to fodder cultivation, integrated pest management, road construction, community forestry and management of schools in the watershed. For other details, refer to **Annex C**.

**Figure III-7: Different levels of fishing intensity in the Rupa Tal region** (SB Adams)

Tourism, both domestic and international, is an important economic benefit of freshwater biodiversity and wetlands in some areas of Nepal and has the potential to be developed further. Over 7,000 tourists visit Gokyo Lake annually (WWF Nepal 2005). The lakes of Pokhara and the Koshi Tappu Wildlife Reserve are major tourist draws, the latter bringing in over 1.3 million Nepali Rupees from 1995-9 (IUCN 2004).

**Figure III-8: Wetland grasses are integral to the traditional building methods of the Tharu people near Chitwan National Park.** (SB Adams)

A 2003 estimate indicated that rafting on the Bhote Koshi River employed 1,600 people and brought in 1.7 million USD per year (IUCN 2004). Sharma (2008) suggested that hill streams could attract many people for fishing and tourism.

## B. Threats to Freshwater Biodiversity

### Direct and Indirect Threats

Threats to Nepal's freshwater biodiversity include flow modifications (including hydropower development and surface and groundwater extraction), water pollution and urbanization/population growth, watershed and habitat alteration (including conversion of wetlands to agricultural lands), invasive species, overfishing and illegal fishing, and climate change(Allen et al. 2010b). The categories are overlapping, synergistic, and many present both direct and indirect threats to biodiversity.

Although to date hydropower development in Nepal has been minimal (Figure III-9 ), it poses one the greatest looming threats to freshwater biodiversity in the country and has been cited as the largest threat to fishes of the Ganges River (Sarkar et al. 2012). "In India, all tributaries of the Ganges are controlled by barrages diverting flow for irrigation," resulting in declines in fish catches and species diversity (Sarkar et al. 2012). Dams interrupt essential migrations and home range movements, fragment large populations into populations too small to be viable (WWF Nepal 2006), and alter nearly all riverine processes from hydrologic regimes to sediment and nutrient transport to thermal processes (Dudgeon 2000a; IUCN 2004; Rajashekariah et.al. 2012). They alter lateral and vertical, as well as longitudinal linkages. Nepal requires that hydropower operations leave at least 10% of the dry season flow in rivers at all times. We found no firm scientific basis for the 10% figure. Environmental Impact Assessment reports documented the 10 % flow estimation based on the annual average flows of the rivers. Therefore, leaving 10% of the flow in the river is undoubtedly inadequate to conserve most freshwater species (Rajashekariah et.al. 2012); furthermore, the criterion is not adhered to.

Our team visited two "run-of-river" hydropower facilities, both of which completely dewater the river downstream of the dams during the dry season. It was mentioned that the authorities considered the supply of electricity more important than the ecological benefits of a flowing river. Conversely, high dams often dampen seasonal fluctuations in discharge, thereby creating a disturbance to species adapted to flood pulses (Dudgeon 2000a,b).

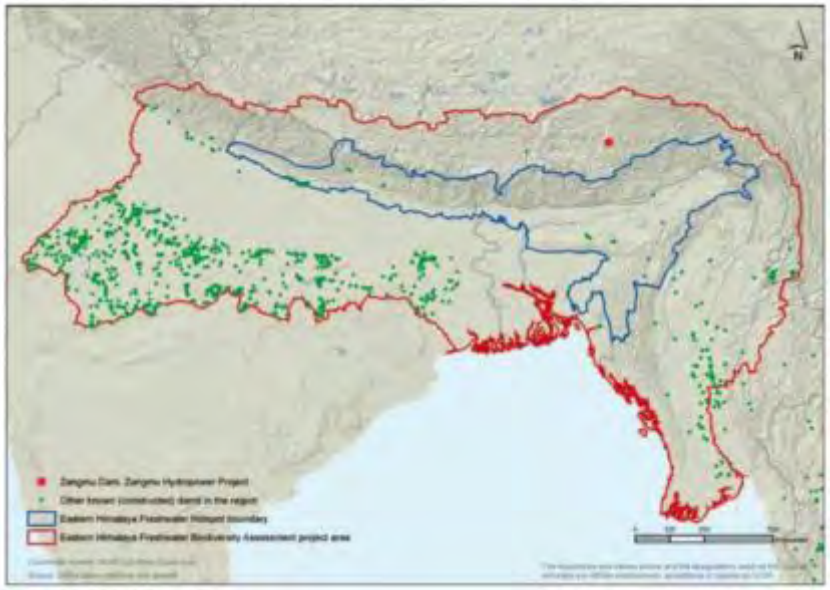


**Figure III-9: Location of currently known dams (green points) throughout the Eastern Himalaya region. Note the very large number of dams in the southern parts of the Ganga River catchment and parts of Myanmar … With the exception of the Zangmo dam, the map only shows *current dams* visible on Google Earth, not those under construction or planned. Source: Global dams database and Geowiki (Mulligan *et al.* 2010)."** (From Allen et al. 2010a)

A single dam can eliminate migratory species from an entire river basin.

> "*A high dam has been planned for some time just upstream of the [Ganges River] dolphins' current (or at least recent) range in the Karnali River, Nepal. If built, this structure would almost certainly eliminate the small amount of dolphin habitat in Nepal's last river with a potentially viable dolphin population [Smith and Reeves 2000]. Disturbance and environmental degradation associated with geotechnical feasibility studies and bridge and road construction for the dam already may have contributed to a decline in the number and range of dolphins above the Nepal-India border [Smith 1993, Smith et al. 1994]*" (Smith and Braulik 2012).

No dam influencing Nepal's rivers in Nepal or India has successfully provided passage for migratory animals. The Gharial Breeding Center in Chitwan District is essentially supplying India with Gharial because many of the released animals pass downstream over a barrage and cannot return. For high dams, providing upstream passage solves only part of the migration problem. Because many migratory animals depend on currents for downstream navigation cues, large reservoirs often disrupt downstream migrations, causing animals to perish in the reservoir.

Urbanization and population growth present many threats to freshwater species. The most obvious are dewatering and altering of freshwater habitats, including floodplains. Floodplain development is often appealing, but in Nepal, where species are adapted to monsoon flood

pulses, such development presents risks to many species, as well as to the people occupying the floodplains. Other threats from urbanization include excessive water extraction, overharvest - often by illegal methods - and pollution (Sarkar et al. 2011).

Surface water extraction, for agriculture, industry, or household use, reduces the habitat area and volume available to freshwater species. Smaller water volumes also lead to changes in water temperature, nutrient cycling, and pollutant concentrations.

Freshwater pollution has many sources in Nepal (Shah and Shah 2009) and requires much more attention from both research and regulatory arenas. Contamination by human waste is rampant, and cremation is a locally significant pollution source. Other pollution sources are agriculture, industry, urban runoff, and mining. While water pollution has serious consequences for human health, it also affects freshwater biodiversity. Benthic invertebrates species and dissolved oxygen levels in the Bagmati River declined precipitously as the river passed through the Kathmandu valley (Shah and Shah 2009), and a reach of the river in the valley harbors no fish (Sharma 2008). Professor S. Sharma (pers. comm. KU 15 July 2014) related how human wastes from tourist facilities created ecosystem alterations in a high mountain lake. Mercury pollution is an issue in some areas (e.g., Phewa Lake) and is thought to originate from both atmospheric deposition and fertilizers (Sharma et al. 2013; S. Sharma, pers. comm. KU, 15 July 2014). Methyl mercury, a highly toxic form of mercury bioaccumulates, creating health hazards for people eating predaceous fishes (Sharma et al. 2013). In addition, in a reservoir, where at least some of the water is commonly depleted of oxygen, inorganic mercury is converted to methyl mercury and becomes available for uptake by animals at all trophic levels (Slotton et al. 1995; Kelly et al. 1997; Canavan et al. 2000)..

Nonpoint source pollution from urban and agricultural runoff threatens biodiversity. An estimated 2,600 tons of pesticides and 1.15 million tons of chemical fertilizers entered the Ganges River annually in the early 2000's (IUCN 2004). In Indian portions of the Ganges River basin, water salinization resulting from high salt loads in returning irrigation water is a problem (Sarkar et al. 2012). Point source pollution from industry is presumably an issue in Nepal, but we found little documentation of the problem. Finally, sediment pollution affects freshwater species by:1) filling interstitial spaces in the substrate, eliminating living space for many invertebrates and some vertebrates, 2) abrading gills and other tissues, causing direct or indirect mortality, and 3) increasing turbidity and reducing foraging efficiency for sight-feeding predators. At very high levels, sediment aggrades river and lake beds, reducing the volume of water they can hold and increasing flooding. This, in turn, can cause people to channelize rivers, leading to detrimental effects on many species. Extraction of sand, gravel and boulders from rivers and streams, particularly in the Siwalik Hills, is a contentious issue in Nepal that has heavily engaged the local population, business sector and policy makers in recent years (e.g., Dixit 2014b). Sand and gravel extraction from riverbeds creates extremely high sediment loads downstream. As well as creating direct negative impacts, the sediment can create habitat alterations that adversely affect animal behavior. Little is known about impacts of such activity in Nepal.

Overharvest and illegal fishing methods are a frequently-cited threat to freshwater species (Dudgeon 2000b). We read and heard many accounts of unsustainable fishing methods. The most egregious method is by poisoning. Typically, organochlorines, which are persistent carcinogens that bioaccumulate (S. Sharma, pers. comm. KU, 15 July 2014), are dumped in a river, and the dead animals are then collected with nets. This is extremely detrimental as it kills all animals in the affected reach. We found no research on persistence of the chemicals or on health effects on people who consume fish killed in this way. Many accounts attributed such methods to people coming from cities, but some to participation by whole villages. Another increasingly common fishing practice is to use small mesh nets, allowing the fishers to catch

small fishes that sometimes receive a higher price per kg than do large fishes. Finally, with little regulation and enforcement of fishing levels, Nepal currently has minimal ability to prevent overharvest that could lead to collapse of fisheries. This applies to harvest of many freshwater groups (e.g., birds, turtles), not just fishes.

Climate change is likely to affect freshwater species via numerous avenues. Precipitation and hydrological regimes have already become less predictable and characterized by more frequent extreme events (e.g., droughts, floods)(Rasul 2014; Sherpa 2014). Anecdotal reports indicate that monsoons have already become less predictable. Glacial lake outburst floods affect freshwater species as well as humans and alter habitats by scouring rivers. Loss of glaciers and reduced snowpack will reduce dry season river flows in high elevation streams and in major rivers. Climate warming will directly influence survival and distributions of some species, and will likely have the strongest effects in high elevation habitats. Increases in water temperatures and shifts in fish distributions and life history timing have already been documented in some upper tributaries to the Ganges River in India (Sarkar et al. 2012). Some predict that warming in freshwater habitats will create completely novel freshwater communities.

Construction of roads, railways and other infrastructure will have indirect effects on freshwater species. Road and railway crossings can create migration barriers if improperly designed (see dam effects above). Sediment production from current road building practices is extreme (see above for effects). Finally, roads/railways can improve human access to wetlands and thereby increase harvest pressure and illegal harvest.

As in many places, groundwater processes in Nepal are poorly understood. However, groundwater is integral to the maintenance of many types of freshwater habitats. Excessive groundwater extraction may lead to water level reductions in rivers, lakes, and springs and to a concentration of pollutants (Dudgeon 2000b; Shah and Shah 2009). Reductions in groundwater can also have important effects on thermal regimes in freshwaters. Drying of springs is important to people as well as to species that live in springs and spring fed habitats (e.g., crabs, Figure III-10). Moreover, springs may provide important water sources for a variety of terrestrial wildlife.

**Figure III-10: Crab extracted from a spring source Chirtungdhara Palpa, Nepal, July 20, 2014** (SB Adams)

## C. Priority Areas for USAID Support

Better surveys of existing biodiversity and improved understanding of species-level taxonomy are needed for national and local level conservation planning (Allen et al. 2010b; Gurung 2012). For fishes, this especially applies to the western and far western regions (Gurung 2012). Information on life history, behavior and ecology of key species is essential to many conservation efforts such as establishing environmental flow levels and designing functional fish passage on dams (Dudgeon 2000b). Deeper understanding of ecological processes and ecosystem functions will assist in assessment of threats to ecosystems and prediction of responses to disturbances such as climate change.

Like many nations, Nepal has focused much more on terrestrial than freshwater conservation. Terrestrial and freshwater priority conservation areas may or may not overlap. When overlap exists, terrestrial conservation efforts do not always benefit freshwater species. Therefore, intentional, coordinated planning and implementation of freshwater protected areas (Gurung 2012; Sarkar et al. 2014), and allowable activities within them may be beneficial.

Development and implementation of practices/mitigations for sustainable development will be essential to freshwater biodiversity conservation in Nepal. In many cases, practices and technologies for sustainable development already exist in Nepal or elsewhere, and the challenge is sharing the knowledge about such practices and promoting/enforcing implementation. In other cases, such as fish passage at dams, new technologies may need to be developed and new information acquired about species' biology to meet the unique challenges presented by local conditions and species.

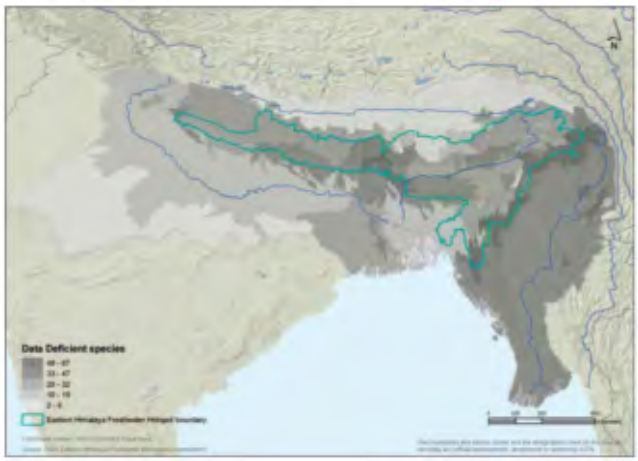
Invasive species are a worldwide threat to freshwater biodiversity and are imposing economic costs in Nepal. Invasive plants currently appear to be a bigger problem than invasive animals in Nepal's freshwater ecosystems; however, little or no research has been conducted on impacts of introduced fishes such as Bighead and Silver Carp or Rainbow Trout. Urgent need exists to provide technology transfer on methods proven successful elsewhere for combating invasive freshwater plants and to develop and test new control methods.

Education about freshwater biodiversity needs to be increased at all levels, from villages to university programs to government officials and politicians. Involvement and education of local people, modeled after community forestry, in freshwater conservation will be useful. One example is the fishing cooperative in Rupa Tal, where water users created an informal system of payment for ecological services to encourage upstream land users to employ practices that improve water quality (Pradhan et al. 2010). The members have tackled issues of sedimentation and pollution from upstream and invasive plants, while creating a profitable fishery and improving education and tourism opportunities. With additional development of aquaculture techniques and training, similar cooperatives should be able to prosper using only native fish species.

Examples of ecotourism related to freshwater biodiversity and ecosystems exist throughout Nepal. Whitewater rafting is popular and lucrative in some areas. Canoe trips are offered in the buffer zone of Chitwan National Park, and bird watching is being promoted in many areas. Fishing as a tourist activity occurs in some locations and has potential in others (Sharma 2008), however, impacts of tourism should be monitored to ensure that tourism, itself, is not negatively affecting biodiversity. Further assistance in developing tourism around freshwater biodiversity could benefit both villagers and aquatic ecosystems.

## D. Knowledge Gaps and Associated Research Agenda

The lack of available information about freshwater biodiversity, as well as its connections to livelihoods, in Nepal cannot be overstated. While we appreciate that conservation actions cannot await more research, we also understand that effective and efficient freshwater biodiversity conservation in Nepal requires additional scientific knowledge and expertise (Dudgeon 200b). Obtaining additional information and developing in-nation expertise can and should occur as a unified process. As an example of the lack of basic information on species, Figure III.11 indicates the number of species in one assessment effort for which conservation status could not be assigned due to insufficient information on range or population size, taxonomy, or threats to the species. Of the fish species evaluated in Nepal, 9% could not be assessed for conservation status. Knowledge gaps are much greater in regards to life history, behavior, ecology, and threat (Dudgeon 2000a; Sarkar et al 2012). Despite the stunning




elevational gradients in Nepal, no studies have documented longitudinal changes in freshwater species composition from headwaters to river mouths (Dudgeon 2000b).

**Figure III-11: The distribution of Data Deficient (DD) species dragonflies and damselflies, freshwater fish, and aquatic mollusks in the Eastern Himalaya project area, based on known and inferred species presence, mapped to river sub-catchments and in some cases sub-country units. The boundary of the Eastern Himalaya Hotspot region is shown in green.** (From Allen et al. 2010a)

Through its world-renowned community forestry efforts, Nepal has clearly demonstrated that engagement of local people is essential to the success of conservation efforts. Moreover, increasing attention is being placed on gender equality and social inclusion issues. Clearly, the people most directly dependent on aquatic biodiversity for livelihoods are the poorest Nepalese with the least voice in decision making. Nevertheless, there is little anthropological understanding of how and to what extent people are directly exploiting freshwater species. Such information will be essential to creating successful and equitable freshwater conservation initiatives. New organizational and educational programs could assist Nepali institutions to better support conservation of freshwater biodiversity. Many such programs, as well as suggested next steps in section IV, are also identified in Nepal's draft Biodiversity Strategy (MoFSC 2014). See Box III-1 for ideas on educational programs.

**BOX III-1: Regional Water Programs & Information Sources Freshwater Biodiversity Education: a Multifaceted Approach**

Conserving freshwater biodiversity in Nepal will only be successful if Nepali people, from politicians to villagers, care about preserving it. To care about it, they first must know about it and understand its importance. As the population urbanizes and indigenous knowledge of freshwater ecosystems is lost, this becomes an increasing challenge. We recommend a multifaceted education effort focusing on several key topics but presented with differing levels of complexity to different target audiences. The topic areas include:

1. The globally significant levels of freshwater biodiversity in Nepal
    a. This could become a point of pride for Nepal
    b. Emphasize the globally-unique, rapid transition from high mountains to Tarai.
    c. Begin with interesting examples of species or groups (e.g., diadromous fish that migrate between high mountains and sea, animals with unusual life cycles, biggest and smallest examples of animal groups, interesting –looking species)
    d. Discoveries await! Let people know that there are still freshwater species, including fish, waiting to be discovered in Nepal.
2. Just because you can't see it doesn't mean it's not important. Functional roles of freshwater ecosystems and biodiversity, including microscopic organisms (in other words, ecosystem services). Include links to public health and economy.
3. How Nepalis use freshwater species. Examples of the many direct and indirect way that Nepalis depend on freshwater biodiversity.

4. Threats to freshwater ecosystems and species. Important that this be realistic without creating a feeling of hopelessness.
5. Examples of ways to minimize threats. Success stories are important. But it is also useful for people, especially students, to understand that some solutions to threats await development.

We found that the level of awareness about freshwater biodiversity was fairly low in Nepal, so we recommend development of education programs targeted at diverse groups simultaneously. Below is a prioritized list of target audiences with some examples of approaches and partners.

I. Engineers/professionals
   a. "Greening" of engineers. Support a National Consultation on the "Greening" of Engineers to develop concrete proposals for how this can/should be done.
   b. Support the Nepal Engineering College Interdisciplinary Water Resources Management Masters Program and promote a freshwater biodiversity component in the program.
   c. Support avenues, perhaps a center of excellence, to promote ongoing synergies between engineers designing infrastructure (e.g., hydropower facilities/roads) and freshwater biodiversity experts.
   d. Support academic exchanges designed to improve engineer's understanding of freshwater biodiversity.

II. Universities
   a. Support an academic training program in fisheries that includes strong ecology and conservation components, not just aquaculture.-"It is clear that a 'center of excellence' should be initiated to keep vigilance on fish diversity conservation activities in Nepal" (Gurung 2012).
   b. An expanded academic aquatic ecology and conservation training program. The Aquatic Ecology Center at KU is an excellent beginning but needs to be expanded as well as structured so that high-performing professors and researchers are better allowed to focus on academic and research activities. The program should include training in modern taxonomic/genetic methods for diverse freshwater taxa (Allen et al. 2010).
   c. Support development of a Freshwater Conservation Biology course and text book targeted at students in other disciplines (e.g., engineering, aquaculture, forestry, hydrology, etc.) to introduce them to Nepal's freshwater biodiversity and the many conservation threats. Course should include an anthropological component addressing human reliance on freshwater biota.

III. Politicians/government officials
   d. Support short symposia or workshops to educate politicians, government employees, and others about freshwater biodiversity and its values (e.g., WWF Nepal 2006).
   e. See also 5 d,e below.

IV. Students – elementary through high school
   f. Support development of curricula on freshwater biodiversity targeting various age-levels. These can be short units from which teachers can pick and choose according to their needs. Curricula should tie into general curriculum requirements so that required skills (e.g., math, reading) are addressed using the units. Appropriate design will require consultation with Nepali educators (public and private).
   g. Support development of an Adopt-a-Stream type program in which school classes or villages collect data on local streams.

V. Villagers/VDCs/other local-level groups/urban public
   h. Support development of extension-type continuing education programs equipped to train diverse groups (e.g., engineers, teachers, planners, village groups, national park guides) in aspects of freshwater biodiversity, aquatic ecosystem services, and applied methods for solving conservation issues (e.g., invasive plant control).
   i. Support Hariyo Ban and NTNC to include freshwater biodiversity components in training program for National Park guides.
   j. See Adopt-a-Stream, (4b above).
   k. Support biodiversity messages through media. Sponsor short radio, TV, or newspaper highlights of biodiversity topics. Possibly support more extensive programming such as weekly TV or radio show.
   l. Produce posters or brochures highlighting freshwater biodiversity.

Government- and policy-level changes might include:

- One governmental organization to coordinate efforts on water and freshwater biodiversity.
- A format for engaging public policy debate on environmental flows. The issue of not even releasing the 10 % environmental flow and other related issues must be brought to public debate and to research and brainstorming forums that would inform the general public, create a broader awareness of the problem and lead to essential solutions.
- Relevant government positions that require degrees in the fields discussed above.
- Ideally, Nepal and India would coordinate freshwater biodiversity research and management strategies (WWF Nepal 2006). One avenue would be for Nepal to coordinate basin-wide conservation efforts, especially for migratory species, with the recently-formed National River Ganga Basin Authority in India (Sarkar et al. 2012).). Publicly-available water-related data could be an important first step in this direction (e.g., dam-release river flows; Rajashekariah et al. 2012)

At the individual level, there is a great need for permanent positions to expand the avenues for graduates in aquatic biodiversity, ecology, and related fields so that expertise is retained in the country. Lack of attraction and retention in these fields due to lack of permanent positions and laboratories equipped for cutting-edge research is currently a major problem for Nepal. In addition, short-term exchanges (e.g., Fulbright scholarships) to train people in specific areas of interest in freshwater biodiversity conservation could be helpful.

Specific research recommendations are presented in Annex D.

<u>Importance of making USAID/Nepal-funded research results and data internationally accessible</u>
Research components funded by USAID should emphasize outputs in the form of peer-reviewed publications in indexed regional or international journals. We, and others, find that one reason Nepal has had difficulty moving forward in the area of freshwater biodiversity conservation is due to the relative lack accessible, peer-reviewed research and management papers. Producing such papers will have several benefits including: 1) ensuring that solid science underlies USAID development efforts, 2) making hard-earned results readily available to future efforts [rather than data disappearing when a project ends; Allendorf et al. 2012], 3) putting Nepal's freshwater resources in larger regional and global contexts, which will in turn attract more international interest, support, and feedback, and 4) providing wide acknowledgment of USAID's role in Nepal's efforts to sustainably develop and conserve its freshwater resources. Likewise, we echo Allendorf et al.'s (2012) call for all projects to have a plan at the outset for making the data collected publicly accessible.

We understand that preparing high quality peer-reviewed papers will be especially difficult and time consuming for some Nepali investigators for whom research may not be a priority and, therefore, suggest that USAID provide editorial assistance to investigators to assist with technical writing for peer-reviewed publications. Alternatively, funds could be provided to US scientists to assist with this time-consuming task.

# Section IV. Recommended Themes and Program Ideas for USAID Support of Water Resources Management and Freshwater

## A. Understanding Water Resource Management (WRM) and Freshwater Biodiversity (FWB): Critical Knowledge/Research Gaps

### a) Freshwater biodiversity, understanding the local context: knowledge compilation, collection, and dissemination

Understanding the distribution of native species is fundamental to any conservation planning or implementation, especially in the context of national hydropower planning. It is also critical to help develop Nepali human capacity in the field of freshwater biodiversity by developing taxonomic and ecological expertise as well as in the sociology of freshwater resource use by various ethnic groups. Suggested avenues of support include:

1. Digitize the Nepal Biodiversity Profiles (Biodiversity Profiles Project 1995; 16 vols.) and disseminate them widely.
2. Determine or create a repository for all publications/reports/electronic documents encountered relating to FW biodiversity.
3. Facilitate compilation of taxonomic and distribution data from literature/reports on all aquatic groups not included in recent IUCN Red list reviews and creation of a freshwater biodiversity distribution database available on a publicly-accessible website. Continue to add data from subsequent projects to the database, and include high quality photos to aid in identification.
4. Conduct aquatic biodiversity inventories, especially in mid-west and far-west regions. Include indices of species abundance and document altitudinal ranges and major habitat types used. Add data to database mentioned above. A reasonable goal would be to inventory one major basin per year or several "marginalized rivers" and add the results into regional/national planning efforts and biodiversity database.
5. Facilitate coordination/collaboration among biologists from across the Hindu-Kush Himalaya on these topics as well as on questions of life history, behavior, and ecology of species would improve the ability to conserve biodiversity, minimize duplicative efforts, and enhance the knowledge of all participants. One avenue would be to facilitate interaction of Nepali aquatic biologists/policy makers with new National River Ganga Basin Authority in India.

### b) North-South Chitwan-Annapurna Landscape (CHAL) Transect and other North-South transects.

The North-South Chitwan- Annapurna/Mustang transect that runs from Mustang through the Kali Gandaki gorge between Annapurna and Dhaulagiri (both 8000m+) down into Chitwan at 200m is one of the most remarkable transects on the planet. It compresses within the space of 200 km all of the physiographic and ecological zones of Nepal from the High Himalayas through the Tarai and from the alpine zone and trans-Himalayan rain shadow arid zone of Mustang through the temperate zone to the tropical forests and grasslands. It includes one of the Nepal's largest and most important river basins, important wetlands ecosystems and a diverse range of agro-ecosystems. As a result, careful, systematic, long-term monitoring of an array of physical, biological and socio-economic parameters along this transect would be an invaluable contribution to the understanding of

climate change and climate change adaptation not only for Nepal, but for the Hindu Kush Himalaya and for the global scientific and development communities.

Ideally this transect would be the first of three north-south transects in Nepal: one in the west in the Karnali river basin with its much lower population density, and another in the Kosi river basin in the east.

Proposed next steps:

- Build on work started by Hariyo Ban/NTNC in the CHAL/Kali Gandaki Corridor.
- Identify strong US research partners committed to working on this for 20+ years.
- Add FWB dimensions to the sites.
- Add groundwater (in Tarai and Doon valleys) and springs (hills and mountains) monitoring to the sites.
- Add socio-cultural dimensions (e.g. ongoing I-SET Nepal work along the same corridor[45]).

### c) East-West High Altitude Lakes Transect

Information on physical and biological information on glacial lakes in Nepal is necessary to allow assessment and prediction of changes occurring/anticipated with both climate change/glacial melt and increased tourism at high altitudes. In addition to describing baseline water quality and physical habitat characteristics of Gokyo Lakes, Prof. Subodh Sharma (Kathmandu University/ Aquatic Ecology Center) conducted some of the only work on macro invertebrates in high altitude lakes of the central Himalayas (Sharma et. al. 2010). The project identified some water quality impacts from tourist facilities that need to be addressed for both human and ecosystem health. However, because only one group of lakes has been studied, results cannot be extrapolated to other high altitude lakes. Therefore, we recommend study of biophysical conditions in an East-West transect of glacial lakes across Nepal. This will provide a baseline for examining climate change effects and their variations in these exceptionally sensitive habitats across the country and will also help guide sustainable tourism development that maintains water safe for human consumption. A research initiative could also be taken to study the appropriate technology in treating the solid and liquid waste originating from the service facilities located at high altitudes. The results obtained from these studies will also be of great international interest.

### d) Glacial Melt Monitoring & Training

Provide support for the Asia Bureau's ongoing CHARIS (Contribution to High Asia Runoff from Ice and Snow) glacial melt monitoring project, along with training in conjunction with Kathmandu University's Cryosphere Research Center. This program has technical involvement by ICIMOD and policy involvement from WECS. The current program is evaluating glacial melt rates with automated weather stations, and the university hopes to add additional field sites and sampling equipment, along with travel expenses for graduate students doing remote field work.

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[45] For starters, see Desakota Study Team 2008.

### e) Teesta/Tamor Comparative Study of Hydropower Impacts on FWB

As noted in Section II, an example of the comparison between intense versus minimal hydropower development is currently observable on the Teesta River in Gangtok, India compared to the nearby Tamor River in Nepal (Kanak Dixit, 2014)[46]. These two sites provide an excellent opportunity to contrast effects to freshwater biodiversity and river-dependent economies from two very different hydroelectric development scenarios. Customized research studies focusing on these two rivers and other similar rivers would be highly relevant given the national priority on hydropower development in Nepal.

### f) Environmental Flow: determining appropriate parameters & guidelines for Nepal

Development and implementation of environmental flows below hydroelectric dams to support river dependent communities, ecosystems, and biodiversity is not a new science. Although there is a great deal of information available through organizations such as the Global Environmental Flows Network (www.eflownet.org ) and from other sources, it appears that this information is not being widely used in Nepal. (Smakhtin et.al. 2006, WWF India 2012, Le Quesne et.al.2010, Matthews et.al. 2014, USGS 2013). In fact, the South Asian Workshop on environmental flows was hosted in Kathmandu in 2011; the participant list showed no representatives from the GoN in attendance.[47]

WECS needs to become a leader in the environmental flow determinations for Nepal. This will require engagement in the robust international community actively doing work in this arena. Once engaged, other knowledge/research gaps related to the basic parameters of environmental flow determination, such as presence and status of river-dependent systems and animals, will become especially relevant and important.

### g) Strengthening Civil Society Voices in Irrigation and Water Management

Analyze the organization and effectiveness of the Nepal Federation of Water Users Association Nepal (NFIWUAN). Explore possible synergies with other groups including the Federation of Drinking Water and Sanitation Users Nepal (FEDWASUN) and the Water and Energy Users Federation Nepal (WAFED). Propose organizational and other changes that would allow the Federation of Water Users to take lessons from the Federation of Community Forestry Users Nepal (FECOFUN) experience in forestry thereby strengthening civil society voices in irrigation and water management.

### h) Links between Watershed Management and Hydropower Production

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[46]http://www.ekantipur.com/2014/03/28/oped/the-tamor-and-teesta/387374.html
[47]see https://sites.google.com/site/asianeflownet/ and https://sites.google.com/site/asianeflownet/south-asia-workshop/presentations

Explore connections between watershed management and hydropower production. This could be done using the suspended sediment data routinely collected at hydroelectric plants to explore correlations with upstream land use activities, particularly new road construction. Establishing a link between road-related erosion/landslides and suspended sediment-caused shut downs of hydroelectric power generation would be a strong impetus to develop and implement design and management practices for road construction. This could also shed light on upstream issues such as urban and road network planning.

### i) Global Forest Watch (GFW) 2.0

Explore investing in Global Forest Watch (GFW) 2.0, a remarkable new decentralized, real-time monitoring tool both for WRM issues (e.g. monitoring the status of watershed conditions, haphazard road construction etc.) and for Hariyo Ban work *on REDD+*. [48] In addition, keep track of a) the recently launched Orbiting Carbon Observatory (OCO)-2 designed to measure photosynthesis directly and map the concentration of atmospheric carbon dioxide, net carbon flows and its change over time, and of b) plans by the European Space Agency to launch FLEX (the Fluorescence Explorer) designed to provide information on photosynthesis and plant stress at a resolution of as little as 300 meters.[49]

### j) Mid-Hills Hydrogeology and Groundwater

Groundwater and surface water interactions in the Mid-Hills are complex and changing. There is extensive use of spring sources for water supply and irrigation, and many anecdotal accounts of surface springs drying up. However, there are no measured data to corroborate the accounts or to determine the cause. Although there has been sporadic field research by ICIMOD-NWCF in Dapcha, Tinpiple and Kavre, along with isotope analysis by ISET-Nepal, the dynamics of spring flows and associated aquifer mapping are data gaps. Another key unknown is the effect of road construction and timber harvest on nearby spring sources. These investigations could be a major stand-alone project which should be led by the new Water Resources Commission and involve multiple donors. USAID/Nepal could consult with experts in the US Geological Survey regarding possible USGS participation.

### k) Marginalized Rivers Originating in the Churia and Tarai

Marginalized rivers are those smaller rivers originating in the Churia and Tarai that drain into India. Although small in size, in comparison to rivers like the Gandaki, cumulatively they provide a large economic benefit to local communities. Little is known about freshwater biodiversity in these rivers and its relationship to hydrologic connectivity and groundwater dynamics; perhaps less is known about the socio-cultural relationships between these rivers and the local communities. Similarly, the relationship between the biota and lateral connectivity with the floodplain and vertical connectivity with groundwater is poorly

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[48]See http://www.globalforestwatch.org and http://www.forestlegality.org/document/global-forest-watch-20 USAID/Nepal GIS Specialist Indra Sharan KC knows about GFW and is in touch with some of its developers.

[49]The Economist July 5-11, 2014, p. 64-5 http://oco.jpl.nasa.gov/ and http://www.nasa.gov/topics/earth/features/fluorescence-map.html

understood. A starting point could be supporting graduate students working on these knowledge gaps, particularly in the CHAL-TAL region. Initially, USAID may want to focus on the mid-west, where economic resources are least, or on the far-west, where freshwater biodiversity information is most lacking (Gurung 2012). Work on biodiversity in these rivers may require considerable capacity building for taxonomic expertise in the region.

### I) Invasive Wetland Plants

Invasive wetland plants pose urgent economic and conservation problems throughout much of Nepal. The sooner that control measures are implemented, the more the spread of such species can be slowed. Invasive plants are causing wholesale changes in conditions and processes of freshwater habitats throughout Nepal, as well as creating economic hardships for those whose livelihoods depend on such habitats. The plants are directly and indirectly altering both perennial and seasonal freshwater habitats in ways that negatively affect native biodiversity from insects to tigers. Many of the worst offenders are nuisance species in many parts of the world. As such, numerous efforts have been made to control the species in a variety of ecological and socioeconomic contexts. To promote rapid, cost-effective results and to avoid recreating the wheel, we recommend supporting technology transfer efforts to assist Nepalese authorities and agencies in learning about control methods that have been successful and unsuccessful in other places. We suggest a 4-step approach for each target species: 1) share information on attempted control methods and results from within Nepal and around the world; 2) conduct research on the emergence and control of invasive species in the local context, 3) select promising methods and quantitatively test their effectiveness in Nepal, and 4) rapidly disseminate information, including costs, throughout the country.

One example of a location with major invasive plant problems is Chitwan National Park. Control efforts are under way as part of Hariyo Ban, in concert with the National Trust for Nature Conservation (NTNC); however, results to date are not particularly promising.

NOTE: A key element of improving the understanding of and appreciation for freshwater biodiversity is through education. Our suggestions on this have been presented in Section III, Box III-1 Freshwater Biodiversity Education: a Multifaceted Approach

## B. Re-invigorating the Policy and Program Framework for Water Resources Management

There is a need for a 'whole of government" approach by the GoN for water resources management in the wake of the splitting of the Ministry of Water Resources (MoWR). The lack of a single voice for water resource management has led to ad hoc approvals of hydroelectric dam sites and a lack of a coherent/strategic approach across multiple Ministries regarding water resources development and monitoring. USAID/Nepal could work strategically with government partners, other donors and civil society to help break down the silos between Ministries guiding hydropower development, irrigation, drinking water, watershed management, biodiversity conservation, etc. and work to develop what has been called "the next frontier of hydropower sustainability": planning at the river basin and system scales, rather than project by project with scant if any attention to inter-linkages and cumulative impacts. (IDB, 2013)

At the same time, the GoNs earlier water sector strategy and policies and plans, including the National Water Resources Strategy (2002), the National Water Plan (2005) and the National

Water Resources Policy (2011), need to be reviewed in light of changing circumstances. These changing circumstances include:

- The new political landscape that will be created by Nepal's new Constitution,
- A new economic landscape with many elements including large-scale migration to the Gulf and other regions and signs of long-awaited forward movement in negotiations with India on water and power,
- The emergence of climate change adaptation as an overarching theme of GoN programs, and
- The recent decision to move towards the transformation of the Water and Energy Commission Secretariat (WECS) into a National Water Resources Commission to develop and coordinate water programs across multiple Ministries, civil society, and the private sector. This is a move in the right direction that deserves to be supported. [50]

Establishment of a strong linkage and exchange of portfolios between WECS and diplomatic missions of Nepal should help better implement the water related strategies and facilitate trade of power (Personal Communication, Dipak Gyawali, former Minister for Water Resources).

These discussions cannot be left to "hydrocracies" and "hydrocrats" (Gyawali 2014). Both civil society and the private sector must be given an active voice in the deliberations on water resources policy and programs.

## C. Promoting Hydropower Sustainability

Potential issues to consider in promoting the sustainability of the hydropower development program center on basin planning that maximizes power production while minimizing impacts to marginalized river communities and aquatic species biodiversity; designing mitigation measures that ensure environmental flows in downstream reaches and provide for fish passage past the dams; and investing in watershed management programs to minimize anthropogenic sediment sources (particularly road-related landslides) that halt power generation due to excessive equipment wear.

The Water and Energy Commission Secretariat (WECS) is making decisions on hydropower locations from a master plan that is 20 years old. Supporting WECS to update this plan, with due consideration given to all physical, biological and social factors of the site, would be a large step forward in sustainable development of Nepal's hydropower resources. Master plans for the Karnali and Gandaki basins are currently being revised with funding from the World Bank. A basin-wide planning model recently developed in Latin America by the Nature Conservancy

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[50]As noted in Section I, USAID's current Water and Development Strategy 2013-2018 and Water and Development Strategy Implementation Field Guide (March 2014) are narrowly conceived documents designed to respond to the funding earmarks imposed on USAID by the US Congress. In the interest of balance, if this Assessment was focused on the policy and program framework of USAID rather than of the GoN we would note that the USAID framework deserves a good deal of work. Most of the current strategy, and all of the funding, is devoted to WASH. One parallel in Nepal is that virtually all of the talk about energy is about hydropower. In the USAID Water Strategy agriculture is included as the second Strategic Objective, with funding to come from the Feed the Future (FTF) account. Neither climate change adaptation nor freshwater biodiversity nor "green water" are mentioned. As a result, what could serve as a thought-provoking cross-cutting theme for development policy and programming is limited to a single Congressionally-mandated stovepipe –WASH- with agriculture tacked on as something that is already being dealt with by the Bureau for Food Security that oversees implementation of the Feed the Future program.

(Hartman et al. 2013) may prove useful. Application of results from new freshwater biodiversity inventories would be integral to the comprehensive hydropower planning process.

As discussed previously under Knowledge Gaps, supporting the development of site-specific environmental flows at proposed hydroelectric projects is needed. This is a political issue, not a scientific one. To gain a broad range of support for the effort, USAID/Nepal should consider establishing an advisory committee to assist with final design and oversight of the ENV flow program that includes WECS, relevant GoN Ministries, WWF and IWMI. At the highest level, political support for environmental flow policy is essential for setting strategic direction, securing resources, working with stakeholders and enforcing the policy. A comprehensive framework for implementation requires that relevant laws, policies, regulations and institutions be in place across a wide range of water resource management functions. Environmental flows are inherently interdisciplinary, and may involve agencies that plan and manage hydropower, agriculture, land use, industrial development and natural resources.

Another missing element necessary to mitigate the effects of hydropower development is providing both upstream and downstream passage for migratory fish species past the dams. Many species in Nepali rivers migrate long distances as part of their life cycle, sometimes all the way from the Bay of Bengal to the high Himal. As with environmental flows, technical information and solutions are available through the international community, so the political support must be garnered at the highest levels. This is also an area where USAID may be influential.

USAID supported the development of Environmental Impact Assessment (EIA) scoping guidelines for hydropower in the 2001. USAID/Nepal should consider supporting an update of these documents to incorporate new information on climate change (or other lessons learned) in cooperation with WECS, the World Bank, the Asian Development Bank and other interested donors including the MCC.

Design features of both environmental flows and fish passage require additions to the technical capacities of typical design engineers. Rounding out the engineering knowledge base to include course work and experience in river mechanics, fluvial geomorphology, sediment transport, and fish passage is essential to training the next generation of 'green' engineers capable of resolving the tension between hydropower development, aquatic biodiversity and river-based livelihoods.

Another urgent need is for the design and testing of effective engineering solutions for fish passage (also applicable to irrigation dams and possibly to road/railway design). This effort would begin with literature reviews and consultations with other locations, preferably in Asia, where fish passage operates successfully for fishes that do not jump. USAID support to facilitate international cooperation and discussion on aquatic animal passage issues would help to directly promote freshwater biodiversity conservation.

Yet another useful avenue of support would be to promote indigenous species in aquaculture/hatcheries (relevant to hydropower but also elsewhere) by supporting development of husbandry techniques for captive spawning/rearing of native species. Some work of this nature is ongoing at the Kali Gandaki Fish Hatchery. Along similar lines, a quantitative evaluation of survival of fingerling fish stocked in the Kali Gandaki River would indicate the ecological- and cost-effectiveness of the operations and could lead to improved practices, if necessary.

WRM in Nepal will benefit from lessons learned and the sharing of experience and best practices across the Hindu Kush Himalaya particularly with India (Uttarakhand, Himachal Pradesh, Sikkim and, to a lesser extent, Arunachal Pradesh) and Bhutan. Three areas will be of particular interest: watershed management, hydropower development and freshwater biodiversity.

On hydropower development: recent experience in Uttarakhand and Himachal Pradesh is particularly relevant. In Uttarakhand, a recent Supreme Court of India-mandated independent review of planned hydropower projects raised serious concerns about project siting, design and environmental and other impacts.[51] In Himachal Pradesh, hydropower development in the Sutlej basin has included a Cumulative Impact Assessment Study along with the development of a Fishery Conservation and Management Plan and a Biodiversity Management Plan. GoI Ministry of Environment and Forests (MoEF) approval for hydro projects have included provisions for detailed baseline surveys and a followup study 5 years after the commissioning of the project of impacts on the environment and downstream ecology undertaken by an independent agency to be decided in consultation with the MoEF. Approval has also required non-objection certificates from relevant government, panchayats and local communities. Areas identified for additional study on some of these projects have included: ecological/environmental flows and tunnel impact assessment and management (examining impacts on hydrogeology, local springs and other water sources etc.)

## D. Addressing the Impacts of Infrastructure Development (other than dams) on Water Resources Management and Freshwater Biodiversity

In the context of this discussion, infrastructure refers to roads, railways, and urbanization and industry. Three general categories of impacts on water resources and aquatic ecosystems are: aquatic habitat connectivity (animal passage), providing adequate stream flows (also known as environmental flows), and degradation of water quality.

Focusing on water resources management, the primary pollutant currently affecting water quality is sediment in rural areas. Whereas pollution originating from municipal and industrial sources are of prime importance in urban areas.

Better understanding is needed of how suspended and bed load sediments affect freshwater ecosystems in Nepal. Extensive research on the topic has been done in other regions, but it is necessary to know how well results from those regions translate to Nepal. The ultimate goal is to develop predictions/solutions for sediment effects on livelihoods that depend on aquatic resources.

Water pollution is an important, but very broad, topic. Development support for pollution control could go many directions. In the context of biodiversity, perhaps a good place to start would be with an examination toxin levels in fish consumed by people and subsequent efforts to identify the source of and minimize inputs of the toxins. Another interesting approach would be

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[51] Goswami, U.A. 2013. "Supreme Court-mandated panel to study impact of hydro projects on environment." *The Economic Times*, October 23. http://articles.economictimes.indiatimes.com/2013-10-23/news/43326239_1_hydropower-projects-hydro-projects-basins

to document changes (or lack thereof) in toxin levels before and after (or in basins with and without) implementation of Integrated Pest Management practices.

Next steps for USAID/Nepal involvement will depend on how it decides to proceed with the findings and recommendations of the recently completed Hariyo Ban study (*Overview of Existing & Planned Key Infrastructure in the TAL & CHAL Landscapes and its Environmental & Social Impacts*) along with the findings of the recent visit to Nepal by E3/Leslie Johnston. Modest resources and support may be available from the E3-funded BUILD program (Biodiversity Understanding in Infrastructure & Landscape Development) being implemented by the Conservation Strategy Foundation. Important targets of opportunity include the "greening" of engineering in Nepal, starting with the training of young engineers, and serious attention to work in U.S., China and elsewhere on "natural infrastructure" (Aspen Institute 2012, Gartner et.al.2013, Gleason et.al. 2012, Katoomba XVIII 2013, Reid 2014, WBCSD nd)

Another opportunity would be to engage the Millennium Challenge Corporation (MCC) on these issues, as well as hydropower sustainability, linked to the new MCC program in Nepal.

## E. Developing Watershed Management Best Practices

For watershed management to be most effective, it requires application of an accepted suite of demonstrated effective techniques applied in the highest priority areas. Development of this suite of techniques and a geographic prioritization system are key elements to be considered for future interventions.

Given the age and type of analyses used in the 1983 DSCWM watershed condition assessment, coupled with the amount of watershed management activities being proposed and the expected impacts of climate change, more work is needed to coordinate work among proponents. Assessments at the basin scale to evaluate watershed conditions and prioritize areas for intervention would be useful and cost effective. This is an avenue of involvement for USAID/Nepal that could inform ongoing activities in currently funded programs like Hariyo Ban.

Finding a way to require engineering support for new road construction, or at least application of best management practices, will be a critical component to minimizing impacts to communities, aquatic biodiversity, and hydroelectric power production in the future. A possible intervention by USAID/Nepal would be to develop and market a codified set of Best Management Practices for road construction and maintenance intended for distribution at the VDC level and up.

As noted earlier, WRM in Nepal will benefit from lessons learned and the sharing of experience and best practices across the Hindu Kush Himalaya particularly with India (Uttarakhand, Himachal Pradesh, Sikkim and, to a lesser extent, Arunachal Pradesh) and Bhutan. Three areas will be of particular interest: watershed management, hydropower development and freshwater biodiversity.

On watershed management: Like Nepal, India has a long history of working on watershed management with mixed results. Watershed development in one part of India, Maharashtra, dates back to the 1942 Bombay Land Improvement Schemes Act. In 1982 the state launched a Comprehensive Watershed Development Program. In 1992 it launched a new program, Jal Sandharan. At the national level India set up a National Watershed Development Project for

Rainfed Areas. By the late 1990s annual expenditure on watershed development in India exceeded US$500 million. An evaluation of some of these efforts was carried out by the International Food Policy Research Institute (IFPRI) in 2002. (Kerr, 2002)[52]

During the past decade watershed programs have been developed linked to efforts at carbon sequestration. For example, the Improving Watershed Management Practices and Rural Livelihoods through Carbon Sequestration Project – A Bio-Carbon Sub-Project of Mid Himalayan Watershed Development Project, part of a World Bank-supported Mid-Himalayan Watershed Development Project (MHWDP).[53] India's National Rain-fed Authority developed Common Guidelines for Watershed Development Projects in 2011.[54]

## F. Urban Water: Harnessing the Private Sector

The current focus of development programming in Nepal is toward rural areas and the 'rural poor'. While this is important, it misses a large percentage of the population. Nepal, like most other developing countries, is rapidly urbanizing. The pace of this urbanization out paces the cities' ability to provide adequate sanitation and clean water.

USAID and other donors need start taking urban Nepal (much more) seriously. The current tilt in development programming and investment focused heavily on rural areas and the "rural poor" misses two key drivers of the current situation: (i) Nepal like every other country on the planet is rapidly urbanizing and (ii) urban centers play a key role in incubating innovations that later spread into rural areas.[55] It is both surprising and sobering to see donors driving around Kathmandu in their high-end, air-conditioned 4WD "bubbles" apparently oblivious to the severe water & air quality issues plaguing the Kathmandu Valley. These issues were mirrored in the other urban areas and secondary cities visited during the field trip through Pokhara, Butwal, Bhairawa and Bharatpur.

We believe the time has come to start incorporating urban elements into a number of USAID/Nepal's programs, starting with water. An entry point could be to work with private entrepreneurs like SMART Pani to develop viable models for water supply and waste management that could spread to other urban centers around the country (Moench et.al.1999, Moench et.al. 2003, Shrestha and Shukla 2014 and, on traditional water systems, Colopy 2012 Chapter 6 and Agrawal & Narain 1997). We are not suggesting that USAID fund urban water infrastructure. That a) takes levels of resources that USAID doesn't have, and b) has been and should continue to be the domain of the World Bank and ADB. Where USAID could play a useful role is in helping to catalyze a debate about the kinds of infrastructure that are both appropriate and sustainable starting with a discussion about centralized vs decentralized water supply and waste disposal systems.

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[52] http://www.ifpri.org/sites/default/files/publications/rr127.pdf

[53] http://www.worldbank.org/projects/P093720/himachal-pradesh-mid-himalayan-watershed-development-project See also http://www.worldbank.org/projects/P104901/himachal-pradesh-watershed-management-project

[54] http://www.indiaenvironmentportal.org.in/content/349544/common-guidelines-for-watershed-development-projects-2011/

[55] Parts of USAID appear to have forgotten that in the 1980s and 90s USAID had one of the most innovative and forward-looking urban programs of any donor (run through the Regional Housing & Urban Development (RHUDO) offices) and that in the early 90s a conscious decision was made to move AID/Washington management of these programs from the domains of economic growth and the private sector into the Global Bureau Environment Center. Urban environmental management, starting with water then quickly moving to air, deserves to be "re-discovered". USAID/Nepal could lead the way.

## G. Water and Sanitation for Health/Hygiene (WASH): Linking into the Natural Resources Management (NRM)/Water Resources Mainstream

The decision by the USAID Health Office to move the WASH program into the new NRM/WRM program is an important development for USAID, for Nepal and could have echoes beyond Nepal. This link between environmental health and NRM/ENV beginning with programs in fecal sludge management should be both nurtured and strengthened. Given the rapidly urbanizing centers and declaration of Open Defecation Free (ODF) administrative units, initiatives in managing the solid and liquid wastes originating from urban and peri-urban areas must be designed and implemented. A model developed by the Africa Biodiversity Collaborative Group (ABCG 2013) which outlines ways to integrate WASH & Healthy Society and WASH & Healthy Ecosystems deserves to be examined in the context of Nepal realities and adjusted if/as appropriate.

In addition, USAID/Nepal could consider incorporating Helvetas WASH plus the 3Rs (retention, recharge, and reuse) into USAID funded programs.

## H. Supporting Gender and Social Inclusion in WRM & FWB

The central issues for women and marginalized groups related to water are having access to land and water, having a voice in decision making, and the 'feminization' of rural production systems in light of large-scale emigration of Nepali men to the Gulf.[56] There are a number of avenues for USAID/Nepal to support educational programs that would benefit women and the more systematic inclusion of the voices of women and socially marginalized groups into discussions and decisions about water resources. These include support to the WWF/Conservation Mentors Program and the Resources Himalaya Environment Graduates in the Himalayas (EGH) program, with particular attention to women and socially marginalized groups. In addition, issues of providing either equal or even more engineered sanitation facilities to women particularly in the crowed public places and highways needs to be addressed.

Other opportunities include providing support to the Women Leading for Change in Natural Resources Management (WLCN) network, supporting the Nepal Engineering College Interdisciplinary Water Resources Management Master's Program, as well exploring the needs of the Padma Kanya Campus Environmental Science degree programs.

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[56]There is an extensive literature on women & water, some of it included in the Bibliography (Annex I). One source that deserves attention is follow-up to the Bhutan +10 Gender and Sustainable Mountain Development in a Changing World (October 2012) Seehttp://www.icimod.org/bhutan+10/and https://www.youtube.com/watch?v=C7Sq-UVTKG8&list=UUV4FLs92YEJGIP7uaN4CQVQ&index=32

# I. Incorporating Support from Across the USG & Weaving Water into Ongoing USAID Programs

## a) Support from across the USG

### 1. State Regional ENV hub for South Asia

The ENV Hub is positioned to take the lead on important regional dimensions of WRM, feeding information and ideas into USAID programs as appropriate. The Hub could highlight and assist the GoN in carefully considering the shape of hydropower development across Nepal. Key issues include the suitability of high dams in seismically active zones and high sedimentation rates that will rapidly fill the reservoirs behind dams if they are built. The recommendations of the World Commission on Dams deserve to be reviewed along with the work of the Nepal Water Conservation Foundation in 2004 looking at the recommendations of the WCD and the issues of dams & development in Nepal, along with the more recent literature.[57] The recent decisions on hydropower in neighboring Uttarakhand may provide useful lessons for Nepal.

On the issue of active seismicity along the Himalayan range and its implications for the construction of high dams, the work of Roger Bilham and colleagues deserves both thoughtful review and careful consideration.[58]

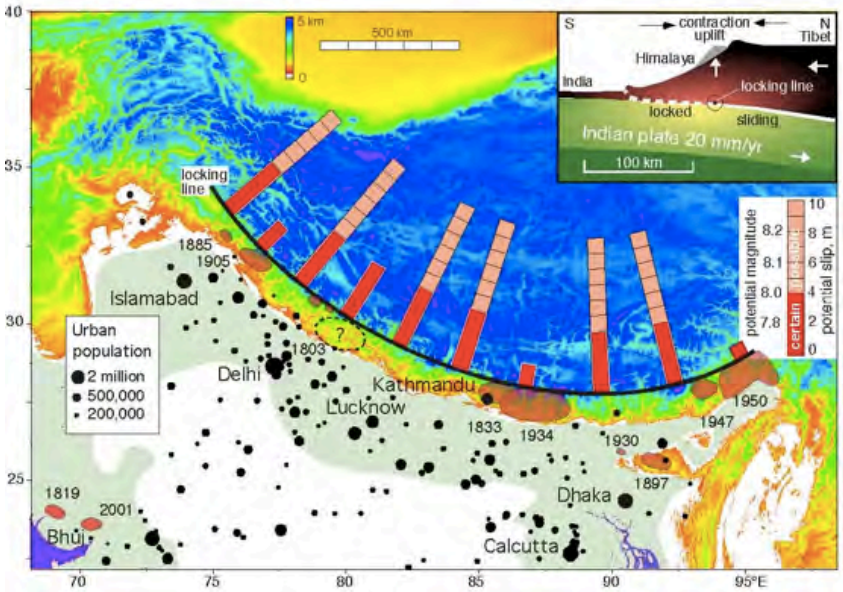


**Figure IV-1: The Indo-Asian collision zone.** (Bilham, Gaur and Molnar 2001)[59]

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[57] Ajaya Dixit, Pradeep Adhikari and Shiva Bisangkhe (Eds). 2004. *Constructive Dialogue on Dams and Development in Nepal.* Kathmandu: Nepal Water Conservation Foundation for IUCN/Nepal. See also Dixit and Gyawali 2010, Barr et.al. 2013, Dharmadhikary 2008, Goswami 2013, Grace 2012, International Rivers 2008, Leslie 2014, Schneider 2014 & 2014a, Skinner and Haas 2014 and Kraljevic et.al. 2013. The Kraljevic et.al. document enumerates "7 Sins of Dam Building" as follows: Building on the wrong river, neglecting downstream flows, neglecting biodiversity, falling for bad economics, failing to acquire a social license to operate , mishandling risks and impacts and blindly following temptation/bias to build.

[58] See Bilham et.al 2001, Bilham 2004 as well as GON & MCC. 2014, p.36-8 on seismic risks. Also Grumbin et.al. 2013.

2. **Millennium Challenge Corporation (MCC)**
   Work with MCC staff on hydropower sustainability and the impacts of infrastructure on freshwater biodiversity linked to the new MCC Threshold Program for Nepal and possible future MCC investments in the energy/hydropower and transportation sectors.

3. **Peace Corps**
   Explore the possibility of recruiting Peace Corps volunteers to support USAID/Nepal water-related work.

4. **Fulbright & International Visitors Leadership Program (IVLP)**
   Fulbright and IVLP have a long history in Nepal.[60] USAID/Nepal could program US Fulbright and IVLP support for key WRM and FWB research. One example would be providing a mechanism for researchers/professors to collaborate with the Kathmandu University Aquatic Research Center.

   Additionally, efforts could be made to identify Nepali Fulbright and IVLP alumni working in the water resources arena. Soliciting their input and engagement on potential WRM and FWB programs could be quite beneficial.

5. **US Geological Survey, Army Corps of Engineers, and US Forest Service**
   Each of these federal agencies has experience with development and implementation of environmental flows below dams or drainage diversions. Engaging experts in this arena to help guide the development and implementation of environmental flows in Nepal would be a significant step forward in ongoing hydropower design and implementation process.

**b) Weaving Water into ongoing USAID programs**

USAID/Nepal has a number of ongoing programs where additional support for elements of water resource management and freshwater biodiversity could be enhanced or introduced over the medium-term following design of the NRM program.

1. **Hariyo Ban**
   Provide additional support for the infrastructure unit, work on freshwater biodiversity, and watershed best management practices in CHAL and TAL.

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[59] **Danger Zone**: This view of the Indo-Asian collision zone shows the estimated slip potential along the Himalayas and urban populations south of the Himalaya(U.N. sources). Shaded area with dates next to them surround Epicenters and zones of rupture of major earthquakes in the Himalaya and the Kachchh[Kutch] region, where the 2001 Bhuj earthquake occurred. Red segments along the bars show the slip potential on a scale of 1 to 10 meters, that is, the potential slip that has accumulated since the last recorded great earthquake, or since 1800. The pink portions show possible additional slip permitted by ignorance of the preceding historic record. Great earthquakes may have occurred in the Kashmir region in the mid 16th century and in Nepal in the 13th century. The bars are not intended to indicate the locus of future great earthquakes, but are simply spaced at equal 220 km. interval, the approximate rupture length of the 1934 and 1950 earthquakes. Black circles show population centers in the region; **in the Ganges plain, the region extending ~300 km south and southeast of the Himalaya, the urban population along exceeds 40 million** (Bilham et.al. 2001. Emphasis added)

[60]Examples of Fulbright scholars working on water issues include Cheryl Colopy. 2012. *Dirty, Sacred Rivers: Confronting South Asia's Water Crisis.* Oxford University Press, New York and Tyler McMahon's thesis, *Economics of Urban Rainwater Harvesting* and the follow-up that included the establishment of Smart Pani. http://oneplanetsolution.com/about/our-history/ and http://oneplanetsolution.com/portfolio_item/suman-shakyas-home-in-chakupat-a-complete-rainwater-harvesting-system/

2. **KISAN/Feed the Future**

The Nepal Feed the Future FTF) Strategy FY2011-15 notes:
"Improved irrigation, including small water storage, micro/drip irrigation, and energy efficient pumping technologies, will improve climate change resiliency and address vulnerability of smallholders to frequent fuel shortages."

The strategy also notes that:

"Conservation agriculture (CA) approaches (e.g. zero tillage) for staple crops can save labor when machinery is included, while also conserving water and fuel for pumping and improving soil quality. The labor benefit is of particular value in Nepal, where increasing labor shortages are affecting farm households, particularly female-headed households. When coupled with small irrigation and water storage systems, the CA approaches are important for climate change adaptation.", and

"FTF will conduct an assessment of the impact of the selected value chains on natural resource management (NRM) and engage with technical advisors in Washington to ensure that these considerations are incorporated during program implementation. To address environmental and climate change resiliency, the USG will include analysis of impacts on ecosystems and climate change from FTF investments and activities when appropriate. This will help to internalize environmental sustainability as part of long-term food security and contribute to building climate change resilience of vulnerable populations."

Options for support include exploring opportunities to:

- Promote farmer managed irrigation systems in the Salyan Valley and similar areas with IWMI and the Farmer Managed Irrigation System Promotion Trust, and
- More systematically integrate Climate-smart Agriculture into both the KISAN and the new FFP program. USAID may wish to request assistance in this effort from the BFS NRM and Climate-Smart Agriculture Advisors.[61]

3. **PACT/Sajhedari Bikaas Project**

The Assessment Team heard from many donors and government officials about all of the VDC-level and DDC-level plans that they have prepared and all of the Committees that have been established to implement these plans (watershed plans, water master plans, MUS/multiple use system plans, transportation master plans, local climate adaptation plans, community climate adaptation plans…the list goes on and on). When we asked to see examples of these plans, no one was able to show us any. Several promised to send us examples. With the exception of two watershed management plans from ICIMOD prepared under the ADB-supported HIMALI project, none have been sent. This has led us to wonder about the plans, about possible disconnects between donor narratives in Kathmandu and realities on the ground, and about the multiple, too-often-donor-driven, local level Committees that have been set up across

[61]Moffat Ngugi and Mike Colby. This would be in lieu of the Nepal FTF Natural Resource Assessment that was proposed in 2012 .

Nepal to implement the many plans.[62] As an important counterpoint, we were impressed with the thoughtfulness of the PACT staff we met and the careful and deliberate process PACT will be using to engage with VDC-level planning.[63] In our view, local level investments in WRM under the new NRM program should wait to learn from PACT experience.[64] In the meantime, there is a need to better understand the inner workings of the Ministry of Federal Affairs & Local Development, starting with the sections of the Ministry that work on environment and on water.[65]

As such, this project will provide:

- An entry point into the detailed VDC planning process with the possibility of support if/as WRM projects emerge as VDC priorities, and
- A "learning & innovation lab" using the project's detailed knowledge of and experience with local-level planning, priority setting and environmental review to develop strategies for engaging with the Ministry of Federal Affairs & Local Development in the CHAL and TAL landscapes and beyond.

4. **Mercy Corps/Inclusive Resource Management Initiative (IRMI)**
   If water conflict emerges as an issue in IRMI VDCs, support study and careful documentation with the Natural Resource Conflict Transformation Center-Nepal for wider dissemination, starting with KISAN & Sajhedari Bikaas which are working in the same Tarai Districts

5. **Initiative for Climate Change Adaptation**
   Adopt lessons learned and innovative water-use technologies from ICCA into other programs as appropriate.

6. **Disaster Risk Reduction Office**
   Encourage proactive planning for private sector-led, decentralized urban water supply and household level storage that will prove more resilient in disaster scenarios and explore incorporating WRM elements into the new Food For Peace program.

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[62] For a sobering assessment of development planning, see the work of William Easterly *The White Man's Burden, The Elusive Quest for Growth* (2006) and, most recently, *The Tyranny of Experts* (2013)

[63] Unfortunately we were not able to meet with PACT COP Nick Langdon. He brings a wealth of Nepal and South Asia experience to the Sajhedari Bikaas project. We understand that PACT is using a detailed and reliable annual assessment of VDC capability carried out by the Ministry of Federal Affairs and Local Development as one tool in their work on VDC-level planning.

[64]The mantra for this element of the program would be "Make Haste Slowly". Given everything that is already going on in many (most?) VDCs, a key contribution of the new NRM project would be to carefully and deliberately work out how holistic water resources management planning can be carried out at the VDC level in a way that builds on existing local-level processes rather than parachuting in yet another donor/project-driven process that will likely wither as soon as the donor/project resources dry up.

[65]Unfortunately we did not have time to meet with the Ministry of Federal Affairs and Local Development. It plays a central role in all local development programs. The tendency of many donors to work with and through "technical Ministries" rather than with the Ministry of Local Development is something that deserves careful review.

# Annexes

## Annex A. Synopsis of Institutions, Legislation, Policies, Strategies, Plans and Programs Relevant to Water Resources Management and Freshwater Biodiversity in Nepal

### 1. Institutions

#### a. National Planning Commission (NPC)

NPC is the apex planning and policy making body in Nepal. It has planning jurisdiction over all the Ministries and public sector agencies in Government of Nepal (GoN) to formulate periodic and annual plans and oversee their implementation in an advisory capacity. The Commission is constituted under the chairmanship of the Prime Minister with full time and ex-officio Members.

#### b. Ministry of Irrigation (MoI)

The GoN has formed two ministries - the Ministry of Irrigation (MoI) and the Ministry of Energy (MoE) - by splitting the Ministry of Water Resources (MoWR). The two departments under this Ministry are: Department of Irrigation (DoI) and the Department of Water Induced Disaster Prevention (DWIDP). The departments have been mandated to execute the policies, strategies and plans in their respective fields.

#### c. Ministry of Energy (MoE)

The Ministry of Energy authorizes all the works related to hydropower that used to be looked after by the Ministry of Water Resources. Other components of energy viz. petroleum fuel, solar energy, biogas, etc are under the jurisdiction of other Ministries.

#### d. Ministry of Forests and Soil Conservation (MoFSC)

The Ministry of Forests and Soil Conservation is the lead GoN Ministry for biodiversity conservation, primarily through the Department of National Parks and Wildlife Conservation (DNPWC). The Ministry also has a Department of Soil Conservation and Watershed Management (DSCWM) that is active in watershed-based planning and working with District Development Committees (DDC) and Village Development Committees (VDC) on watershed management activities.

#### e. Water and Energy Commission Secretariat (WECS)

Established in 1981, WECS is headed by the Executive Secretary and consists of four Directorates: Energy Planning Directorate; Water Resources Planning Directorate; Social, Economic and Environmental Directorate; and Legal and Institutional Arrangements Directorate. WECS is charged with developing policy and planning projects in the areas of water and energy. Oversight is provided by the Water and Energy Commission, established in 1975, chaired by the Ministry of Energy and including the Member of the National Planning Commission responsible for Water Resources, the Secretaries of 11 GoN Ministries, two experts nominated by the GoN (water resources & energy specialists), the Dean of the Institute of Engineering (Tribhuvan University), the President of the Nepal Engineers' Association and a representative of the

Federation of Nepalese Chamber of Commerce and Industry. In its most recent budget (July 2014) the GoN proposed transforming WECS into a national Water Resources Commission.

### f. Department of Water Supply and Sewerage (DWSS)

Established in 1972, DWSS leads GoN efforts in the water supply and sanitation sectors in Nepal. The mission of DWSS is to provide access to at least a basic level of water supply services and sanitation facilities to all the people of Nepal. The role of DWSS has been transformed from a program implementer to a facilitator.

### g. Department of Irrigation (DOI)

Under the Ministry of Irrigation, the DOI is responsible for executing irrigation projects related to both surface and groundwater, including the planning and design of major and minor irrigation systems. A National Irrigation Development Committee has been formed with a view to implement large irrigation programs/projects.

### h. Nepal Electricity Authority (NEA)

NEA was established in 1985 as a public corporation with the franchise for power generation, transmission and distribution throughout Nepal and to engage in power exchange (both buying and selling) with India. NEA's responsibilities include supporting the GoN to determine long term and short term power policy; generating, transmitting and distributing electricity; and planning, constructing, operating and maintaining power stations, distribution systems and all associated facilities required to provide electricity. In its most recent budget (July, 2014) the GoN raised the possibility of breaking up the NEA into 3 organizations: one responsible for power generation, another for transmission and a third for distribution.

### i. Department of Hydrology and Meteorology (DHM)

Currently part of the Ministry of Science, Technology and Environment (MoSTE), DHM was created in 1967. It became a wing of the DoI for some time and evolved into its present form under the then Ministry of Environment in 1987. The mandates of the Department include: collection and dissemination of hydrological and meteorological information for water resources, agriculture, energy and other development activities; and issuing hydrological and meteorological forecasts for the public, mountaineering expeditions, civil aviation and for the mitigation of natural disasters.

### j. Other water resources management-related institutions

Other institutions linked to Water Resources Management and Freshwater Biodiversity in Nepal include: National Development Council (NDC), National Water Resources Development Council (NWRDC), Ministry of Physical Planning and Works (MoPPW), Ministry of Agriculture and Cooperatives (MoAC), Ministry of Federal Affairs and Local Development (MoFALD), Nepal Water Supply Corporation (NWSC), Kathmandu *Upatyaka Khanepani* Limited (KUKL), and the Rural Water Supply and Sanitation Fund Development Board.

## 2. Legislation- Acts, Rules and Regulations

According to the Interim Constitution of Nepal (2007), it is the responsibility of the state to use existing natural resources including water resources of the country in the interest of the nation. As water is a basic requirement for life, under international law, the right to water is implicitly

and explicitly protected as a human right. Some of the important water-related legislation includes:

**a. Nepal Water Supply Corporation (NWSC) Act (2nd Amendment- 2007)**

The NWSC Act is a part of overall institutional reforms in the urban sector. It provides the legal base for transfer of ownership of water supply and wastewater service systems owned by NWSC to any designated organization as decided by the Government. It also opens the door for NWSC to engage private companies to operate and manage its systems under management contracts.

**b. Water Supply Management Board Act (2006)**

The Water Supply Management Board Act (2006) places emphasis on the participation of local bodies and institutions in water supply and wastewater sector development in urban areas. It allows for the establishment of autonomous and independent water supply management boards for a municipality or a group of municipalities at local level, for the provision of services, and for the involvement of the private sector in the management and operation & maintenance of the systems.

**c. Water Supply Tariff Fixation Commission (WSTFC) Act (2006)**

This act created an autonomous corporate body empowered to fix the tariff for water supply and wastewater services independently at a reasonable price based on level of service and cost recovery. Initially focused on the Kathmandu Valley, the WSTFC will eventually be responsible for the regulation of water supply and wastewater services throughout the country.

**d. Irrigation Regulations-2000 (Revised 2004)**

The GoN developed Irrigation Regulations in 2000. These were revised in 2004 after the split of the Department of Irrigation into two: the Department of Irrigation (DoI) and the Department of Water Induced Disaster Prevention (DWIDP).

**e. Local Self Governance Act – LSGA (1999)**

The LSGA provides the legal basis for the devolution of responsibilities and authorities for social, economic, institutional, and physical infrastructure development, including water and sanitation systems to local government. It also gives a high priority to a variety of themes including working wuth socially marginalized groups, equity, the adoption of rights-based and participatory approaches to project work, maximum use of local resources and the protection of the environment.

**f. Drinking Water Regulations, 1998**

These regulations spell out the arrangements, delineation of authority, work and duties of Village Development Committees (VDC), Municipalities, and District Development Committees (DDC) in relation to drinking water and sanitation. Provisions are also

made regarding local institutions' rights to use natural resources and assess taxes on the use of those resources.

### g. Electricity Regulations 1993 (BS 2050)

"Electricity Regulations 2050" comprise of set of rules to exercise of the power conferred by Section 40 of the Electricity Act, 2049. These rules include provisions relating to various licenses (eg licenses to conduct surveys; licenses for the production, transmission and distribution of electricity; provisions relating to inspection and investigation etc.) The regulations also spell out arrangements for water pollution control and environmental impact assessment for hydropower projects.

### h. Water Resources Regulations-1993

Under the provision of the Water Resources Act, 1992, the GoN introduced the Water Resources Regulations, 1993. The Regulations empower the GoN to form District Water Resources Committee for granting licenses for water resources utilization (Rule 8).

### i. Electricity Act 1992 (BS 2049)

The Electricity Act 2049 provides for licensing the private sector for the generation, transmission and distribution of electricity. The maximum period of a license will be 5 years for the project survey and 50 years for generation, transmission or distribution of electricity. However, no license is required for the generation, transmission and distribution of electricity up to 1000 KW. There is a provision of economic exemption for environment-friendly industries.

### j. Water Resources Act, 1992 (BS 2049)

The Water Resources Act, 1992 has been enacted to ensure the rational utilization, conservation, management and development of water resources in Nepal. The main objectives of the Act are to legally define the process for determining beneficial uses of water resources, preventing environmental and other hazardous effects and keeping the water resources free from pollution.

### k. Nepal Drinking Water Corporation Act, 1989

The Act includes provisions for the overall management of water resources, identification of priorities for water utilization, arrangement for ownership of water resources, prohibition of water pollution, and arrangements for property acquisition and compensation.

### l. Solid Waste Management Act, 1987

Under this Act solid waste management centers are to be established for the purpose of managing solid waste. Arrangements have been proposed to control water pollution due to solid waste disposal.

### m. *Muluki Ain* 2020 B.S. (National Code of Conduct, 1963)

The National Code of Conduct asserts that priority should be given to the use of water for irrigation. Arrangements have been proposed for managing irrigation systems and upgrading traditional farming systems.

### n. Essential Commodity Conservation Act, 1955

Under provisions of this Act, drinking water is regarded as an essential commodity to be managed for strict conservation. Illegal use, misuse, theft and loss of water are to be strictly prohibited.

### o. Other water related acts, rules and regulations

Other legislation linked to Water Resources Management and Freshwater Biodiversity include: Aquatic Life Protection Act, 1961 (Amendment 1999); Forest Act 1992 (BS 2049); Forest Rules 1994 (BS (amendment 2001); Soil and Water Conservation Act 1982 BS 2039); Land Acquisition Act 19 77 (BS 2034); Land Reform Act 1964 (BS 2021); Local Self Governance Rules, 1992 (BS 2049); and National Parks and Wildlife Conservation Act 1973 (2029); Environment Conservation Act, 1997; Forest Regulations, 1995; Buffer Zone Regulations, 1996; and Environment Conservation Regulations, 1997.

## 3. Policies

### a. Urban Water Supply and Sanitation Policy-2009

This policy reinforced the State's commitments of drinking water supply, sanitation and sustainable environmental condition in urban areas. It highlights the need of an Umbrella Act of water supply and sanitation sector.

### b. Water Induced Disaster Management Policy-2006

For the management of water-induced disasters as a part of river basin management and Integrated Water Resources Management, Government of Nepal introduced this policy after Department of Water Induced Disaster Prevention (DWIDP) was formed. Its main objectives include mitigation, preservation, reclamation, institutional development for the control of water induced disasters and management of flood affected areas. It also defines the role of various institutional bodies in the management of rivers.

### c. Rural Water Supply and Sanitation National Policy-2004

It highlights the role and responsibilities of local bodies, users committees, participation and decentralization which are duly focused on sustainability and institutionalization of sanitation programs. Some of its main features include a National Goal of universal drinking water and sanitation coverage by 2017. Provision to allocate budget of WASH sector for sanitation and hygiene promotion, and spelt out the greater role of users' committees, the catalytic role of schools and students, mobilization of private sector organizations, multi stakeholders' platforms, promotion of hygiene behaviors, inclusion of women in WUSC and strengthening participation of gender, caste and deprived ethnic community to improve their access.

### d. New Irrigation Policy-2003

In order to overcome the setbacks of the Irrigation policy 1992, New Irrigation Policy was introduced in 2003. The new policy realizes that if irrigated cropping intensity is to be increased or year round irrigation is to be provided, the erstwhile strategy of taking up periodic streams, which carry virtually no water in dry season and carry more sediments than water in monsoon, flash floods, has to be altered and has incorporated the necessary strategies to overcome it.

### e. Hydropower Development Policy-2001

The Hydropower Development Policy-2001 aims at propelling the economic growth and prosperity of the country by providing electricity at low cost and supplying to the people at reasonable prices through the optimal utilization of the available hydropower resources of the country. It pledges to integrate electrification with economic activities and to develop hydroelectricity to meet the domestic demand with due emphasis on rural electrification and export of surplus energy.

### f. Irrigation Policy, 1992 (Revised-1997)

Irrigation Policy was introduced in 1992. The objectives included cost-effectiveness and sustainability, uniformity in implementation procedure, reduction of government's involvement, preserving traditional irrigation methods, institutional reform, and research capability enhancement. The 1992 policy was amended in 1997 with emphasis on rehabilitation of FMISs and additional objectives of reducing government's recurrent cost in irrigation and maintaining regional balance.

### g. Other water related policies

Some of the other policies relevant to the two sub-sectors specified are: National Wetland Policy, 2003; Climate Change Policy, 2011; National Land Use Policy, 2012; and National Agro-biodiversity Policy, 2007

## 4. Strategies

Water Resources Strategy (WRS)-2002

*In 2002, Nepal formulated a national strategy for the development of water resources sector with a goal of "living conditions of Nepali people are significantly improved in a sustainable manner". The WRS identified 'Appropriate & efficient irrigation available to support optimal, sustainable use of irrigable land' as one output to be expected by the end of 2027.*

To move toward this goal, ten strategic outputs were identified as follows:

2. Security
    a. Water Induced Disasters
    b. Environmental Action Plan on Management of Watersheds and Aquatic Ecosystems
3. Use
    a. Water Supply, Sanitation and Hygiene

b. Irrigation for Agriculture
c. Hydropower Development
d. Industries, Tourism, Fisheries and Navigational Uses

4. Mechanisms
    a. Water-related Information Systems (Decision Support System for River Basin Planning and Management)
    b. Regional Cooperation Frameworks
    c. Legal Frameworks
    d. Institutional Mechanisms

**a. Nepal Biodiversity Strategy-2002**

In this strategy, the GoN commits to the protection and wise-use of biological resources, protection of ecological processes and systems and equitable sharing of all ensuing benefits on sustainable basis. These benefits are related to livelihoods and economic development of people.

b. **National Conservation Strategy (NCS)-1988**

Nepal was one of the first countries to prepare a National Conservation Strategy under IUCN guidelines. The NCS stresses sustainable use of natural resources and compatible land-use. The Strategy has four objectives: help satisfy the basic material, spiritual and cultural needs of the people of Nepal, both present and future generations; ensure the sustainable use of Nepal's land and renewable resources; preserve the biological diversity of Nepal in order to maintain and improve the variety of yields and the quality of crops and livestock; and maintain the variety of wild species, both plant and animal, and the essential ecological and life-support systems, such as soil regeneration, nutrient recycling and the protection and cleansing of water and air. The NCS is currently being revised and updated as a strategic framework that incorporates the many relevant policy and strategy documents that have been developed by the GoN since the late 1980s.

**c. National Strategy: Communication, Education, Participation and Awareness (CEPA) Strategy and Dissemination Framework for the Conservation and Wise-use of Wetlands in Nepal, 2011-2015.**

This strategy provides overall guidance for the conservation of wetlands and their use for nature conservation including the livelihoods of local communities.

## 5. Plans and Programs

**a. National Water Plan (NWP)-2005**

The NWP constitutes of the set of activities (programs and projects) that are being or will be implemented to achieve the strategic targets. It was prepared to operationalize the Water Sector strategy of Nepal approved by the Government in January 2002. The broad objective of the NWP is to contribute in a balanced manner to the overall national goals of economic development, poverty alleviation, food securities, public health and safety, decent standards of living for the people, and protection of the natural environment.

**b. Three Year Interim Plan (2067/68-2069/70 or 2010-2013)**

This plan is the twelfth periodic plan which has been approved by the government after completion of the eleventh three year plan (2064/65-2066/67). The overall goals of the plan are to meet the targets set by the Millennium Development Goals by the year 2015, generate respectful and profitable employment, eliminate economic disparity, achieve regional balance in development, and reduce the level of poverty from 25% to 21% through sustainable and broad-based economic development. A key objective of the plan is to increase the productivity and agriculture production with the help of reliable irrigation. Strategies, working policies and programs have been developed to achieve the goals and objectives of the plan.

**c. National Adaptation Programs of Action (NAPA), 2010**

Nepal's NAPA preparation process was completed in September 2010. The process involved six thematic working groups representing about 80 institutions and experts. The extensive consultation process – held at the local, regional and national levels – involved over 3000 farmers, practitioners, parliamentarians, policy-makers, thematic working group members and experts. The final document has nine priority, integrated profiles that include urgent and immediate adaptation needed to address extreme climate events and their consequences.

**d. Local Adaptation Plans of Action (LAPA), 2011**

As a means of implementing NAPA and integrating adaptation options into development policy and planning processes, Nepal prepared guidelines for Local Adaptation Plans of Action (LAPA.) LAPAs identify local adaptation needs that focus on reducing local climate risks and vulnerabilities, and increasing resilience. The LAPA framework ensures that the process of integrating climate change resilience from local-to-national level planning is bottom-up, inclusive, responsive and flexible. The LAPA process has been piloted in 10 districts of western Nepal.

**e. Pilot Program for Climate Resilience (PPCR), 2011**

In order to combat the negative impacts of climate change in Nepal, the Pilot Project for Climate Resilience (PPCR) builds upon the GoN's ongoing programs to address poverty and support the country's long-term vision to achieve a climate-resilient development. For the purpose, five broad interventions are being implemented by the Ministry of Science, Technology and Environment (MoSTE) with assistance from the Asian Development Bank and the World Bank.

**f. Other water related plans and programs**

Other selected plans and programs include: Terai Landscape Strategic Plan, 2004; Master Plan for Forestry Sector, 1989 (updated in 2014); Agriculture Perspective Plan, 1995 (updated in 2014); Tenth Five-Year Plan, 2002-2007; Three-Year Interim Plans, 2007-2010, and 2010-2013; Nepal Biodiversity Strategy Implementation Plan, 2006-2010 (updated in 2014); and Integrated Landscape Planning Directives, 2012

## **Annex B.** Water Resources Management in Nepal: ongoing programs[66]

1. **Water and Energy Commission Secretariat (WECS):** WECS has been implementing Integrated Water Resource Management/ Integrated River Basin Management (IWRM/IRBM) activities in different catchments of the Indrawati sub-basin since June 2010. These activities cover selected VDCs within 3 districts of namely, Sindhupalchowk, Kavrepalanchowk and Kathmandu. WWF/Nepal is assisting to implement the program and the Ministry of Foreign Affairs, Government of Finland is providing support. The project focuses on: environmental sustainability, social equity, economic efficiency, promotion of alternative livelihoods and institutional sustainability.

2. **Ministry of Forests and Soil Conservation** has been leading the Chure Conservation Program since 2012. The Rashtrapati Chure Terai Madhesh Conservation Committee provides guidance to this project. The Department of Forests and the Department of Soil Conservation and Watershed Management are implementing the program which is focused on decreasing the rate of deforestation, and forest degradation and controlling the illegal extraction of natural resources such as sand and boulders along the Churia and inner Tarai regions. The project covers 27 Tarai districts of Nepal.

3. **Department of Soil Conservation and Watershed Management (DSCWM)** is implementing the project "Participatory Watershed Management and Local Governance Project (PWMLGP)". The Japan International Cooperation Agency (JICA) is funding the project. The project was launched in 2009 for five years. The project objective is to improve participatory watershed management by strengthening the local governance system. The project covers 34 VDCs in 6 Districts of the Western Development Region: Syangja, Myagdi, Baglung, Parbat, Kaski, Tanahu, and 2 Districts of the Central Development Region: Kavre and Sindhupalchowk.

4. **United States Agency for International Development (USAID)** is funding the project Knowledge-based Integrated Sustainable Agriculture and Nutrition (KISAN). KISAN is a five-year project (2013-2017) initiated under USAID's Global Feed the Future Initiative. The project aims to improve food security, increase income, and diversify diets for 160,000 disadvantaged rural households, for about one million rural Nepalese people across 20 districts through integrated agriculture and nutrition activities.[67]The project is being implemented by a consortium led by Winrock International. The members of the consortium include Center for Environmental and Agricultural Policy, Research, Extension and Development (CEAPRED), Antenna Foundation Nepal, Development Project Service Center (DEPROSC), Nutrition Promotion and Consultancy Services (NPCS), and Nepal Water for Health (NEWAH). The project is working in Kapilbastu, Palpa, Agarkhachi, Gulmi, Banke, Bardiya, Surkhet, Dailekh, Jajarkot Dang, Salyan, Rukum, Rolpa, Pyuthan, Baitadi, Kailali, Kanchanpur, Doti, Accham, and Dadheldhura.

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[66]What follows is a list of the programs that the Assessment Team came across during the literature review and field visit segments of the Assessment.

[67]We understand that the nutrition component of KISAN has been discontinued. We also understand that the water resources/irrigation element of the project is limited, but could be expanded if additional resources were made available.

5. **Japan International Cooperation Agency (JICA)** is providing support to Department of Water Supply and Sewerage (DWSS) to implement a project for Capacity Development on Water Supply in Semi-Urban Areas in Nepal. The project aims to improve technical support services provided by the Department of Water Supply and Sewerage (DWSS) District Offices to Water Users Service Committees (WUSC) in Morang and Jhapa Districts.

6. **The World Bank** has been funding an Irrigation and Water Resources Management Project (IWRMP) since 2008. The project is being implemented by many partners including the Groundwater Resource Development Board in Butwal and Rupandehi. IWRMP has been working to improve agriculture productivity and the management of selected irrigation schemes in Nepal as well as enhancing institutional capacity for integrated water resources management. The project works mainly through four components: Irrigation Infrastructure Development and Improvement; Irrigation Management Transfer; Institutional and Policy Support for Improved Water Management; and Integrated Crop and Water Management. The project covers selected schemes in the mountain, hill and Terai districts of the Western, Mid-Western and Far Western development regions (40 districts) as well as working on improving and expanding ground water irrigation in the Tarai.

7. **Asian Development Bank (ADB)** is funding the project Building Climate Resilience of Watersheds in Mountain Eco-Regions (BCRWME) of Nepal (2014-2020). The Department of Soil Conservation and Watershed Management (DSCWM) is implementing the project. The project aims to provide access to reliable water resources for domestic purposes and irrigation for communities living in the watersheds of Nepal's river systems which are significantly vulnerable to climate change. The project covers the Lower West Seti and Budhi Ganga watersheds of the Karnali River basin. The project area includes parts of Accham, Bahjung, Baitadi, Bajura, Dadeldhura, and Doti districts.

8. **Institute for Social and Environmental Transition (I-SET)Nepal** is implementing the project Understanding the Cross Scale Implications of Forest and Water Management for Adaptation and Mitigation in the Nepal Himalaya with support from International Development Research Centre (IDRC) and ISET-International. The main objective of the project is to increase the understanding of climate change and its implications for agriculture, forestry, livelihoods, and vulnerability in the Middle Hills of Nepal. The project aims to generate policy-relevant information to enhance adaptation to climate change and improve food security. The project investigates critical challenges, particularly the roles and inter-linkages between forest, agriculture and water management strategies in both adapting to and mitigating the impacts of climate change. The project covers six VDCs in the western region of Nepal: Kagbeni (Mustang District); Ramche (Myagdi District); Rupakot VDC and Rupa Lake watershed (Kaski District); Madanpokhara (Palpa District); Hansapur (Arghakhanchi District); and Dubiya (Kapilbastu District).

9. **HELVETAS-Nepal (Swiss Association for Development and Cooperation)** has been implementing the project Effective Water Governance in Asian Highlands since September 2012. The project is funded by Canada's IDRC. The main partners in the three-country project (Nepal, Pakistan and China) are HELVETAS in Nepal and Pakistan and the Centre for Mountain Ecosystem Studies at the Kunming Institute of Botany in Yunnan, China. The major objectives of the project are to assess climate change and its impact on water resources at the regional, basin and local levels and to build awareness of and preparedness for effective water resource management in the Asian Highlands by encouraging local adaptive livelihood options and improved regional and sub-regional water governance. In

Nepal this research project is being implemented in Sindhupalchok district focused in theMelamchi watershed which includes eight VDCs: Melamchi, Talamarang, Mahankal, Dubachour, Palchok, Ichok, Kiul and Helambu.

10. **International Development Enterprises (iDE)** has been implementing the project Solar Multiple Use Systems (MUS) since 2012. The project is funded by Renewable World. The main objective of the project is to pioneer the design and demonstration of solar-powered pumping for multiple use water systems designed for domestic and agricultural needs. The project is being implemented in Syangja (2 sites), Kaski (1 site), Gulmi (1 site) and Rupendehi (1 site).

11. **Himalayan Cryosphere, Climate and Disaster Research Center (HiCCDRC),** Kathmandu University is currently offering an M. S. in glaciology. This two year Master's Degree program aims to produce professionals with interdisciplinary skills in cryospheric science. For their thesis works, students conduct research on various aspects of glaciers and glacial lakes. The program is supported by Cryosphere Monitoring Project (Funded by the Norwegian Ministry of Foreign Affairs, Royal Government of Norway through ICIMOD) and CHARIS (Contribution to High Asia Runoff from Ice and Snow) project which is funded by USAID through the National Snow and Ice Data Center at the University of Colorado.

12. **International Union for the Conservation of Nature (IUCN)** is providing technical support to the National Planning Commission (NPC) to prepare a National Conservation Strategy Framework. This work is based on a review Nepal's National Conservation Strategy-1988. The Strategy Framework is intended to be an umbrella strategy linking various GoN strategies and filling any gaps that have been identified in these existing strategies. The Strategic Framework is expected to include policy guidance on the management and conservation of water resources. The framework strategy is expected to be in place by early 2015.

13. **The International Center for Integrated Mountain Development (ICIMOD)** has been implementing a variety of regional projects on environmental change and ecosystem services in mountain regions across the Hindu Kush Himalayas. Among these is the Himalayan Climate Change Adaptation Program (HICAP) aimed at generating knowledge of climate change impacts on natural resources, ecosystem services and local communities. ICIMOD is preparing to start the project Himalayan Adaptation, Water and Resilience (HI-AWARE). The partner organizations of this project are: the Energy Research Institute (TERI), New Delhi, India; Alternate Energy and Water Resources Institute (CAEWRI) of the Pakistan Agricultural Research Council (PARC), Islamabad, Pakistan; Alterra-WUR, Wageningen, the Netherlands and Bangladesh Centre for Advanced Studies (BCAS). The research will be focused on glacier and snowpack dependent river basins and improving the livelihoods of communities in these river basins.[68]

14. **Nepal Engineering College (NEC)**, Pokhara University, is offering an M. Sc in interdisciplinary water resource management. The syllabus includes an innovative mix of science and social science courses .The program attracts female students by providing

[68]For additional information see Http://www.icimod.org

scholarships. As a part of their Masters' thesis, students conduct research on various aspects of water resources management.

15. **International Water Management Institute (IWMI) - Nepal** is contributing to improved planning and decision making in water resource management at all levels through analysis of topographical, hydrological and meteorological data; developing dynamic hydrological models, and conducting research on the likely impacts of climate change on the water resources.[69]

## Annex C. Freshwater Biodiversity in Nepal: ongoing programs[70]

### 1. Department of National Parks and Wildlife Conservation (DNPWC), Ministry of Forest and Soil Conservation (MoFSC), Government of Nepal ( GoN)

Under the umbrella of Pilot Program for Climate Resilience (PPCR), DNPWC is executing "Enhancing Climate Resilience of Endangered Species Project" The development objective of this project is to assist the GoN to develop and implement climate-resilient biodiversity plans for selected protected areas and to improve the livelihoods of communities in the buffer zones. The details of the project can be found the World Bank Website given below. The project document specifies that the proposed project would be designed to increase the resilience of endangered species, ecosystems and ecological processes while improving the well being of natural resource dependent communities by reducing the decline in biodiversity in two pilot protected areas and its surrounding landscape. Project activities would be structured around three themes: (i) improved information, knowledge and capacity regarding climate change impacts and resilience measures on the natural habitats of endangered species; (ii) improved natural habitats and eco system health; and (iii) improved well being of natural habitat dependent communities. [71]

More information on the project can be found at: http://documents.worldbank.org/curated/en/2013/01/17355631/nepal-enhancing-resilience-endangered-species-climate-change-project The safeguard documents of the project can be found on DNPWC website: http://www.dnpwc.gov.np/index.php/page/30

### 2. Local initiatives for Biodiversity, Research and Development (Li-Bird)

Li-Bird is implementing a project entitled "Mobilizing Local Institutions for Sustainable Management of Watershed Services in Nepal" since 2014. The project aims at scaling up payments for watershed services (PWS) system for sustainable management of biodiversity and natural resources in order to improve livelihoods of the rural poor in the mid-hills of Nepal.

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[69] For additional information see http://www.iwmi.cgiar.org/regions/asia/south-asia-region/spotlight-on-nepal/iwmi-in-nepal/

[70] What follows is a list of the programs that the Assessment Team came across during the literature review and field visit segments of the Assessment. Several additional programs were discovered by NDRI after the Out-Brief.

[71] As of July 2014, it was reported that the project faced some difficulties in implementation. The Assessment team was told at one meeting that this component of the PPCR was going to be dropped.

Begnas and Rupa lake watersheds in Lekhnath Municipality are covered in the project. The Swiss-Re Foundation is the key donor for the project.

The project will review the lessons learned from the functioning model of PWS in the Rupa lake watershed, strengthen the system and replicate it into the larger Begnas lake. The project will bring sellers and buyers together and put a functioning PWS system in place in the Begnas lake watershed. The project contributes to the Lekhnath municipality and local communities' vision of developing their landscape as an Agro-biodiversity Heritage Area.

### 3. Ministry of Forests and Soil Conservation (MoFSC), Government of Nepal

A project entitled "Ecosystem based Adaptation in Mountain Ecosystems in Nepal" has been implemented under the leadership of MOFSC since July 2012. The intervention covers the Panchase in Kaski, Parbat and Syangja districts. The Ecosystem based Adaptation Nepal (EbA-N) project aims to enhance capacity of local communities, demonstrate EbA measures for continued provision of ecosystem services, and support in strengthening the institutional capacity of key national Nepalese actors to build and better integrate ecosystem resilience options in national, sub-national and local level plans. The initiative has been funded by UNDP, UNEP and IUCN. The extent to which freshwater biodiversity has been included as an element in the project is not clear.

### 4. Nepal Electricity Authority (NEA) and Nepal Agriculture and Research Council (NARC)

NEA established the Kali Gandaki Fish Hatchery in 2002 with NARC as the implementing partner and funded the hatchery for 5 years. Thereafter NARC has had to find its own funds to operate the hatchery. The Hatchery is located in the Powerhouse premises of Kali Gandaki Hydropower Station. The main objective of the fish hatchery is to produce indigenous fish species of Kali Gandaki River for restocking both up and downstream from the dam/power plant intake and to strengthen the income and employment opportunities for fishing communities through fisheries management.

The scope of the project includes: breeding and restocking of indigenous fishes; collection and biological study of fish species of Kali Gandaki; limnological study of Kali Gandaki River**;** status of fish fauna and catch trend in Kali Gandaki River**;** growth study of Sahar, Katle, Asala and Gardi in captivity; formulation and development of feed for indigenous fish species; training/awareness program for local community to make them familiar with fish conservation; and regulation of aquatic and fish cultivation and trapping and hauling to restock long and short migratory fish species in the river.[72] Starting last year the hatchery also provided fish stock for the Middle Marsyangdi Hydropower project.

### 5. Ministry of Forest and Soil Conservation (MOFSC), Government of Nepal (GoN)

[72]Based on the Assessment Team visit to the fish hatchery it was not clear a)the extent to which "indigenous" fish remain a priority, and b)the extent to which the other objectives of the project had been met.

MOFSC is also implementing "Conservation and Sustainable Use of Wetlands in Nepal (CSUWN)" since 2008. The key project partners are GEF/UNDP and IUCN Nepal. The project had two major demonstration sites, both Ramsar sites, which reflected their unique importance among global wetlands. The Koshi Tappu Wildlife Reserve, situated in eastern Nepal, covers together with its buffer zones an area of 348,000 ha. The Ghodaghodi Lake Area (GLA) is located in Kailali district in the Far Western Nepal and covers an area of 2,563 ha. Approximately 150,000 people from over 25,000 households live in the project demonstration areas.

The overall goal of the project was to ensure maintenance and enhancement of wetland biodiversity and environmental goods and services for improved local livelihoods in Nepal. The project objectives were to strengthen national and local capacity in ecosystem management and sustainable use of wetland biodiversity. The project aimed to achieve these objectives through policy development and developing sustainable livelihood options for the local people. The project will ensure that national policies and planning frameworks identify and protect wetlands of global significance and threatened species, including migratory species. Awareness and capacity of Nepal to engage in and to promote international policies and collaborative efforts for wetlands conservation will be strengthened.

### 6. Rupa Lake Restoration and Fisheries Co-operative

The Rupa Lake Co-operative was established in 2002 with an aim to: rehabilitate the Rupa Lake to its prior state, generate income for its members through sustainable fishing and conserve local biodiversity. The wetland biodiversity of the area has been documented in the community biodiversity register and the areas around the lake have been conserved as habitat for white lotus, water chestnut, migratory birds, indigenous fish and wild rice. The co-operative provides grants to 17 community forest user groups and 19 watershed groups under its Payment for Environmental Services (PES) project. In co-operation with LI-BIRD, IUCN and World Vision, the co-operative has established the Rupa Lake Wetland Information and Resource Center. [73]

### 7. Sustainable Development Facility (SDF), Kailali

SDF implemented "Sustainable Development Project" in Kotatulsipur, Sandepani, and Ramsikharjhilla VDCs of Kailali District. This was part of the UNDP administered GEF Small Grants Programme for Nepal. Co-funding partners for this project were the Alternative Energy Promotion Center (AEPC), District Development Committee (DDC), Village Development Committee (VDC), Community Based Organization (CBOs), Poverty Alleviation Program and Safer Motherhood Program. The project aimed at biodiversity conservation through local capacity building for sustainable management of local forest resources, wetlands and sub-watersheds. Key activities included: Formation of CBOs, support for biogas and improved cookstove installation, management of Ghodaghodi lake and its watershed area, promotion of Non-timber Forest Products (NTFPs) and construction of Irrigation canals and check dams,

[73] Additional information is available at http://landscapes.ecoagriculture.org/global_review/rupa_lake_nepal

adult literacy on environment management, and income generation activities (vegetable farming, poultry, goat keeping, bee keeping and fish farming).[74]

### 8. Community Sustainable Development Organization (CSDO)

CSDO implemented the "Jakhera wetland and Chure Conservation Project" focusing on Jakhera wetland at the foothills of Chure hills in Sonpur VDC of Dang District. The project was funded by UNDP under the GEF Small Grants Program Nepal. The project aimed at improving hill and wetland ecosystem through the mobilization of self governing CBOs and ensuring sustainable livelihoods of local people. The main activities included: a biodiversity inventory, wetland management and watershed conservation, developing tourism opportunities (picnic spot and boating), fish farming, tree plantation, and improved cookstove and and biogas construction. The project was carried out under a district level Jakhera Wetland and Chure Conservation Coordination Committee under the chairpersonship of the DDC. Its members consist of representatives from the line agencies of the District. [75]

### 9. Rufford Small Grants Foundation (http://www.rufford.org/ )

a. *Understanding dolphin populations*: A project aimed at understanding populations of the most endangered Ganges river dolphins (Platanista gangetica) in Nepal and initiating local efforts to conserve remaining population has been implemented. The project covers the Mechi, Sapta Koshi, Narayani, Karnali and Mahakali rivers. The project aims at identifying the population status along Nepalese waterways (four major river systems where dolphins were noted once), understanding the character of available habitat (depth and width of river, disturbance, habitat types and riparian types) in the river systems, identifying the possible livelihoods alternatives for the river dependent community (fisherman) and raising the awareness among local residents living near to the river system and increase their participation in conserving dolphins and their habitat. It is expected that deliverables of the project will be useful for field-level conservation planning of the dolphin population and its prime habitat for conservation organizations in Nepal. Department of National Park and Wildlife Conservation, responsible government body for wildlife conservation, and other its partner organizations like WWF/Nepal, NTNC and IUCN will use the information for conservation initiatives. Information reported by this project will act as touchstone for the preparation of a Dolphin Conservation Action Plan in Nepal.

*b.* *Rapti River Conservation Education Project* (RRCEP): The main aims of this project are to understand the impacts of sand & gravel excavation on aquatic and terrestrial biodiversity and to alert and educate concerned stakeholders in order to reduce further deterioration of the Rapti River.

### 10. Aquatic Ecology Centre, Kathmandu University

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[74]The degree to which freshwater biodiversity is an explicit focus of this project is difficult to ascertain. This project was implemented from 1998-2000. It would be instructive to see what traces of it remain and the extent to which freshwater biodiversity was included as a conscious part of wetland management. For details see the GEF Small Grants Project website http://www.sgp.org.np

[75]This GEF Small Grants project was implemented from 2001-2003. Like the project above, it would be instructive to see what traces of it remain and the extent to which freshwater biodiversity was included as a conscious part of wetland management.

Selected research projects executed by the Aquatic Ecology Centre (AEC) under the supervision of Professor Subodh Sharma include:

a. Development of an Assessment system to Assess the Ecological Status of rivers in the Hindu Kush-Himalayan region (ASSESS-HKH): This was a collaborative effort between AEC, several Academic Institutes in Europe and a few local agencies in Nepal. Field studies were conducted in selected rivers of the HKH region and sampling protocol & site selection criteria were developed.

b. Fish Farming Development in Nepal (FFDN): This is a collaborative effort of AEC, Norwegian University of Science and Technology (NTNU), Norway; Tribhuwan University (TU), Nepal and Department of Fisheries, Government of Nepal. Ten doctoral students are pursuing PhD dissertions under the project.

c. Climate change impacts on freshwater ecosystems in Goyko and associated lakes. Gokyo is a high altitude lake located at 5000 m in the Sagarmatha National Park in Solukhumbu District and has been declared as a Ramsar site. The project serves as a demonstration study of high altitude lakes in Nepal and the region. One PhD and two Master students are carrying out research studies under this project.

d. Study of water quality of Panchpokhari Lake System: Panchpokhari and its associated lakes are located in Sindhupalchowk district of Nepal. As of site for recreation and mountaineering activities, the surrounding areas of high altitude lakes are under pressure due to infrastructure development and expanded settlement zones. This is posing threats to the water quality and ecological integrity of the lakes. The study aims to address the issue by identifying the extent of the water quality deterioration. One doctoral and four undergraduate students are conducting research studies under the project.

## Annex D. Freshwater Biodiversity: Priorities for Knowledge Synthesis, Technology Transfer, and Research

The following list was prepared to assist USAID/Nepal in planning the new Natural Resources Management (NRM) project under a tight deadline, before the full report was finalized. For each freshwater biodiversity research gap that we identified as worthy of support, we provide a sample of short-term (within first year), mid-term (years 1-5) and long-term (beyond the 5-year project cycle currently being planned) activities. Topic areas relate to those described in Section IV of the report. Many of the activities are intended to fill important gaps in available information or to synthesize existing information and make it more readily available to people working in water resources management and freshwater biodiversity fields throughout the region and beyond. Furthermore, many of the suggested activities are expansions of excellent ongoing work or are suggestions for support (and sometimes expansion) of existing proposals. Where possible, we included individuals or programs that either have the capacity or existing structure to implement the activity or who may be able to suggest others with appropriate expertise or facilities; the individuals/programs named are just possibilities.

## FRESHWATER BIODIVERSITY KNOWLEDGE GAPS

### Aquatic Biodiversity, Understanding the Local Context: Data Collection, Compilation, and Dissemination

Understanding distribution of native species is fundamental to any conservation planning or implementation, especially in the context of national hydropower planning. It is also critical to help develop Nepali human capacity in this area by developing taxonomic and ecological expertise.

SHORT-TERM

-Digitize 1995 Nepal Biodiversity Profiles (16 vol.) (Hariyo Ban & TMI). Output: PDF of this excellent resource.

-Determine repository for all publications/reports/electronic documents encountered relating to FW biodiversity. Consider funding an intern to make as much as possible available electronically. Output: centralized information source to expedite future actions.

-Compile taxonomic and distribution data from literature/reports on all aquatic groups not included in recent IUCN Red list reviews. (May require computer programming skills to develop database, or could perhaps partner with an existing organization such as NatureServe). Output: Aquatic biodiversity database.

-Conduct aquatic biodiversity inventories, especially in mid-west and far-west. Include indices of species abundance and document altitudinal ranges and major habitat types used. Year 1: Identify partners and focal basins/create inventory plan.

MID-TERM

-Make taxonomy and distribution of aquatic biodiversity database compiled in the short term available in a website with distribution maps and, where possible, accompanied by high quality photos of species to aid in identification. Incorporate IUCN Red List data if possible. This will provide an accessible basis for information on freshwater biodiversity that can be used as a resource in compiling materials for raising awareness of policy-makers as well as in development, resource management, education, and tourism. (Many possibilities for who could do this in Nepal or US. Will require computer/website expertise; collaboration across Nepal to obtain photos.). Output: searchable database on website.

-Conduct aquatic biodiversity inventories, especially in mid-west and far-west. Include indices of species abundance and document altitudinal ranges and major habitat types used. Inventory one basin per year or several "marginalized rivers" originating in Mid-Hills. Outputs: peer-reviewed publication on each year's results. After 5 years, publication of data analyzed at larger spatial scale. Feed results into regional/national planning efforts and biodiversity database.

-Apply biodiversity results to comprehensive hydropower planning efforts and watershed condition assessments.

LONG-TERM

-Annual or biennial updates to database/website incorporating results of new research.

-Develop new directions based on needs identified in first 5 years.

**East-West High Altitude Lakes Transect (canary in the coal mine)**

SHORT-TERM

-Expand S. Sharma's (KU) work on freshwater ecology of high lakes so that results can be extrapolated across the high mountains of Nepal. This study will provide baseline information for climate change adaptation and prediction of biotic responses. Year 1:hire personnel, design study, initiate sampling (S. Sharma, KU). Output: study plan and initial data.

MID-TERM

-Research implementation, analysis, and dissemination (S. Sharma, KU). Outputs: peer-reviewed publications, workshops, educational materials.

-Application of results to climate change predictions and adaptation plans (S. Sharma, KU and others working on climate change adaptation).

**North-South Longitudinal Assessment of Biodiversity in At Least 3River Basins, Beginning with Annapurna-Chitwan Transect**

SHORT-TERM

-Identify partners and rivers for longitudinal river study to include biodiversity surveys, groundwater dynamics, and socioeconomic use of and dependence on freshwater biodiversity; determine sites for both intensive initial sampling and long-term monitoring; decide upon sampling methods and study design. Output: study plan.

MID-TERM

-Spatially-intensive survey of aquatic biodiversity along 3 major rivers to assess species distributions associated with changing habitats. Outputs: peer-reviewed publication of spatially-intensive results after year 2. Make results available to: biodiversity database; comprehensive hydropower planning efforts; watershed assessment efforts; IUCN Red List reviewers.

-Identify locations of community changes, if any, and choose long-term monitoring sites that will enable assessment of community changes over time.

-Establish long-term groundwater monitoring sites near biodiversity sites. Outputs: peer-reviewed publication on groundwater dynamics and relation to river hydrology after year 2; publication on temporal variability after year 5. Recommendations for development activities to conserve and recharge groundwater resources and to assist villages with water accessibility.

-Re-survey long-term monitoring sites annually to determine degree of interannual variability in groundwater and species relative abundances and, thus, to determine future monitoring frequency necessary to detect changes due to climate change, hydropower development, or land-use changes, etc. Outputs: peer-reviewed publication on temporal variability in species distributions and abundances after year 5; recommendations for future monitoring frequency.

-Assess socio-cultural/economic use of and dependence on freshwater biodiversity resources along transect. Coordinate with GESI efforts. Outputs: peer-reviewed paper and recommendations for development to assist communities relying on aquatic resources, especially in light of hydropower/climate change impacts.

-Application of results to climate change adaptation plans and hydropower comprehensive planning efforts after year 2.

LONG-TERM

-This should be a long-term effort in order to assess and respond to changes in freshwater biodiversity due to climate change, hydropower, changes in land use, etc. Continue monitoring sites at intervals recommended by mid-term study.

**Glacial Melt**

SHORT- and MID-TERM

-Provide USAID/Nepal support for ongoing Asia Bureau regional CHARIS project with KU Cryosphere Research Center

**Mid-Hills Hydrogeology of Groundwater**

SHORT-TERM

-Identify study area and partners and compile/map anecdotal information about springs drying and local assumptions about causes of drying. Examine the socioeconomic impacts of and adaptations to spring drying. Output: preliminary report and map of spring conditions, and social impacts.

MID-TERM

-Based on initial findings of drying patterns of springs and suggested causes, initiate study to test hypotheses of root causes of spring drying. Outputs: peer-reviewed paper on pattern and causes of spring drying. Suggestions for options to restore/maintain spring flows, especially in context of climate change predictions.

- Analysis of local responses to spring drying. Recommendations for best development options to assist villages where spring drying is occurring/predicted. Output: peer-reviewed publication and detailed recommendations to USAID for development assistance.

LONG-TERM

– continue assisting villages in adapting to changing groundwater.

**Tarai: Marginalized Rivers originating in the Mid-Hills**

SHORT-TERM

Identify partners and refine questions about aquatic biodiversity and its relationship to hydrologic connectivity, groundwater dynamics, and socio-cultural/economic dependencies. Consider focusing on mid-west where economic resources are least or far-west where FW biodiversity information is most lacking (Gurung 2012). May require considerable capacity-building for taxonomic expertise in the region.

MID-TERM

-Initiate improved aquatic biodiversity inventories in marginalized rivers, especially in mid-west and far-west Nepal. Conduct further taxonomic work to describe new species if necessary. Outputs: peer-reviewed journal publication on aquatic biodiversity patterns after year 2. If necessary, additional papers describing new species after year 4.

-Develop understanding of the relationship of biota to hydrologic connectivity longitudinally, laterally (with floodplain) and vertically (with groundwater).

-Develop better understanding of groundwater dynamics of these rivers. Links to groundwater topic (above). Output: peer-reviewed paper. Predictions of river responses to climate change.

-Investigate socio-cultural and economic relationships to these river systems and predicted socioeconomic impacts if freshwater biodiversity resources are lost. Outputs: peer-reviewed publication. Suggest development options to help villages use freshwater biodiversity in more sustainable manner and, if necessary, for helping diversify livelihoods.

LONG-TERM

-Possibly expand work to other marginalized rivers to allow extrapolation across the Tarai.

**Invasive Wetland Plants**

SHORT-TERM

-Identify scientists who can provide immediate technology transfer on invasive aquatic plant species control – what has worked elsewhere and what has not. Output: succinct summaries/pamphlets on eradication/control techniques useful elsewhere for each species and preferably field visits/workshops in Nepal.

MID-TERM

-Research on efficacy and cost-effectiveness of existing approaches to invasive plant control/eradication in Nepal context and development/testing of new approaches.

-Possibly support development of new uses of the invasive wetland plants.

LONG-TERM

-If evaluation indicates that program is successful, continue on, with adjustments as necessary. The problem of invasive freshwater plants will still be there in 5 years! New invasives will arrive, and existing invasives will arrive in new areas where people will need technology transfer to learn how to cope with them.

## IMPACTS OF INFRASTRUCTURE (INCLUDING HYDROPOWER) DEVELOPMENT ON FRESHWATER BIODIVERSITY

### Hydropower-related issues

SHORT-TERM

-Environmental Flows study to determine flows necessary to maintain some ecological function and support of livelihoods downstream of dams – literature review and study design (USFS; S. Sharma, KU). Output year 1: research team formation and study plan.

-Understand life history, behavior, and ecological needs of freshwater species. This is a fundamental precursor to designing effective aquatic animal passage at dams and to predicting impacts of hydropower development on aquatic biodiversity and, thus, on livelihoods of those depending on freshwater resources. Priority species might be those of conservation concern or high economic importance. Year 1: identify partners, develop study plans.

-Effective engineering solutions for aquatic animal passage (also may be applicable to road/railway design)(establish engineer/biologist team(s) to address issue). Year 1: identify partners, initiate literature reviews or consultations with others, preferably in Asia, where successful fish passage is operating.

MID-TERM

-Environmental Flows. Year 2-3: Conduct research. Outputs: Peer-reviewed paper including specific environmental flow recommendations and details on any additional work needed.

-Understand life history, behavior, and ecological needs of freshwater species. Conduct studies on life history/migration timing of fishes (and possibly other animals – e.g., shrimps, dolphins, amphibians), swimming abilities, and habitat needs. Outputs: peer-reviewed papers and recommendations for infrastructure features necessary to support species.

-Effective engineering solutions for aquatic animal passage. Years 2-5: develop and test aquatic animal passage designs. Outputs: design recommendations and prototypes.

LONG-TERM

-Environmental Flows study – expand to different types of rivers (e.g., from major rivers to those originating in Mid-Hills)

-Understand life history, behavior, and ecological needs of freshwater species. Apply results to aquatic animal passage and environmental flow issues. Expand to other species/regions.

-Continue to adapt/test designs for aquatic animal passage as necessary.

**Promote indigenous species in aquaculture/hatcheries (relevant to hydropower but also elsewhere)**

SHORT-TERM

– solicit proposals/study plans for developing necessary husbandry techniques for captive spawning/rearing of native species. Year 1 – identify partner and focal species.

-scientifically evaluate survival of stocked fingerlings (identify investigators/ partner with Kali Gandaki Hatchery or other hatchery and partner with fishing villages in systems where fish are stocked). Design study to quantitatively assess survival and, thus, determine if hatchery practices are cost-effective or how to improve practices.

MID-TERM

– develop necessary husbandry techniques for captive spawning/rearing of native species. Outputs: Rearing techniques for several native fish species.

-scientifically evaluate survival of stocked fingerlings. Continue work on survival of stocked fish.

LONG-TERM

– develop necessary husbandry techniques for captive spawning/rearing of native species

– continue with other species. Evaluate long-term success of stocking efforts.

-scientifically evaluate survival of stocked fingerlings of additional species. Continue evaluation focused on long-lived species. Transfer methods to other hatcheries or help develop new hatcheries.

**Sediment effects on aquatic ecosystems**

SHORT-TERM

-How do results from other eco-regions translate to Nepal with respect to impacts of suspended sediments and bed load sediment effects on aquatic communities? We repeatedly heard and saw that sediment is a huge issue in aquatic systems, but the extent of the effects on aquatic biodiversity in Nepal are unknown. Ultimate goal is to develop predictions/solutions for sediment effects on people who directly depend on aquatic resources for their livelihoods. Year 1: conduct literature review for findings on sediment effects from Hindu-Kush Himalayas or at least in Asia.

MID-TERM

-Study effects of various sediment levels on aquatic communities. Partner with Marsyangdi hydropower plant to capitalize on their data.

**Facilitate international cooperation**

SHORT- AND MID-TERM

-Facilitate international cooperation/discussion on aquatic animal passage

-Encourage interaction of Nepali aquatic biologists/policy makers with new National River Ganga Basin Authority in India

LONG-TERM

-expand international cooperation to more aquatic issues and payments for ecological services.

**Pollution treatment/management and planning related to development/ industrialization**

SHORT-TERM

**-**This is an important, but broad, topic that we added at the last minute. It could begin with any of a variety of objectives and go many directions. Perhaps examining levels of toxins in fish consumed by people is a good starting point. Or one could look at changes in levels of toxins before and after (or in basins with and without) implementation of Integrated Pest Management practices.

**Other possible areas to support**

1. Educational efforts related to aquatic biodiversity

   -Support an **Adopt-a-Stream** type program schools and/or village groups

   -Photo cards helping fishermen identify threatened species.

   -Develop freshwater biodiversity textbooks for Nepal. Include an **aquatic ecology textbook** specific to Nepal(S. Sharma and others, KU).

   -Increasing awareness generally, and specifically with policy makers, of FW biodiversity efforts.

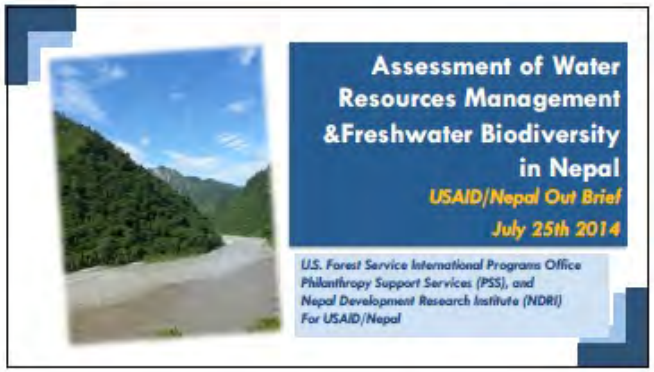
2. Provide technical support to find solution to sediment accumulation in lakes/wetlands (e.g., Rupa Tal, Chitwan NP, and probably many others). Is there a dredging approach that could be adapted to Nepal?
3. Agricultural impacts on aquatic biodiversity – pesticide/fertilizer pollution, water extraction, sedimentation, riparian deforestation.
4. Irrigation: strengthen civil society voices (Federation of Water User Associations – lessons learned from forestry/FECOFUN).
5. Disaster risks in relation to high dams
6. Support/develop ecotourism related to aquatic biodiversity/fishing – build on Hariyo Ban efforts (e.g., training of Chitwan NP guides at Biodiversity Conservation Center. Also Rupa Tal fishing cooperative who are trying to encourage tourism with a trail and nature center)
7. Do aquatic macroinvertebrate and fish distributions make sense with the identified 10-12 ecoregions of Nepal that are based primarily on tree species? Understanding this would be very helpful for large scale development and conservation planning. (This need was stated by S. Sharma, KU).
8. Develop wastewater treatment systems for high elevations (This need was stated by S. Sharma, KU. Would be an excellent topic for "green engineers" as it represents intersection of biology and engineering).
9. Sustainable fisheries issues. Support expansion of community fishing organizations to discourage overharvest, minimize fishing with electricity/poison, and encourage

movement toward payment for environmental services by community fishing groups (Rupa Tal fishing cooperative excellent model…except for use of introduced species).

Assess issues of invasive aquatic animals and vectors of introduction (e.g., aquaculture, pet trade, inadvertent introductions). We have found no information on the impacts of introduced carps or rainbow trout on Nepal's aquatic ecosystem.

# Annex E. Out-Brief and Related Materials[76]

8/14/14



[76]Related Materials: Suggestions were submitted to USAID/Nepal on Proposed Next Steps and on Suggested Followup (additional individuals and organizations to consult)

1

## Major River basins of Nepal

"Water .....wends its way through a multitude of disciplines: geography, geology, hydrology, meteorology, climatology, biology, ecology, agronomy, engineering, economics, history, law, political science, urban planning, and public policy, to name some that spring to mind."

Source: Hurley Bay Chair, Biodiversity Awareness coaching Stephen Grace 2012 Does Nelson Rye Water Stewardship Be Well and Will Determine its Future

"Climate change will express itself through water"

Dipak Gyawali

"If mitigation is about CARBON, then Adaptation is about WATER".

John Slater, MLA, Parliament Secretary of Water Supply and Allocation to the Minister of Environment, Province of British Columbia (October 2010)

## Groups consulted during the Field Visit portion of the Assessment

**Government of Nepal**

- National Planning Commission
- Ministry of Forests & Soil Conservation
- MoFSC, Department of Soil Conservation & Watershed Management
- MoFSC, National Trust for Nature Conservation
- Ministry of Science, Technology & Environment
- Ministry of Agriculture, National Agriculture Research Center
- Ministry of Energy (Middle Marsyandi & Kali Gandaki power plants)
- Ministry of Irrigation, Groundwater Development Board (Bulwal office)

**Researchers/Think Tanks/Consulting Groups/NGOs**

- Kathmandu University
- Pokhara University – Nepal Engineering College (in Kathmandu)
- Tribhuvan University – Institute of Forestry
- ICIMOD
- IWMI
- TMI
- ISET-Nepal
- WWF/Nepal
- CARE/Nepal
- Interdisciplinary Analysts
- Resources Himalaya
- FMS Promotion Trust
- Himal SouthAsia
- Humane Society International

## Groups consulted during the Field Visit portion of the Assessment

**Other Donors**

- World Bank
- Asian Development Bank
- Helvetas (Switzerland)

**Private Sectors**

- Smart Part/One Planet Solution Pvt. Ltd
- Lahmeyer International Consultant on Middle Bhotekoshi Hydro Project

**USAID Projects**

- WWF/ Hariyo Ban,
- Winrock/KISAN, IDE/ICCA,
- PACT/ Sajhedari Bikaas,
- Mercy Corps/IRMI

## Purpose and Objectives of the Assignment

**Purpose of the Assignment**

- Conduct country-level water resources management and freshwater biodiversity analyses for Nepal
- This will inform USAID's approach to natural resources management, including biodiversity conservation and climate change adaptation and mitigation, in Nepal for the five year period of 2015-2019.

1. Objective
   - A report on the status of water resources management and fresh water biodiversity in Nepal
2. Objective
   - Recommendations for USAID to address the conservation and development challenges and opportunities associated with these two areas

## Key Questions?

**Water Resources Management**

1. What is the status of Water Resources Management in Nepal, including its relationship to social development and political economy; the key institutions, policies, and laws (including international treaties) affecting water resources management, and how these interact with one another?
2. What are the threats to water resources in Nepal? What are the trends and what is the magnitude of impact of these threats?
3. What research or further understanding is necessary for management of water resources for multiple uses at the basin and sub-basin level by the government, civil society, local actors, donors, and other partners?
4. What is the priority geographic region(s) to work in water resources management and/or freshwater biodiversity conservation?

## Key Questions?

**Freshwater Biodiversity**

1. What is the status of freshwater biodiversity in Nepal, including ecosystem diversity, species diversity, threatened & endangered species, genetic diversity, ecological processes and ecosystem services, and values and economics of biodiversity?
2. What are the threats to that freshwater biodiversity, including direct threats and indirect threats or root causes of the direct threats?
3. Given the gaps in information, what are the priority areas for freshwater biodiversity research necessary to understand and conserve this diversity?

## Program Ideas/ Recommendations

1. Understanding water resources management/climate change adaptation & freshwater biodiversity in Nepal: critical research gaps
2. Policy & program framework for water resources management & freshwater biodiversity
3. Hydropower sustainability
4. Watershed management: best practices
5. Impacts of infrastructure development on freshwater biodiversity
6. Urban water: harnessing the private sector
7. WASH: Linking into the water resources mainstream
8. Gender, Social inclusion & Water
9. Incorporating support from across the USG& weaving water into ongoing USAID programs
10. Pending issues & questions: some preliminary thoughts

# 1. Understanding Water Resources Management(WRM), Climate Change Adaptation(CCA) and Fresh Water Biodiversity(FWB) in Nepal: Critical Research Gaps

## CCA and FWB: Critical Research Gaps

**A. North-South transects of FW biodiversity in at least 2 river basins**

*"Indeed, **Nepal is a natural laboratory** to understand morphological and physiological variations in organisms in relation to altitudinal changes (Gurung et al., 2017b)."*

I. Build on work started by Hariyo Ban/NTNC in the CHAL/Kali Gandaki Corridor –establish long-term aquatic biota reference sites in rivers and associated floodplains.
II. Add FW biodiversity dimensions – initial intensive surveys to identify areas of rapid species turnover; long-term on subset of sites
III. Identify strong US, long-term research partners (e.g., Smithsonian, US Universities, School for Field Studies (http://www.fieldstudies.org/))
IV. Add groundwater monitoring
V. Add socio-cultural dimensions
- how are livelihoods dependent on aquatic ecosystems and how is that changing (e.g., recent work by Institute for Social and Environmental Transition along the same corridor)
- what are GESI-related issues?

## CCA and FWB: Critical Research Gaps

**B. East-West High Altitude Lakes transects**

i. High altitude lakes excellent indicators of climate change effects ("Canary in the coal mine")
ii. Support expansion of impressive work by Kathmandu Univ (KU), Aquatic Ecology Center in Solukhumbu to other high altitude lakes across Nepal (e.g., Rara Lake, etc.)

**C. Glacial Melt**

i. Provide USAID/Nepal support for ongoing Asia Bureau regional CHARIS project with KU Cryosphere Research Center

**D. Mid-Hills Hydrogeology of Groundwater**

i. Anecdotal information that springs are drying up.
ii. No data to corroborate this or identify causes

## CCA and FWB: Critical Research Gaps

**E. Terai: Marginalized Rivers originating in the Churia**

i. Improved aquatic biodiversity inventories, especially in far west
ii. Understand relationship of biota to hydrologic connectivity longitudinally, laterally (with floodplain) and vertically (with groundwater)
iii. Better understanding of groundwater dynamics of these rivers
iv. Socio-cultural relationships to these river system

**F. Invasive Wetland Plants**

i. Economic / Ecological impacts huge!
ii. Technical assistance to provide existing information on what works and what does not for controlling invasive plant species (possibly utilize US Forest Service expertise)
iii. Research on efficacy of existing approaches and development/testing of new approaches

## CCA and FWB: Critical Research Gaps

**G. Global Forest Watch** 2.0

http://www.globalforestwatch.org
http://www.forestlegality.org/document/global-forest-watch-20

** Explore investing in this remarkable new decentralized, real-time monitoring tool both for WRM issues (eg monitoring the status of watershed conditions, haphazard road construction etc) and for Hariyo Ban work on REDD+*

## CCA and FWB: Critical Research Gaps

**Mid-hills Hydrogeology**

- Extensive use of spring sources for water supply and irrigation
- Emerging use to fill up the plastic-ponds in the night
- Multi-use systems (MUS) with gravity and solar (Ex. IDE project)

- Drying up of the Spring Sources
- Diminishing flows of the spring sources

- Sporadic field research activities (ex. ICIMOD-NWCF action research in Dapcha and Tinpiple, Kavre, and Isotope analysis-ISET-Nepal)
- Dynamics of spring flows, aquifer mapping along with their vertical and horizontal connectivity
- Impact of road construction and timber logging on the spring

## 2. Policy & program framework for water resources management & freshwater biodiversity

## Policy and Program :WRM and FWB

- Urgent need for a "whole of government" approach by the GON to WRM in the aftermath of the splitting of the Water Resources Ministry

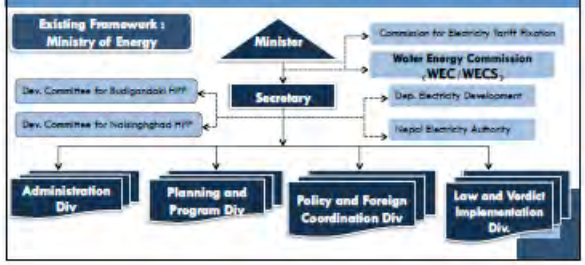
*Examples: ad hoc approval of hydro sites, lack of a coherent/strategic approach across multiple Ministries to WRM development, Groundwater Development Board with detailed monitoring of both shallow & deep aquifers in the Terai only looking at water for irrigation – no connection to drinking water programs or the monitoring of arsenic for human health*

- Need for the conservation &biodiversity elements of WRM to be added to the policy & program mix and for the tourism industry (trekking, rafting etc.) to be factored into WRM decisions. Also need for multi-disciplinary input into decision making (***not just engineers!***)

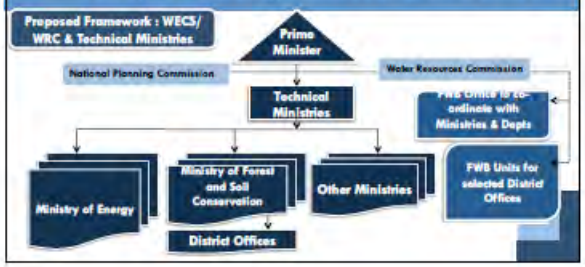
## Policy and Program :WRM and FWB

- Encouraging recent developments: proposal in the budget last week to transform WECS into a Water Resources Commission. Initial brainstorming meeting with former Secretaries of WECS and other WRM experts….with more meetings planned. Not clear to what extent voices outside of government and "experts" will be included in these discussions
- These developments should be monitored with a view to identifying areas for possible future assistance

## Policy and Program :WRM and FWB




## Policy and Program :WRM and FWB




## 3. Hydropower sustainability

## Hydropower Sustainability

Key Interactions:

- Demand for Power (National/ International)
- Livelihoods
- Aquatic Biodiversity
- River Dynamics

## Hydropower Sustainability (cont.)

Key Elements to Consider:

**Basin Planning**

Designation of
- Power Rivers
- Free Rivers (without dam)

**Design & Mitigation**

- Environmental Flows
- Fish Passage
- Operation & Maintenance

**Capacity Building**

'Greening' of Engineers

## 4. Watershed management: best practices

## Watershed Management

- Water Quantity/Supply (Multiple human uses /wildlife/ ecosystem uses
- Water Quality
- Livelihoods

## Watershed Management (cont.)

*Not a New Idea…*

- Ongoing: DSCWM, PPCR, HELVITAS, etc.
- Lessons Learned: Himachal Pradesh, Uttarakhand, Sikkim, Bhutan

*Recharge, Retention, Re-use*

## Watershed Management (cont.)

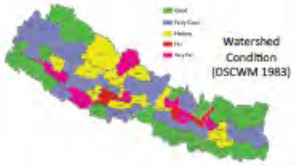
*But there are new twists…*

Road Design and Transportation Planning

## Watershed Management (cont.)

*Prioritize Interventions*

- Watershed Scale
- Prioritization and Watershed Plans
- Focus Efforts within Current Framework
- USFS Experience




## 5.Impacts of infrastructure development on freshwater biodiversity

## Impacts of infrastructure development on freshwater biodiversity

**Infrastructure types: Dams, Roads, Railways, Urban Development & Industries**

**Examples**

**Dams/Barrages**

- Aquatic animal passage
  - Gandak Barrage on Narayani river preventing upstream passage of gharial and dolphins.
  - Kaligandaki & Marsyangdi dams – NO fish passage

- Environmental Flows
  - Need scientific basis
  - Need enforcement of environmental flow policies
- High Sediment Levels
  - Research into effects on benthic community, fish, and other biota
  - Economic impacts! -dam operations, lake bed aggradations, river bed aggradations/degradation

## Impacts of infrastructure development on freshwater biodiversity

**Dams/Barrages cont.**

- Reservoir impacts on biota (especially for high dams)
- Water quality impacts: e.g., temperature, oxygen levels, pollution accumulation, potential for methyl mercury formation in anoxic waters

**Roads/Railways**

- Impacts of high sedimentation on flora and fauna, including contribution to wetland plant invasions
- Potential for aquatic habitat fragmentation
- Effects of increased human access to FW habitats

**Development and Industrialization**

- Pollution, sedimentation, dewatering, changes in river bed elevation
- Impacts on aquatic ecosystems and thus on livelihoods and tourism.

## Impacts of infrastructure development on freshwater biodiversity

**Beginning to Address Key Issues**

1. Understanding of local context – improve knowledge of taxonomy and distribution of fishes and other aquatic biota, including altitudinal ranges. Build capacity in taxonomic fields.
2. Understand life history, behavior, and ecological needs of aquatic species
   - Priority species those of conservation concern or high economic importance
3. Design and test effective engineering solutions (e.g., fish passage, road construction)
4. Promote indigenous species in aquaculture/hatcheries – develop necessary husbandry techniques
5. Research on sediment effects on aquatic ecosystems
   - How do results from other eco-regions translate to Nepal?
6. Facilitate international cooperation/discussion on aquatic animal passage
   - Encourage interaction with new National River Ganga Basin Authority in India
7. Pollution treatment/management and planning related to development/ Industrialization

## Impacts of infrastructure development on freshwater biodiversity

- Build on the recent Hariyo Ban study (Overview of Existing and Planned Key Infrastructure in the TAL & CHAL Landscapes and its Environmental & Social Impacts) and on the recent visit of E3/Leslie Johnston
- Explore links to the AID/W supported BUILD project (Biodiversity Understanding in Infrastructure and Landscape Development) being implemented by the Conservation Strategy Fund (CSF) with partner Pro-Public in the Himalayas
- Explore the applicability of recent Ecosystem Marketplace/Forest Trends work in China on "*natural infrastructure*".

## 6. Urban water: harnessing the private sector

## Urban water: harnessing the private sector

- Identify ongoing private sector-led opportunities starting in the Kathmandu Valley including
  - i. Rainwater harvesting/ Groundwater recharge: 5 star hotels & private homes
  - ii. Private sector FSM (fecal sludge management)
- Work with private entrepreneurs (SMART Pani & others) to develop viable models that can be spread to other urban centers including secondary cities/towns

## 7. WASH: linking into the water resources mainstream

## WASH: linking into the water resources mainstream

a. Move USAID/Nepal WASH into the WRM mainstream, starting with Fecal Sludge Management (FSM)

b.
- Consult the USAID-supported developed by the Africa Biodiversity Collaborative Group (ABCG, 2013).
- The Guidelines call for an integrated theory of change: WASH & healthy society and WASH & healthy ecosystems. Authors included Jennifer Platt from WASH Advocates.
- Consider presenting the Guidelines to the Nepal WASH donor group and arranging for modifications that will fit the Nepal situation

c. Consider incorporating the Helvetas WASH + 3Rs into USAID funded programs. (3Rs=retention, recharge & reuse)

## 8. Gender, Social Inclusion & Water

## GESI and Water

- An important element that needs additional work. Many key contacts were not available during our visit
- Central issues include: access to land & water, voice in decision making, and the "*feminization*" of rural production systems in light of widescale immigration to the Gulf
- Support Nepal Engineering College (PokharaUniv) Interdisciplinary Water Resources Management Masters program
- Explore possible support for Padma Kanya Campus Environmental Science BS/ MS programs
- Explore support for, Women Leading for Change in Natural Resources Management (WLCN), WWF/Nepal Conservation Mentors program and Resources Himalaya Environment Graduates in the Himalayas (EGH) network

## 9. Incorporating support from across the USG & weaving water into ongoing USAID programs

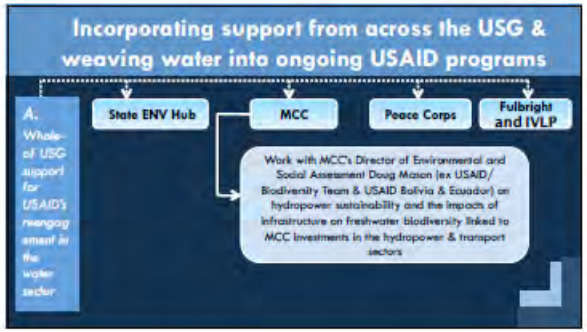
## Incorporating support from across the USG & weaving water into ongoing USAID programs

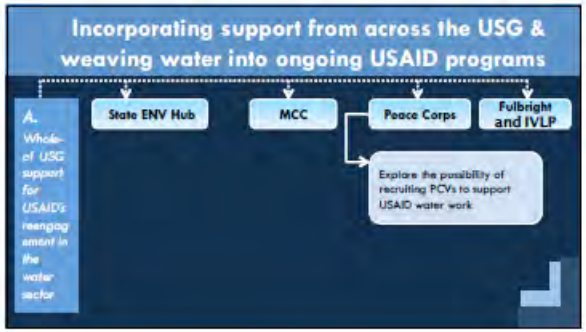
A. Whole-of USG support for USAID's reengagement in the water sector

State ENV Hub | MCC | Peace Corps | Fulbright and IVLP

Lead on the important regional dimensions of WRM, feeding information and program ideas into USAID programs as appropriate

Highlight and assist the GON to carefully consider and address issues with "high dams" ( e.g tectonics, sedimentation) including a review of
(i) recommendations of the World Commission and Dams, and
(ii) recent developments in neighboring Uttarakhand including the decision not to go forward with any new high dams and recommendations from a Supreme Court-mandated high level panel to either scrap or redesign 23 of 24 proposed "run-of-the-river" project proposals


Incorporating support from across the USG & weaving water into ongoing USAID programs
A. Whole-of USG support for USAID's reengagement in the water sector
State ENV Hub
MCC
Peace Corps
Fulbright and IVLP
Work with MCC's Director of Environmental and Social Assessment Doug Mason (ex USAID/ Biodiversity Team & USAID Bolivia & Ecuador) on hydropower sustainability and the impacts of infrastructure on freshwater biodiversity linked to MCC investments in the hydropower & transport sectors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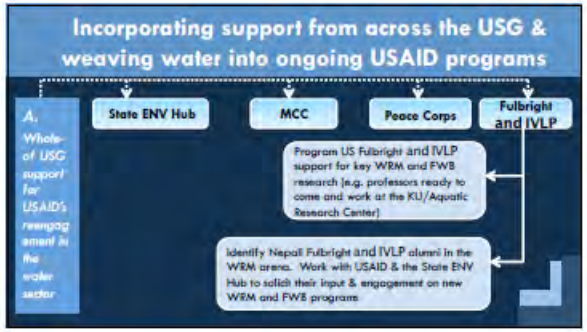
Explore the possibility of recruiting PCVs to support USAID water work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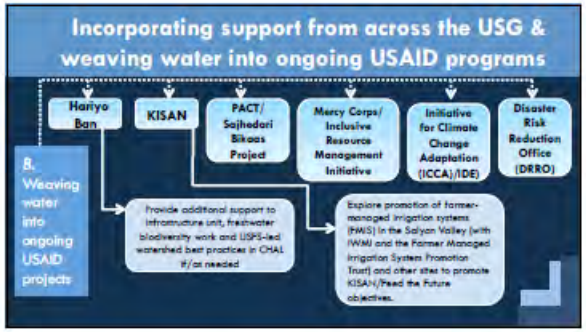
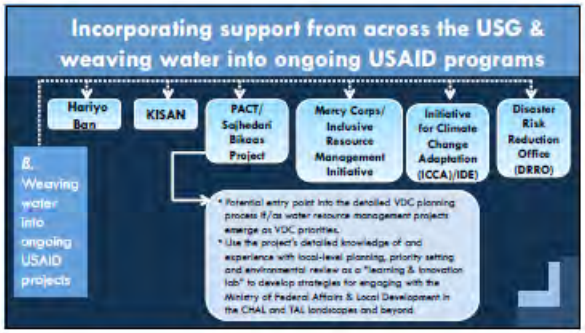
Fulbright and IVLP
Program US Fulbright and IVLP support for key WRM and FWB research (e.g. professors ready to come and work at the KU/Aquatic Research Center)
Identify Nepali Fulbright and IVLP alumni in the WRM arena. Work with USAID & the State ENV Hub to solicit their input & engagement on new WRM and FWB programs


Incorporating support from across the USG & weaving water into ongoing USAID programs
B. Weaving water into ongoing USAID projects
Hariyo Ban
KISAN
PACT/ Sajhedari Bikaas Project
Mercy Corps/ Inclusive Resource Management Initiative
Initiative for Climate Change Adaptation (ICCA)/IDE)
Disaster Risk Reduction Office (DRRO)
Provide additional support to infrastructure unit, freshwater biodiversity work and USFS-led watershed best practices in CHAL if/as needed
Explore promotion of farmer-managed irrigation systems (FMIS) in the Salyan Valley (with IWMI and the Farmer Managed Irrigation System Promotion Trust) and other sites to promote KISAN/Feed the Future objectives.


Incorporating support from across the USG & weaving water into ongoing USAID programs
Hariyo Ban
KISAN
PACT/ Sajhedari Bikaas Project
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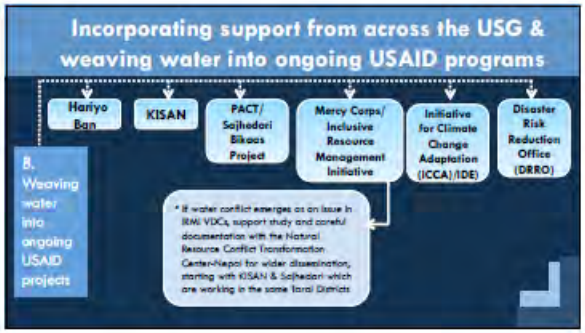
Initiative for Climate Change Adaptation (ICCA)/IDE)
Disaster Risk Reduction Office (DRRO)
B. Weaving water into ongoing USAID projects
* Potential entry point into the detailed VDC planning process if/as water resource management projects emerge as VDC priorities.
* Use the project's detailed knowledge of and experience with local-level planning, priority setting and environmental review as a "learning & innovation lab" to develop strategies for engaging with the Ministry of Federal Affairs & Local Development in the CHAL and TAL landscapes and beyond.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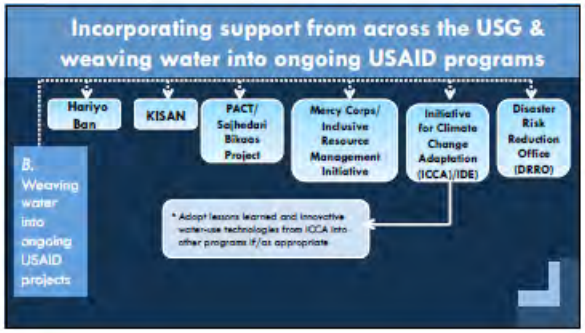
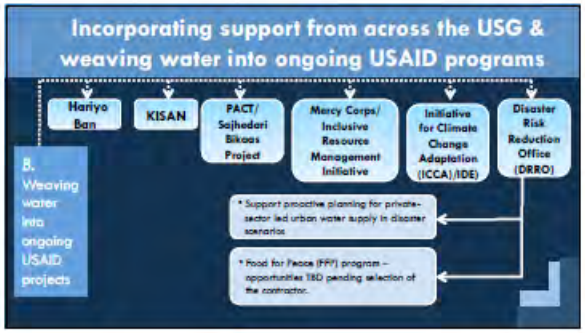
Mercy Corps/ Inclusive Resource Management Initiative
Initiative for Climate Change Adaptation (ICCA)/IDE)
Disaster Risk Reduction Office (DRRO)
B. Weaving water into ongoing USAID projects
* If water conflict emerges as an issue in IRM VDCs, support study and careful documentation with the Natural Resource Conflict Transformation Center-Nepal for wider dissemination, starting with KISAN & Sajhedari which are working in the same Terai Districts


Incorporating support from across the USG & weaving water into ongoing USAID programs
Hariyo Ban
KISAN
PACT/ Sajhedari Bikaas Project
Mercy Corps/ Inclusive Resource Management Initiative
Initiative for Climate Change Adaptation (ICCA)/IDE)
Disaster Risk Reduction Office (DRRO)
B. Weaving water into ongoing USAID projects
* Adopt lessons learned and innovative water-use technologies from ICCA into other programs if/as appropriate


Incorporating support from across the USG & weaving water into ongoing USAID programs
Hariyo Ban
KISAN
PACT/ Sajhedari Bikaas Project
Mercy Corps/ Inclusive Resource Management Initiative
Initiative for Climate Change Adaptation (ICCA)/IDE)
Disaster Risk Reduction Office (DRRO)
B. Weaving water into ongoing USAID projects
* Support proactive planning for private-sector led urban water supply in disaster scenarios
* Food for Peace (FFP) program – opportunities TBD pending selection of the contractor.

## 10. Pending issues & questions: some preliminary thoughts

## Pending issues & questions: some preliminary thoughts

1. Agricultural impacts on aquatic biodiversity – pesticide/fertilizer pollution, water extraction, sedimentation, riparian deforestation.
2. Irrigation: strengthen civil society voices, Federation of Water User Associations – lessons learned from forestry/FECOFUN
3. Disaster risks in relation to high dams
4. Ecotourism related to aquatic biodiversity/fishing – build on Hariyo Ban efforts (e.g., training of Chitwan NP guides at Biodiversity Conservation Center)
5. Educational efforts related to aquatic biodiversity
   - Adopt-a-Stream type program proposed by S. Sharma at Kathmandu U.
   - photo cards helping fishermen identify threatened species.
   - Develop freshwater biodiversity textbooks for Nepal.

## Pending issues & questions: some preliminary thoughts

6. Do aquatic macro invertebrates and fish distributions CO-relate with the identified 10-12 eco-regions of Nepal that are based primarily on tree species?
7. Develop environment-friendly wastewater treatment & FSM systems for emerging/secondary cities and towns (compare centralized with de-centralized systems)
8. Sustainable fisheries issues. Expansion of community fishing organizations to discourage overharvest and to minimize fishing with electricity/poison.
9. Assess issues of invasive aquatic animals and vectors of introduction (e.g., aquaculture, pet trade)

*Crayfish in Kathmandu aquarium store– July '14*

➢To be prepared enroute back to the US:

- *The material presented here broken down into Short (6-12 months), Medium (1-5 years) & Longer (5+ years) Term Program Ideas with possible partners & funding mechanisms*

**Sun Koshi rafting declared best in the world:** Lonely Planet, the largest travel guide book publisher in the world, has named Sun Koshi River Rafting as the best rafting river in the world. The travel guide book, in its article Hold tight: the world's best rafting rivers, declared the Sun Koshi as the best in the world, followed by the Maggie River in Canada, Zambezi River in Zimbabwe/Zambia, Alsek River in USA/Canada, Middle Fork of the Salmon River in USA, Franklin River in Australia, Rio Futaleufú in Chile, Rio Cenepa in Peru, Colorado River in USA, and Nare River in Italy.

EVERYDAY
FRESH FISH FROM THE LAKE
KoPila
Thank You!!!

## Annex H.[77] Biographical Sketches of Team members

**Dr. Susan B. Adams** is a Research Aquatic Ecologist with the USDA Forest Service in Oxford, Mississippi. She received a Ph.D. in Organismal Biology and Ecology from the University of Montana, an M.S. in Fisheries Management from the University of Idaho, and a B.A. in Biology from Carleton College. She is the Team Leader of the Aquatic and Terrestrial Fauna Team in the Southern Research Station's Center for Bottomland Hardwoods Research. Dr. Adams has experience with land management in relation to aquatic resources as well as with research in the areas of fish ecology, astacology (crayfish), and herpetology, and is interested in how both long- and short-term disturbances influence aquatic ecosystems. She has also participated in several program reviews, both internal and external to the Forest Service. Dr. Adams is an adjunct faculty member at four universities, has published more than 30 research papers, and is the president-elect of the International Association of Astacology.

**Dr. Tara Nidhi Bhattarai** is an Associate Professor in Department of Geology in Tri-chandra campus. He is a geologist by training and has a PhD degree from Kyushu University in Japan. He has been Independent Consultant/Principal Investigator for various projects related to hazard and vulnerability mapping and Disaster Risk Management (DRM) for more than 20 years. He has recently been involved in economic impact assessment of climate change in water sector in Nepal, a Climate & Development Knowledge Network (CDKN) project. He has also contributed to the Government of Nepal's Pilot Project for Climate Resilience (PPCR) on water issues. He was also involved in framing the 10 year Climate Change Adaption Road Map for Securing Fresh Water Systems of Nepal Himalayas (country paper) under the Nepal Adaptation Plan of Action (NAPA). He has trained various district level technical implementation task group members including District Disaster Relief Committee (DDRCs) and Village Development committee (VDCs) representatives on preparation of community based vulnerability mapping and best practice examples of DRM and climate change adaptation.

**Dr. Nawa Raj Khatiwada** is an Associate Professor in Department of Environment Science and Engineering at Kathmandu University. He is an Environmental Engineer by training and has earned his doctoral degree from Asian Institute of Technology in Bangkok, Thailand. Dr. Khatiwada has more than 20 years of professional experience in the field of water and wastewater management. He was recently involved in Pilot Project for Climate Resilience (PPCR) program initiated by the Government of Nepal which was aimed at developing projects which would contribute in creating climate resilient development. He has also recently been involved as a National Environmental Specialist in conducting an Environmental Impact Assessment (EIA) study report for the Bagmati River Basin Improvement Project, an Asian Development Bank(ADB) funded project. He has also been Independent Consultant/Principal Investigator for various projects related to Climate Change Adaptation (CCA), Disaster Risk Assessment, Environmental Impact Assessment (EIA), Waste Management Practices and Water Supply and Sanitation Projects. He has provided training for Senior and mid-level officers and managers in EIA and CCA related issues.

**Ms. Sona Shakya** is a senior researcher at the Nepal Development Research Institute (NDRI). She has completed her Master's degree in Natural Resources Management from the School of Environment, Resources and Development, Asian Institute of Technology (AIT), Bangkok. She has four years of experience working on various impact assessments and evaluation surveys particularly in the fields of food security, livelihood and climate change working with the clients from various NGO/INGOs including CGIAR/Climate Change, Agriculture & Food Security (CCAFS), ICIMOD, Plan International, United National Population Fund (UNFPA), UNDP, Good Neighbors International (GNI), Alternative Energy Promotion Center (AEPC), etc. While at AIT she worked as a Research Associate under the Making Mekong Connected (MMC) Project funded by World Agroforestry Centre (ICRAF) in Kunming, China. Additionally she has been trained in Land

[77] Note: Annexes F (Persons Contacted & Schedule of Field Visits) and G (Statement of Work) have been deleted from this version of the report.

Degradation Assessment and Monitoring for Sustainable Land Management and Climate Change Adaptation in South Asia (LADA Tool) and Integrated Phase classification for Chronic Food Security (IPC version 2.0).

**George F. Taylor II** is a natural resource management/environment expert with 35 years of experience in policy analysis; program design and implementation; and project, program and institutional evaluation across Asia, Africa and Latin America. He is currently Director of International Programs at Philanthropy Support Services (PSS) Inc. Mr. Taylor is a "global nomad" with deep roots in South Asia (India and Nepal). In addition to short-term assignments in some 30 countries, he has spent eleven years living and working in West Africa (Nigeria, Mali, Niger) and several years in South America (Bolivia). From 1984-1989 he served as Chief of the Natural Resources & Institutional Development Division in the Office of Agriculture and Rural Development of USAID/Nepal. In that capacity he oversaw USAID's work in forestry, water resources management and support for university-level education in forestry and agriculture. Mr. Taylor is a graduate of Woodstock School in Uttarakhand, India. He has an MS in forest resource management and policy/ international forestry from the SUNY College of Environmental Science & Forestry. He has received several awards including a Superior Honor Award from USAID for his work on forestry in Nepal (1989), the *Chevalier de l'Ordre du Merite Agricole* from the Government of Niger (1992), and USAID's highest recognition for environment work, the Molly Kux Environment Award (1999).

**Mark *R.* Weinhold** is the Forest Hydrologist and Watershed/Fisheries Program Manager on the White River National Forest in western Colorado. He received his B.S. degree in Civil Engineering from Oregon State University, an M.S. in Hydraulic Engineering and Hydrology from Colorado State University, and is slowly working on his Ph.D. in Hydraulic Engineering at Colorado State University. He is heavily involved in the Forest Service's aquatic organism and fish passage program (AOP) as a member of the national teaching cadre, as a developer of a computer-based e-learning tool for road-stream crossing design, and through development of implementation and effectiveness monitoring protocols for AOP projects. He is also a principal member of the National Virtual Design Team which provides technical assistance on fish passage and watershed restoration projects to National Forests across the United States. He has developed and implemented a number of climate change vulnerability and watershed condition assessments, as well as assisting the Forest Service International Program with a climate change needs assessment in Vietnam and spatial planning training in West Kalimantan, Indonesia. His past and current graduate work in civil engineering have largely focused on open-channel hydraulics and modeling sediment transport in gravel-bed rivers.

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