ICIMOD

RESOURCE BOOK

Multiscale Integrated River Basin Management

From a Hindu Kush Himalayan perspective

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RESOURCE BOOK

Multiscale Integrated River Basin Management

From a Hindu Kush Himalayan perspective

Editors

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Contents

Acronyms and abbreviations

AMD	Afghanistan Meteorological Department
ANDMA	Afghanistan National Disaster Management Authority
CBFEWS	Community-Based Flood Early Warning System
CDAFN	Community Development and Advocacy Forum Nepal
CSIRO	Commonwealth Scientific & Industrial Research Organization
DHM	Department of Hydrology and Meteorology
DPSIR	Driver-Pressure-State-Impact-Response
FAO	Food and Agriculture Organization
GAM	Gender Analysis Matrix
GCMs	General Circulation Models
GWP	Global Water Partnership
GLOF	Glacial Lake Outburst Flood
HKH-HYCOS	Establishment of a Regional Flood Information System in the HKH
IBT	Inter-basin Water Transfer
ICT	Information and Communication Technology
IFM	Integrated Flood Management
IRBM	Integrated River Basin Management
IWRM	Integrated Water Resources Management
KM	Knowledge Management
KPU	Kabul Polytechnic University
KU	Kabul University
LDOF	Landslide Dam Outburst Flood
MAIL	Ministry of Agriculture, Irrigation & Livestock, Afghanistan
MEW	Ministry of Energy and Water
MoFA	Ministry of Foreign Affairs, Afghanistan
MRRD	Ministry of Rural Rehabilitation and Development
NEPA	National Environment Protection Agency
NGO	Non-governmental Organization
OECD	Organisation for Economic Co-operation and Development
OLI	Operational Land Imager
PGN	Practical Gender Need
PMIS	Participatory management of the irrigation system
RCP	Representative Concentration Pathway
RDS	Regional Database System
RFIS	Regional Flood Information System
RMV	Resilient Mountain Village
SDG	Sustainable Development Goal
SPIP	Solar Powered Irrigation Pumps
TBRM	Transboundary River Basin Management
VDC	Village Development Committee
WECS	Water and Energy Commission Secretariat
WMO	World Meteorological Organization
WUMP	Water Use Master Plan

Foreword

Managing water resources is a critical challenge in the mountain and hill regions of the Hindu Kush Himalaya (HKH). Not only is demand increasing – for domestic use, irrigation, industry, and energy – the effects of climate change are now being seen in river basins in the form of changes in the hydrological regime and less predictable hydrological cycles. Extreme events such as floods and droughts are becoming more common and affecting communities and their livelihood activities across the region. There is an urgent need to manage the water resources in a more effective and equitable way that takes into account the water needs for all stakeholders and sectors.

The International Centre for Integrated Mountain Development (ICIMOD) has been promoting integrated approaches to mountain development focused on landscapes and river basins for many years. The limitations of sectoral approaches, in which interventions in one sector can have negative impacts on another leading to rejection of measures, increases in conflicts, and poor social and environmental outcomes, can be seen across the region. ICIMOD's approach in its work across river basins is holistic, flexible, and inclusive, transcending scales, administrative boundaries, modalities, and disciplines in its research and pilots. This approach promotes Integrated River Basin Management (IRBM) with a focus on mountain specific issues as a means of developing solutions that address the needs of all the different users of basin water, both upstream and downstream, including the environment itself as well as the different drivers of change. Examples include using the perspective of upstream-downstream linkages in resources management and provision of incentives for providing ecosystem services and flood early warning systems. The approach acknowledges the nexus between water, energy, food, and ecosystem issues, and helps develop a better understanding of upstream-downstream linkages as well as the linkages between natural resources management and sustainable livelihoods.

As a regional knowledge centre, ICIMOD supports regional collaboration and develops and shares information and knowledge resources with its member countries to implement IRBM at different scales. In 2018, ICIMOD organized its first dedicated training on IRBM in the form of a workshop on "Multiscale Integrated River Basin Management from a Himalayan Perspective" under the Strengthening Water Resources Management in Afghanistan (SWaRMA) Initiative for participants from Afghanistan. The training focused on a multiscale framework using both natural and social sciences to foster understanding of issues, impacts, and related responses for sustainable water resources management at the river basin scale with a focus on mountain specific issues. IRBM is of increasing importance in all the HKH countries, and there is a widespread need to build the knowledge and capacity of planners and other stakeholders across the region in the concepts of mountain-focused IRBM and the challenges in implementation. ICIMOD has adapted and expanded the resource materials used in the training to make the information available to a wider audience. The result is this Resource Book, presenting both an overview of the fundamental concepts behind IRBM and its development, and practical examples of IRBM issues and actions, especially in mountain areas. I hope that it will prove useful as a resource both for those preparing training courses and for other interested practitioners and stakeholders across the region.

David Molden, PhD
Director General, ICIMOD

ICIMOD's approach in its work across river basins is holistic, flexible, and inclusive, transcending scales, administrative boundaries, modalities, and disciplines in its research and pilots. This approach promotes Integrated River Basin Management (IRBM) with a focus on mountain specific issues to address the needs of all the different users of basin water, both upstream and downstream, including the environment itself.

Preface

The IRBM approach is becoming increasingly important in the HKH region both for tackling problems of water scarcity and water-related hazards as well as for maximizing the benefits of socio-economic development while protecting the mountain ecosystem. With climate change, mountainous countries are likely to face increased challenges in managing their water resources in a balanced way that benefits people, the economy, and the ecosystem. Integrated Water Resources Management (IWRM) and IRBM approaches are slowly being adopted into national policies and plans, but to be successful, implementation needs to be supported by an enabling environment, management instruments, and institutional and governance mechanisms. This in turn requires that decision makers and professionals in fields related to water resources management understand the principles of IRBM and important aspects of implementation.

There is a widespread need in the HKH region for building capacity in the IRBM approach with a focus on mountain issues. This need is particularly marked in Afghanistan, where professionals have shown their interest to learn about modern approaches to water resources management. In 2018, a training course in IRBM was developed as part of the Strengthening Water Resources Management for Afghanistan (SWaRMA) initiative of ICIMOD, which was jointly implemented by the Ministry of Energy and Water of the Government of Afghanistan, the Government of Australia, the Commonwealth Scientific and Industrial Research Organisation (CSIRO), and ICIMOD. The 12-day training workshop on "Multiscale Integrated River Basin Management from a Hindu Kush Himalayan Perspective" was held in Kathmandu in early 2019 with 14 participants from different departments and ministries in Afghanistan. The theoretical and practical aspects of water resources management were presented and discussed using group work and role play. The sessions were underpinned by a three-day field visit along the Koshi river basin in Nepal, where participants could directly experience IRBM issues in the field.

The resource book developed for the participants was further tested during the training and subsequently refined and expanded to become the publication presented here – a resource book on IRBM theory and practice for professionals across the Himalayan region and beyond. The resource book provides the broad framework and basic materials needed to develop a course on IRBM for trainees from anywhere in the HKH region and beyond, and particularly from HKH river basins with strong upstream-downstream linkages. It has eight modules that together cover the physical, social, institutional, and governance aspects of IRBM and its application in practice.

How to use this resource book

The resource book can be used as basis for developing a training programme on IRBM for participants from a particular country or interested in a particular river basin. The trainer should select individual modules according to the specific needs and interests of the group. Each module can be converted into a programme of a few hours to one or two days which can be linked together to form a training programme. Trainers and resource persons should include people with training in both the biophysical and the social sciences so that they can foster an understanding of the issues, impacts, challenges, and related responses. The training schedule and presentation slides and other training materials used in the original course (available online, Annex 1b, www.slideshare.com/ICIMOD) can be used as a base and customized for the particular group. The examples can be adapted and extended according to the situation in the basin of interest. Participants can use the Driver-Pressure-State-Impact-Response (DPSIR) framework described in Module 1 in a group session early in the process both to help them understand the situation in their basin or country and to provide the trainer with a better understanding of the specific issues and challenges in the river basins of concern to the participants.

Module 8 is crucial – it provides practical observation of relevant issues at river basin scale from upstream to downstream and demonstrates river basin management issues in practice from a linkages perspective. This module – a field visit from upstream to downstream along a basin – both sets the scene for understanding the concepts of IRBM and helps participants integrate the theoretical learning from the modules. The module can be used in different ways. Participants may start by reading Module 8 to set the scene before the training. The actual field trip may be held at the start of the training, allowing the relevance of each module to be understood in the practical context, or after the theory led sessions to consolidate the learning. During the field trip itself, participants should observe the physical changes, culture, needs, and approaches of the populations and ecosystems from upstream to downstream in the basin of interest from a water resources perspective. It is important to consider the underlying linkages and the different challenges and opportunities for achieving effective, equitable, and sustainable use of the water resources. If it is not possible to carry out a physical trip, then attempt an imaginary journey based on the known situation of the basin of interest using Module 8 as a guide.

The resource book can also be used as a stand-alone introduction and resource book for anyone who wishes to obtain an overview of the significance of IRBM, what it entails, and how it can be applied, especially those involved in activities and decision making related to water resource management. IWRM and IRBM practitioners will particularly benefit from learning about the approach and tools needed to apply IRBM in a mountainous river basin.

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We would like to express our special gratitude to David Molden and Eklabya Sharma of ICIMOD; Mohmmad Rafi Qazizada, Director General Natural Resouce Management, Ministry of Agriculture, Irrigation and Livestock Afghanistan (MAIL) and ICIMOD Board Member for Afghanistan; Khan Mohammad Takal, the Deputy Minister of Ministry of Energy and Water Afghanistan (MEW); Idress Malyar the Deputy Minister of National Environment Protection Agency (NEPA); Mohammad Hassann Faizee the Director General of Security Cooperation, Border Affairs, and Transboundary Water, Ministry of Foreign Affairs Afghanistan (MoFA); Fahimullah Ziaee, the ex Deputy Minister of the Ministry of Agriculture, Irrigation and Livestock Afghanistan (MAIL). Their constructive comments and feedback on the SWaRMA initiative in general and development of this training manual, in particular, is highly appreciated.

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We would also like to thank all the authors and co-authors who contributed to this resource book.

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SWaRMA aims to bolster water resources management in Afghanistan by co-creating learning opportunities.

About SWaRMA

Strengthening Water Resources Management in Afghanistan (SWaRMA) is a two-year project, supported by the governments of Australia and the Government of Afghanistan, and implemented through ICIMOD in collaboration with the Commonwealth Scientific and Industrial Research Organization (CSIRO).

SWaRMA's focal partner in Afghanistan is the Ministry of Energy and Water (MEW). SWaRMA also works closely with the Ministry of Agriculture, Irrigation, and Livestock (MAIL), Ministry of Foreign Affairs (MoFA), Afghanistan National Disaster Management Authority (ANDMA), National Environmental Protection Agency (NEPA), Afghanistan Meteorological Department (AMD), Kabul University (KU), Kabul Polytechnic University (KPU), Aga-Khan Agency for Habitat (AKAH), and other ministries.

This project aims to co-create co-learning opportunities to strengthen water resources management in Afghanistan that are important to Afghanistan's overall development. It aims to do so by assessing water resources at various levels, monitoring cryosphere and flood at the community level, developing and using water information systems, IRBM, and supporting Afghanistan's engagement in regional forums to showcase result based outcomes.

SWaRMA has seven thematic areas for capacity enhancement, co-creating knowledge, and facilitating co-learning platforms:

1. Water availability analysis
2. Cryosphere monitoring
3. Flood monitoring and early warning
4. Water resources management
5. Water resources planning at basin scale
6. Water information system
7. Regional cooperation

RESOURCE BOOK

Introduction

Integrated River Basin Management (IRBM) takes into account sustainable use of water and land resources for livelihoods, the related ecosystems, and disaster risk reduction, all from a gender and socio-economic perspective.

There is increasingly widespread recognition of the interlinked and complex nature of the world in which we live, and that simple solutions to seemingly simple problems are likely to have implications and impacts far beyond those intended. This can be seen clearly in the world of water resources management – a dam built upstream to provide drinking and irrigation water may result in loss of fishermen's livelihoods downstream or of silt to fertilize fields. Clearance of land for farming without measures focused on water retention may result in reduced infiltration, increase risk of flooding, and drying of the springs that provide drinking water to local communities. At the river basin level, there are strong linkages between upstream activities and processes, downstream water availability, geomorphology, and dependent ecosystems. The integrated nature of water resources is inherent in the nature of a river basin. The changing pattern of provision and needs in both the natural world and human society as a river wends its way from source to sea epitomises the concept of connectivity, continuity, and change. A river can be thought of as a long continuous creature, each part linked to, affecting, and affected by the next, with the whole watershed a web of interconnected activities and inputs feeding into and fed by the water course.

Lack of recognition of the importance of these linkages has meant that traditionally water resources management has been done in a sectoral manner, with problems solved in one sector too often leading to problems created in another. The IWRM approach has been introduced in response. The approach promotes coordinated development and management of water, land, and related resources, and has been a part of the global water resource management discourse since the 1990s.

Integrated River Basin Management (IRBM)

IWRM brings together decision-makers and stakeholders across the various sectors related to water and other related resources to make collective decisions for sustainable water resources management. IRBM adapts the principles of IWRM to a river system or a lake basin, thus considering the river (or lake) basin as an integrated whole. These approaches focus on using an integrated approach considering not just the water within the system, but also the entire range of users and drivers. IRBM takes into account sustainable use of water and land resources for livelihoods, the related ecosystems, and disaster risk reduction (DRR), all from a gender and socio-economic perspective. The frameworks promote participatory planning and implementation processes that bring multiple stakeholders to take collective decisions about water and land resources. IRBM focuses on the interconnected nature of water bodies across a landscape or a river corridor, linking headwaters to downstream areas.

IRBM in the HKH region

Water resources management is likely to become increasingly challenging in the HKH region, as elsewhere in the world, as a result of changes in climate, land use, and demographics. The challenges are likely to impact women and men, and people in different social groups, differently, as they have differential access to and control over resources (including water), and this will further increase the potential for instability related to water problems. Many governments in the HKH region have realized the importance of the IWRM approach for meeting these challenges and have initiated steps to use it in IRBM. IRBM in the HKH region has strong upstream-downstream linkages – activities and processes in the upstream areas can have marked consequences in downstream areas – and particular attention should be paid to these linkages. At the same time, hydrological processes in mountainous areas are strongly shaped by the geographic features, and IRBM should pay special attention to processes and impacts driven by topography. IWRM is also important for supporting all the Sustainable Development Goals across the 2030 Agenda . This development has increased the need to build the knowledge and capacity of planners and other stakeholders in the HKH countries on the concepts behind IRBM and the challenges of implementing it.

IRBM as a tool for inclusion

ICIMOD has been promoting an integrated approach to mountain development focused on river basins and landscapes for many years. Its approach in its work on river basins is holistic, flexible, and gender inclusive, transcending scales, borders, modalities, and disciplines. Its approach to IRBM involves acknowledging the nexus of water-energy-food-ecosystem issues, developing a better understanding of upstream-downstream linkages, recognizing the links between natural resources management and sustainable livelihoods, and addressing the environmental sustainability, economic efficiency, and social equity issues in an equitable manner.

ICIMOD's focus is on the mountains and hills of the HKH region. But these mountain and hill areas have a marked impact on people and the environment downstream, and in turn are themselves affected by decisions made and actions implemented in the downstream areas. Considering gender and social inclusion becomes essential to avoid or minimize the politics around resource access and control and make it more inclusive and equitable. By definition, river basins in a mountain region extend from the source area in the high mountains to the downstream plains, and IRBM is both based on and exemplifies the whole concept of upstream-downstream linkages. In practice, however, people living in upstream areas may have little interest in limiting their activities or carrying out interventions whose main intention is to improve or maintain conditions downstream. And they may feel that far from the centres of government, they are overlooked and their needs not recognized by those in the plains. Equally, people living downstream may have little knowledge of how their consumption of water, energy, and other resources, and their decisions on interventions made to meet those requirements, affect the people and environment upstream, and ultimately the whole basin, and how the changes upstream will in turn affect their own activities.

IRBM provides a framework for mutual understanding and recognition of the differential needs of communities and the interlinkages within a basin, the actions required to sustain the whole basin system, the potential impact of actions in one part of the system on another, and the interplay of these factors among women and men. Gender and social inclusion forms an integral part of IRBM to maximize social and economic welfare equitably without compromising the sustainability of vital ecosystems and the environment. IRBM also provides a means for recognizing value contributed in one area that accrues to another, and thus can provide the basis for compensation schemes such as 'payment for environmental services'. In this way, IRBM can be instrumental in achieving recognition for mountain and hill communities, and in providing a platform where their needs are not only heard but recognized as important and actively included in planning, and where their actions are valued. Thus IRBM is a valuable tool for redressing the marginalization of mountain people.

The resource book

This resource book was originally developed for a training workshop on "Multiscale IRBM from a Himalayan Perspective" organized by the Strengthening Water Resources Management in Afghanistan (SWaRMA) Initiative of ICIMOD, and targeted at participants from Afghanistan (Annex 1c). It provides the broad framework and basic materials needed for developing a course on IRBM relevant to anywhere in the HKH region, as well as other parts of the world. It also offers a useful resource for anyone involved in water resources management to gain an overview of IRBM and the associated issues.

The resource book is divided into eight modules which cover both conceptual perspectives and real-world examples related to IRBM: 1) Conceptual understanding of the river basin drivers and their implications for IRBM; 2) Tools and approaches for understanding biophysical change; 3) Gendered vulnerability and the socioeconomic drivers of change; 4) Governance, policy, and institutional framework; 5) Water diplomacy and transboundary cooperation; 6) Operational aspects of water and land management; 7) Knowledge management and communication; 8) Learning from the field: Linking IRBM theory to practice. In the workshop, the modules comprised a vibrant mix of presentations, group activities, and discussions within an overall adult learning approach. The final module (Module 8) underpinned the whole workshop and enabled participants to integrate the theoretical learning on different aspects of IRBM by experiencing real-world examples of IRBM issues at first hand in an upstream downstream context along the transboundary Koshi river basin in Nepal.

The modules are relevant for all the larger mountain basins in the HKH. Most of the examples provided are specific to the context of Afghanistan and Nepal, but can be tailored to the specific needs and conditions in any other basin. The resource book serves mainly as a guide to understanding the natural environment and human systems of river basin components; with various tools provided to help understanding of status and trends. It also covers the operational aspects of water and land management applicable to different scales of a river basin. The resource book can be used as background knowledge or as a basis for delivering a training course on IRBM issues, with appropriate customization based on the objectives, requirements, and central issues in the river basin of concern in the Himalaya.

This resource book provides the broad framework and basic materials needed for developing an IRBM course, serving as a guide to understanding the natural environment and human systems of river basin components.

MODULE 1

Conceptual understanding of river basin drivers and their implications for Integrated River Basin Management

Better understanding of river systems and interactive biophysical and socio-economic components is crucial for effective planning and management.

Nepal, S., Shrestha, A. B., Vaidya, R. A., Wester, P., Khatiwada, K. R., Pradhan, N. S., Bastola, A., Belbase, M., Faqiryar, J. N. (2019). Module 1: Conceptual understanding of river basin drivers and their implications for Integrated River Basin Management. In S. Nepal, A. B. Shrestha, C. G. Goodrich, A. Mishra, A. Prakash, S. Bhuchar, L. A. Vasily, V. Khadgi, & N. S. Pradhan (Eds). *Multiscale Integrated River Basin Management from a Hindu Kush Himalayan perspective* (pp. 1–5). Kathmandu: ICIMOD.

KEY MESSAGES

An understanding of upstream–downstream linkages at micro-, meso-, and macro-scales is needed to implement Integrated River Basin Management (IRBM) in a mountain river basin.

Inter-sectoral coordination (domestic water use, ecosystem, irrigation, hydropower) is important for river basin management.

IRBM can present opportunities for regional cooperation.

1.1. Introduction

This module highlights the overall principles and approach of IWRM in a river basin context (i.e. IRBM, see below). There are a number of components at river basin level – biophysical and socio-economic – which affect the quality and timing of water resources. The interactions among these components can alter resource patterns and availability. Better understanding of river systems and interactive biophysical and socio-economic components is very important for effective planning and IRBM. IWRM provides a framework in which water resource use is prioritized for cross-sectoral integration – for people, food, nature, industry, and other uses. An IWRM approach can be instrumental in developing adaptive solutions to problems involving stakeholders with different interests across the geographical coverage from upstream to downstream areas (Anukularmphai, 2010).

Implementing IWRM in a mountainous river basin requires special attention to the linkages between upstream and downstream areas at micro (local), meso (catchment), and macro (river basin) scales. When a river passes from the headwaters (upstream) to the floodplains (downstream), it connects different elements in the river basin. During this process, the water resources are used for different purposes by various sectors – domestic, agriculture, hydropower, industry, navigation – as well as to sustain the environment. The water resources are also managed by different stakeholders through formal and informal institutions and under regulating norms according to mandate and jurisdiction. The IWRM approach provides a framework to understand river basin drivers and impacts so that appropriate responses can be proposed.

'IWRM has been defined by the Technical Committee of the Global Water Partnership (GWP) as "a process which promotes the coordinated development and management of water, land, and related resources, in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems" (GWP, 2000). An IWRM approach is an open and flexible process, bringing together decision-makers and stakeholders across the various sectors that impact different components of a river basin. It is an important approach for bringing diverse stakeholders to a common table to set policy and make sound balanced decisions in response to the specific water challenges faced (GWP, 2009). Water management is becoming increasingly complex with growing and often conflicting demands from development sectors like agriculture, energy, industry, transportation, and communication. In addition, there are demands from social sectors like education, health, and environment, from local to national levels, so water can no longer be looked at or managed in isolation for equitable distribution, poverty alleviation, and sustenance of ecosystems (Harsha, 2012). IWRM provides an opportunity for maximizing the benefits (e.g. irrigation, hydropower) and minimizing the adverse impacts (e.g. floods, drought) by considering all the legitimate water uses of the river basin without compromising the water needs of vital ecosystems.

IWRM has gained worldwide recognition as an important approach towards more effective management of increasingly scarce water resources. Many countries in the Asian region have accepted and/or adopted IWRM as a strategy for sustainable water management (Anukularmphai, 2010). There are many examples of successful IWRM implementation at the river basin scale (Section 1.3.5 below).

In the UNESCO/NARBO 'IWRM Guidelines at River Basin Level', the term IRBM is referred to in the context of implementing IWRM for the provision of water services at the river basin level. The Guidelines explain further that "The river basin approach seeks to focus on implementing IWRM principles on the basis of better coordination amongst operating and water management entities within a river basin, with a focus on allocating and delivering reliable water-dependent services in an equitable manner. ... A basin-level perspective enables the integration of upstream and downstream issues, quantity and quality, surface water and groundwater, and land use and water resources in a practical manner. ... A basin level perspective also becomes increasingly important in addressing global and local change issues, particularly as climate change impacts are realized through the response of the hydrological cycle, in terms of quality and quantity, with direct impacts on the basin. ... IWRM at the river basin level is the foundation upon which the implementation of adaptation strategies, based on a sequence of climate change projections, and impact assessments can be realized." (UNESCO, 2009, pp. 2-5)

This module highlights the interactions of these water resource systems, including both the natural environment and human systems at a river basin scale from an IWRM perspective. The historical evolution of IWRM and IRBM approaches and some of the applied frameworks are also discussed. The application of these approaches is challenging although some good practices can already be identified. The river basin drivers and their impacts are discussed using the Driver-Pressure-State-Impact-Response (DPSIR) framework. Climate change is considered as a main driver and its impact assessed on the different aspects of a river system, livelihoods, and social systems. The key objective of the module is to build a better understanding of multiscale IRBM with a focus on the HKH region.

IRBM in practice – The most effective way to learn about IRBM and what it means in practice in mountainous river basins is to travel from upstream to downstream along a river basin looking at different aspects of water and water use in the landscape. Module 8 describes just such a journey, dedicated to linking IRBM theory to practice by learning from examples in the field. The Module can be used as a guide to the sort of things to look for in your own journey along a river basin, or as a substitute providing a glimpse of different areas of a basin from the descriptions. The field visit described in Module 8 went from upstream (mountains) to downstream (hills and plains) of the transboundary Koshi river basin, enabling participants to observe the nature of water management and issues relevant to IRBM from small to large scales and along a changing landscape with different issues shaped by geography and climate.

1.2. Learning objectives

The general objective of the module is to facilitate understanding of the main elements of IWRM and IRBM, specifically from the perspective of HKH river basins. The module focuses on the following specific objectives:

1. To develop an understanding of why we need IWRM and IRBM to address challenges in the Himalayan river basins, including regional cooperation
2. To understand water resources and related ecosystems, their uses, and users from biophysical, socio-economic, and political economic perspectives
3. To enable understanding of the river system from an integrated perspective, especially for addressing the challenges of climate change, and to develop a conceptual framework

1.3. Concepts and processes of IRBM

1.3.1. Principles of IWRM and IRBM

Globally, discussions on the need for IWRM gained momentum after the Dublin Statement on Water and Development at the 1992 International Conference on Water and Environment. Water champions of the era saw the need for a holistic approach to managing the water sector by reforming its fragmented institutional arrangements (Serageldin, 1995). However, their focus was on reforming institutional arrangements for coordination between the sub-sectors at a national level only, and did not address the need for coordination over a geographical scale at the river basin level. The need for a river basin level approach emphasizing IRBM based on IWRM became clear as the search continued for institutional arrangements for managing water as "a finite and vulnerable resource", as stated in the Dublin Principles, specifically in the context of the impact of climate change on the hydrological regime.

The IWRM approach is guided by many principles, and there are a number of frameworks that can be used to apply them. A selection of the most relevant are summarized in the following.

THE DUBLIN PRINCIPLES (1992)

The start of IWRM is generally attributed to the 'Dublin Principles' – the International Conference on Water and the Environment (ICWE) held from 26–31 January 1992 in Dublin, Ireland as a preparatory meeting for the United Nations Conference on Environment and Development (UNCED), also known as The Earth Summit, held in Rio de Janeiro in June 1992. The Conference adopted the Dublin Statement on Water and Sustainable Development (also known as the Dublin Principles) which was submitted to UNCED. The Dublin Principles and Conference Report express a holistic, comprehensive, multi-disciplinary approach to water resource problems worldwide based on four guiding principles, which cover environmental, social, political, and economic issues (ICWE, 1992):

1. Freshwater is a finite and vulnerable resource, essential to sustaining life, development, and the environment.
2. Water development and management should be based on a participatory approach, involving users, planners, and policymakers at all levels.
3. Women play a central part in the provision, management, and safeguarding of water.
4. Water has an economic value in all its competing uses and should be recognized as an economic good.

The consensus expressed in the form of these guiding principles recognized that water has multiple uses, and effective and equitable water resource management requires a holistic approach combining social, economic, and environmental factors. The principles on water usage viewed water as an economic good. However, the emphasis on the economic value of water rather than water as a universal right was contested by a number of groups and in November 2002, the UN Committee on Economic, Social and Cultural Rights adopted General Comment No. 15, in which water is recognized not only as a limited natural resource and a public good but also as a human right. The principles also highlighted the need for increased participation of women in water user groups. Women's role as water users was assumed under their traditional role of provisioning water for the household, which meant that involving them in planning and decision making was central to the integrated management of water resources. However, the view of women as water managers adopted a purely functional approach based on efficiency and economics. It did not consider the more important structural approach based on the empowering effects, and did not recognize gender and social differentials in participation within water institutions or the manner in which they operate within the social complexities (Cleaver, 1998).

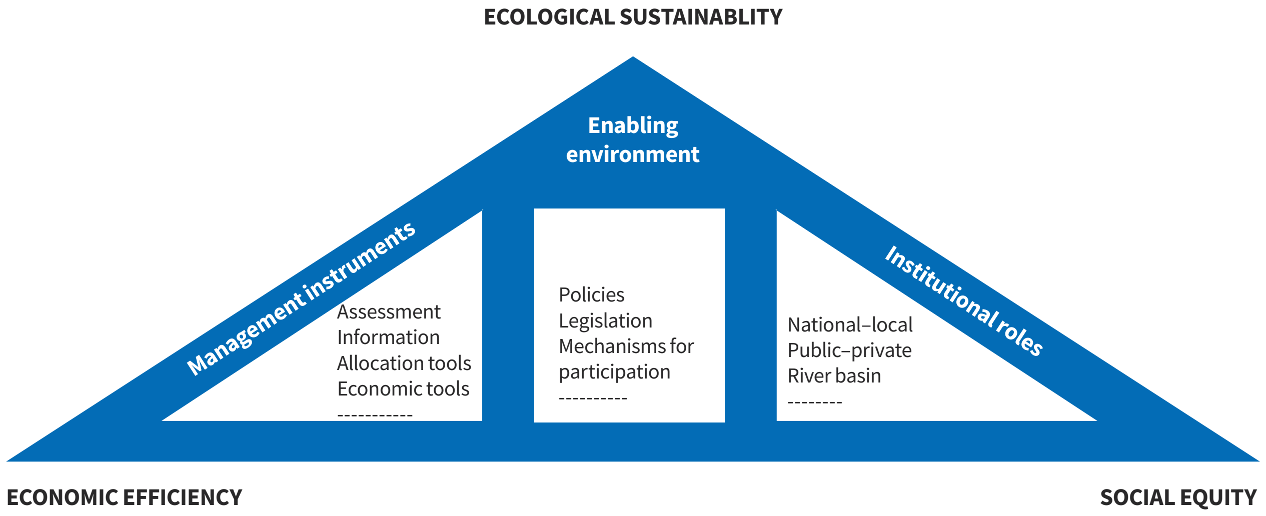
THE GLOBAL WATER PARTNERSHIP (GWP) FRAMEWORK FOR IWRM (2000)

In 2000, the Global Water Partnership (GWP) described the key elements to be considered in order to achieve properly IWRM, including integration of elements in the natural system (e.g. land and water; different types of water; upstream and downstream interests) and in the human system (e.g. cross-sectoral; economic decisions; integration of all stakeholders). They proposed an IWRM framework with three overriding criteria – social, ecological, and economic equity. These are accompanied by a number of complementary elements of an effective water resources management system that must be developed and strengthened concurrently, including the enabling environment, institutional roles and functions, and management instruments (GWP, 2000) (Figure 1). The overriding criteria take account of the social, economic, and natural conditions:

1. **Economic efficiency in water use:** Because of the increasing scarcity of water and financial resources, the finite and vulnerable nature of water as a resource, and the increasing demands upon it, water must be used with maximum possible economic efficiency.
2. **Social justice and equity:** The basic right of all people to have access to water of adequate quantity and quality for the sustenance of human wellbeing must be universally recognized.
3. **Environmental and ecological sustainability:** The present use of the resource should be managed in a way that sustains the vital life-support systems, thereby not compromising the use of the resource by future generations.

Better understanding of river systems and interactive biophysical and socio-economic components is very important for effective planning and Integrated River Basin Management.

FIGURE 1 GENERAL FRAMEWORK FOR IWRM



(Source: modified from GWP, 2000)

WORLD WATER COUNCIL'S WORLD WATER VISION (2000)

In 2000, the World Water Council published its World Water Vision: Making Water Everybody's Business (Cosgrove & Rijsberman, 2000). To ensure the sustainability of water, we must view it holistically, balancing competing demands on it – domestic, agricultural, industrial (including energy), and environmental. Sustainable management of water resources requires systematic, integrated decision-making that recognizes the interdependence of three areas. First, decisions on land use also affect water, and decisions on water also affect the environment and land use. Second, decisions on our economic and social future, currently sectoral and fragmented, affect hydrology and the ecosystems in which we live. Third, decisions at the international, national, and local levels are interrelated.

GANGES-BRAHMAPUTRA-MEGHNA REGIONAL WATER VISION 2025 PRESENTED AT THE WORLD WATER FORUM IN 2000

A water vision for the Ganges-Brahmaputra-Meghna basin with a focus on regional cooperation was prepared by a team from think tanks in Bangladesh, India, and Nepal and presented at the World Water Forum in 2000 (Ahmad, Biswas, Rangachari, & Sainju, 2001). The overriding goal in the formulation of a water vision for the Ganges-Brahmaputra-Meghna region was sustainable human development for peace, stability, and an enhanced quality of life to be achieved through water-based regional cooperation, i.e., a regime of regional cooperation into which the entry point is water but which then expands and embraces all possible directions as it gathers momentum. Clearly, the approach is holistic and multidisciplinary and it calls for congruence of macro, meso, and micro policies within each country and their coordination across regional countries (Ahmad, et al., 2001).

CLIMATE CHANGE AND IRBM

In recent decades, climate change has started to impact different components of the hydrological cycle. Recent studies suggest that climate change is already affecting the temperature and precipitation patterns in the HKH region (Krishnan et al., 2019) and has had a marked impact on the cryosphere (Bolch et al., 2019) and water resources (Scott et al. 2019). Adapting to climatic changes and integrating and mainstreaming adaptation into IWRM and IRBM is a challenging task that requires innovative governance arrangements (Giupponi & Gain, 2017). Clear guidelines for adapting IWRM (and IRBM) to conditions of uncertainty remain to be developed, and the challenges are compounded by the fact that in mountainous areas, the headwater and downstream areas tend to be affected in different ways. Notwithstanding the challenges, Jiménez Cisneros et al. (2014) suggest that IWRM remains a promising instrument for exploring adaptation to climate change.

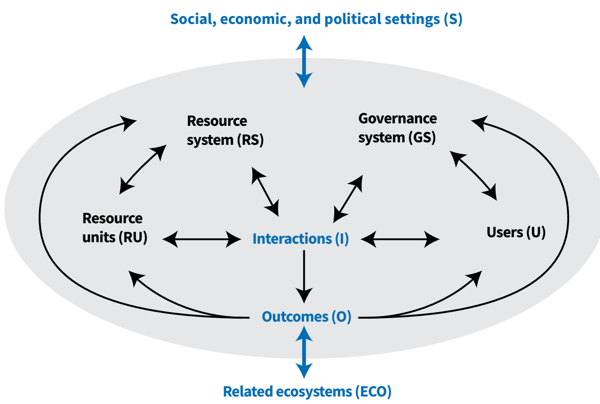
1.3.2. Approaches to IRBM: Applied frameworks

There are a number of frameworks using a multi-disciplinary approach which are relevant to IRBM, especially the SES framework (Ostrom, 2009), the ecological-socioeconomic-political domains framework (Iida, 2018), and the Driver-Pressure-State-Impact-Response (DPSIR) framework (Kristensen, 2004), which are described below. The frameworks are useful for addressing issues of regional cooperation in a river basin, such as DRR, and have been used in an analysis of the Koshi river basin (Iida, 2018; Vaidya, Shrestha, Nepal, & Shrestha, 2019).

SOCIAL-ECOLOGICAL SYSTEMS (SES) FRAMEWORK

The SES framework is a comprehensive conceptual framework for diagnosing interactions and outcomes in SES. The framework provides a list of variables that may be interacting and affecting outcomes. Figure 2 shows the major components of the framework. Resource system refers to the biophysical system, e.g., glaciers, lakes, aquifers, wetlands, and rivers; resource units refer to the units extracted from a resource system, which can then be consumed or used as an input for production, e.g., irrigation water from lakes and rivers, drinking water from springs, electricity from hydropower plants; users refer to the consumers of these resource units; and governance system refers to the processes or institutions through which the rules shaping the behaviour of the users are set.

FIGURE 2 THE CORE SUBSYSTEMS IN A FRAMEWORK FOR ANALYSING SES



(Source: Ostrom, 2009)

BOX 1

THE CASE OF NEPAL'S KOSHI RIVER BASIN MANAGEMENT (KRBM) STRATEGIC PLAN

A set of plans and analytical frameworks were developed for the Koshi river basin in Nepal based on IWRM and IRBM principles. They serve as an example of IRBM plans in the HKH region.

The decade-long discussions among international water experts, multilateral donor organizations, and policymakers at international water and environment meetings helped to inform Nepal's water resources management related policy. The river basin planning framework was highlighted in the Water Resources Strategy of Nepal (WECS, 2002) and National Water Plan (2005) and provisions were made for integrated development at the river basin level in the perspective National Water Plan 2002–2027 (WECS, 2005). These provided the basis for the Koshi River Basin Management Strategic Plan 2011–2021 published in 2011 (WECS, 2011) which uses IWRM/ IRBM principles.

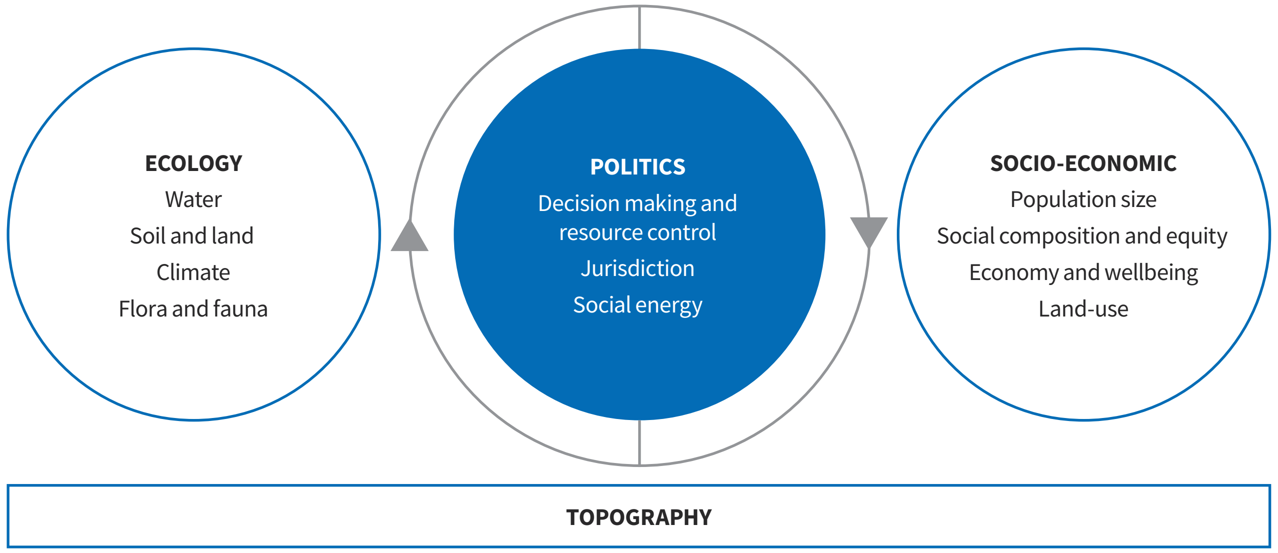
The vision, goal, and objectives of the KRBM Strategic Plan are as follow.

Vision: The country's largest river basin in the Eastern Himalayan landscape of the world's highest ecosystem with tremendous water resources is safeguarded and the ecosystem's integrity is maintained while livelihoods are improved and people's rights over water and related resources are also ensured. (KRBM is IWRM at the Koshi river basin level.)

Goal: The goal of KRBM is to improve the living conditions of the people significantly in a sustainable manner in the Koshi river basin.

Objectives: 1. Economic efficiency; 2. Social equity; 3. Environmental sustainability; 4. Climate change adaptation; and 5. Policy design and institutional development, all for effective IRBM.

FIGURE 3 CONCEPTUAL MODEL OF THE THREE DOMAINS AND LINKAGES AMONG THEM



(Source: Iida, 2018)

Applying this analytical framework to the transboundary Koshi river basin, its resources, their uses, and the interactions with the governance system and users enabled a better understanding of different aspects of river basin management (Vaidya, Shrestha, Nepal, Shrestha, (2019)), which will be useful when developing the detailed KRBM plan.

ECOLOGICAL-SOCIOECONOMIC-POLITICAL (ESP) DOMAINS FRAMEWORK

Transboundary river basin management is geopolitical and requires that the countries involved come together to develop a shared vision and objectives. The ESP domains framework was developed as a tool for analysing the links and interactions between the ecological, socioeconomic, and political situations across a river basin as a basis for developing a shared approach. Figure 3 shows the major components of the framework. It has three domains: the ecological domain, comprising five factors – topography, water, climate, soil and land, flora and fauna; the socioeconomic domain, comprising four factors – population size, social composition and equity, economy and wellbeing, and land use; and the political domain, comprising two factors – factors that can affect decision-making in the political field, and jurisdictions and their boundaries across the river system.

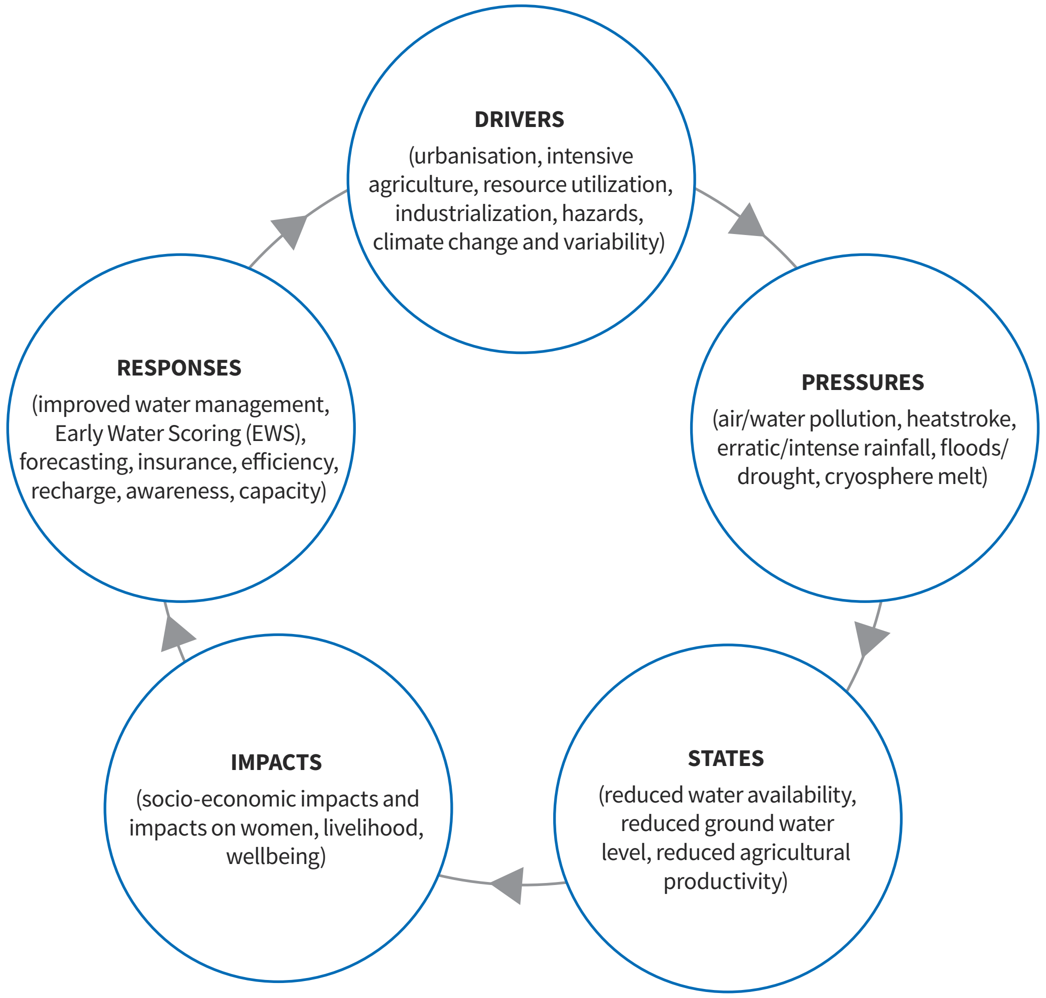
Potential conflicting interests in transboundary water situations can be overcome through mutual trust and understanding, appropriate legal and institutional frameworks, joint approaches to planning and management, and sharing of the ecological and socio-economic benefits, and related costs (UNESCO, 2009)

DRIVER-PRESSURE-STATE-IMPACT-RESPONSE (DPSIR) FRAMEWORK

The DPSIR framework offers a useful approach for assessing and managing different environmental problems. The framework enables detailed assessment of driving forces, pressure, and state of the environment, the impact of the drivers, and the response undertaken (Kristensen, 2004). The details of the framework change according to the problem being addressed. Figure 4 shows the framework in the context of IRBM with examples of the different factors to be considered.

> The ESP domains framework can be used to analyse the interactions between the ecological, socioeconomic, and political situations across a river basin to develop a shared approach.

FIGURE 4 DRIVER-PRESSURE-STATE-IMPACT-RESPONSE (DPSIR) FRAMEWORK FOR A RIVER BASIN



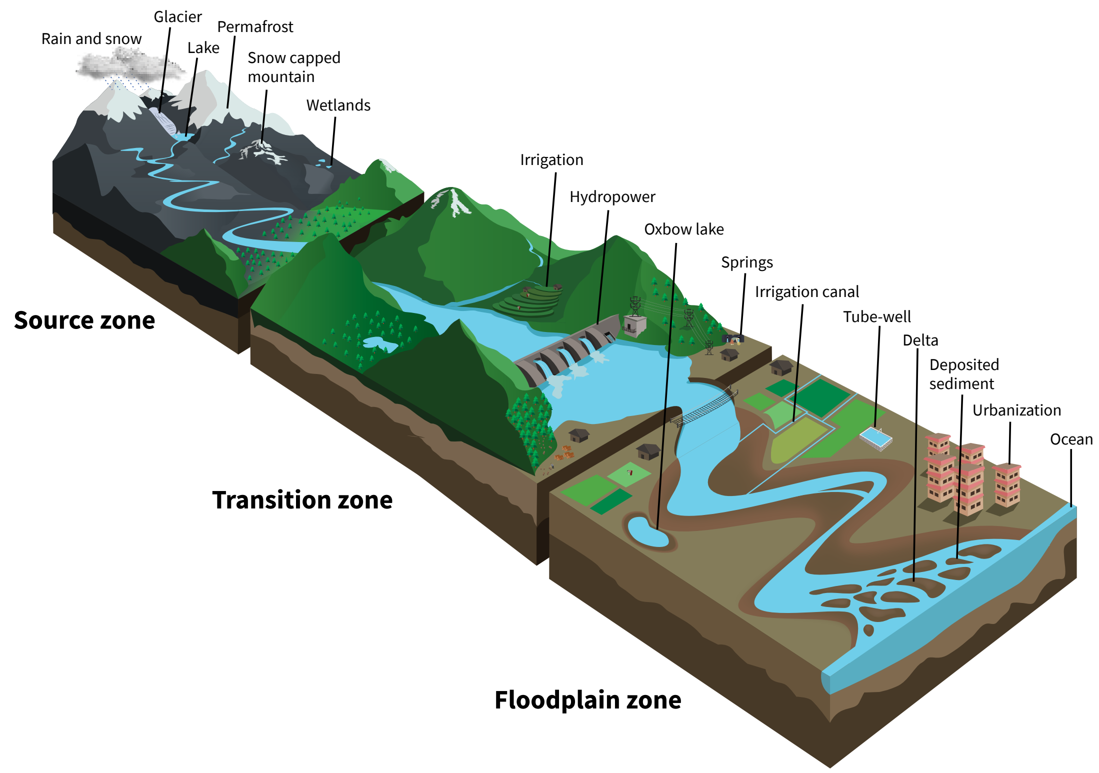
1.3.3. Selected aspects in IRBM

UPSTREAM-DOWNSTREAM LINKAGES

Nepal et al. (2014, 2018) provide a detailed description of the upstream-downstream linkages in a river basin and the way in which these determine the approach to integrated management. The main points are summarized in the following.

A river basin has three major zones – headwater, transition, and floodplain – as shown in Figure 5. The activities and processes in upstream areas can affect downstream water availability, sedimentation, and river morphology. Different processes dominate in each zone. The source zone is the uppermost part of the river basin, characterized in the Himalayan region by steep slopes and high mountains, and dominated by cryospheric components such as snow, glaciers, and permafrost. The main driving factor for environmental change in this zone is global warming, which is affecting snowfall patterns, glacier dynamics, and melt runoff. Meltwater runoff and sediment generated in the glaciated headwaters drain into streams that sustain many rivers in the Himalayan region. Glacial lake outburst floods (GLOFs) are a regular phenomenon in this region which can affect immediate downstream areas. In the transition zone, the river begins to respond to the material received from upstream areas, which can alter the shape and direction of its channels. This zone is dominated by vegetation and farming, but many other anthropogenic activities here rely on land and water resources. Water management in this zone is a critical challenge. Water-related infrastructure such as irrigation canals can reshape water availability in both space and time. The interaction between surface water and groundwater plays a vital role and groundwater storage contributes to flows from springs on the hill slopes. Springs are very common in this zone and are widely used by

FIGURE 5 CONCEPTUAL MODEL OF THE THREE DOMAINS AND LINKAGES AMONG THEM



(Source: Nepal et al., 2018)

middle mountain communities. The floodplain zone consists of extensive floodplains and wide, deep channels. Eroded materials from upstream areas are deposited on the plains because of the low gradient. The river starts meandering in this zone. Flooding and deposition of sediment are the primary driving factors that cause river channels to shift continuously. There is generally a variety of causes and effects in all zones (FISRWG, 1998); the zone concept presented here focuses on the most dominant processes in each.

The River Continuum Concept (Vannote et al., 1980) highlights the continuous linked patterns of ecosystem structure and function along the length of a natural, unperturbed river from upstream to floodplain areas. As the river flows from its source through the middle reaches to the lower end, the indicator organisms change, showing a continuous gradient. This continuum of biotic adjustments and consistent patterns of loading, transport, utilization, and storage of organic matter along the length of a river are a clear representation of the upstream-downstream linkages.

MULTISCALE IRBM

In practice, a river basin is composed of many sub-basins in which issues vary, and it is important to clarify how these sub-units are connected within the larger river basin. This not only applies to issues and related impacts, but also to exploring adaptation options. For example, communities have implemented different measures at a local level to tackle erosion, and the results of these can affect other parts of the basin at both local and basin scale. Thus it is important to gain a good understanding of issues, impacts, and responses across the different scales of a river basin. In transboundary river basins the complexities are increased as the regulations, guidelines, and enabling environment are different across the borders. Activities in upstream nations can affect downstream countries in both beneficial (e.g. higher water availability with good watershed management) and adverse (e.g. intense floods with poor watershed management) ways. IRBM provides a framework for transboundary cooperation in which nations can maximise benefits and minimize impacts.

Multiscale IRBM highlights the importance of the different geographical scales across a river basin and the linkages between them, both top-to-bottom and bottom-to-top. River basin management approaches can be focused at local, watershed/catchment, or river basin (transboundary) levels, corresponding to micro, meso, and macro scales. Since the magnitude and nature of problems differ at different points along the scale, it is useful to consider scale questions within IRBM. Although it may suit individual purposes to focus on one point along the scale, it can also be useful to consider multiscale IRBM, which can link good practices identified at a micro scale to a larger scale, especially in terms of benefit and risk sharing related to water resources management decisions.

IRBM may need to be viewed at a scale that extends beyond the basin boundaries, especially when water is transferred, or its services used, beyond the basin in question as in inter-basin transfers for hydropower generation or agricultural or urban usage. This often happens in the context of spatial variability in water availability between basins. For example, the draft Nepal Water Resources Policy 2016 recognizes the reality of such spatial variability. It suggests that infrastructure development for inter-basin transfer of water may be necessary to resolve such a problem and states that, in case of such an inter-basin transfer all the concerned basins will be considered as well. In effect, the decision-making processes may extend beyond the basin boundaries.

GENDER AND SOCIAL INCLUSION

Many parts of the world are experiencing water scarcity and this is expected to worsen with climate change. Water scarcity can affect agricultural productivity, industrial productivity, and ecosystem functioning, and, as a result, every person. However, the effects will not be the same for all people; they will vary from place to place, and within the same setting the impacts will be different for different groups – women and men, socially disadvantaged and advantaged, old and young, and so on. The different impacts are related to how water is managed – who manages, who controls, and who accesses it. Thus water resource management is highly affected by gender and social dynamics.

Today 'gender' is often explicitly mentioned in water policies in the context of domestic water development. However, women's role in the development and use of water resources as irrigators, fishers, and farmers is much less well recognized. In many water projects, women are only included superficially with brief mentions in water management descriptions, or given power in name only, in some cases even represented by men. Similarly, marginalized social groups are often excluded, with no consideration given to the local cultural and social context or cultural social relations.

It is important to include gender and social dimensions in water management, as measures that fail to take these aspects into account risk failure. Including social and gender dimensions will help to address the differentials that limit the access of women, men, and marginalized people to vital water resources, and bring about more equitable access and control over them. It will also ensure that the contributions of both women and men are recognized, and maximize social and economic benefit, and equitable benefits, from sustainable water management.

SUSTAINABLE DEVELOPMENT GOALS AND IWRM

Water security is key to achieving the Sustainable Development Goals (SDGs). All 17 SDGs are either directly or indirectly related to water resources. Eight SDGs require an increased supply of safe, secure, and reliable water. Six SDGs address social justice and equity, and their attainment will reduce injustice and inequity in access to forests and water. The remaining three SDGs build and maintain an ecological infrastructure that supports the other 14 SDGs by adapting to climate change and securing the integrity of terrestrial and aquatic ecosystems (IUFRO, 2018). At a river basin level, it is very important that all the aspects highlighted in the SDGs are tackled in an integrated way.

ANALYSING CLIMATE CHANGE IMPACT AND RESPONDING TO CHANGE

The DPSIR framework (see section 1.3.2 above) can be used to help analyse climate change impact to support IRBM. Climate change and variability are taken as key drivers of change. The resultant pressures include such things as heat waves, erratic rainfall, intense rainfall, drought, and increased cryosphere melt, which can lead to different states in, for example, the availability and timing of water resources, water quality/quantity, occurrence of water-induced disasters, and reduced groundwater reserves. Many of the potential pressures and impacts in the HKH region have been documented. Climate change is likely to create pressures on the hydrological regime of the major river basins by altering the timing and amount of flow in rivers and creating variation in water availability (Nepal & Shrestha, 2015). Higher than average warming in the high mountains (Kraaijenbrink et al., 2017; Xu et al., 2009) is causing rapid deglaciation in the region (Shrestha & Aryal, 2011), which is also altering water availability. Signs of climate change in the region include increase in temperature, alteration in the frequency and intensity of precipitation, glacier retreat, and creation and expansion of glacial lakes leading to GLOFs, floods, avalanches, and an increase in extreme events (Bajracharya & Mool, 2009). Warming will initially increase annual river flows due to increased glacier and snow melt, but reduce flows in the long run as a result of the decreased volume of snow and glaciers. Lutz et al. (2014) analysed future water availability in the major basins of Asia and projected an increase in annual runoff in the upper Indus basin by 7–12% in 2041–2050 compared to 1998–2007, mainly due to increased melt and an increase in precipitation; Immerzeel et al. (2010) projected a decrease in mean upstream water supply by 20% for the later period (2046-2065) in the Brahmaputra river basin. Too much water from warming-induced melt, extreme precipitation events, and precipitation as rain in place of snow are likely to lead to an increase in floods and landslides threatening infrastructure (hydropower, irrigation, drinking water) as well as lives and livelihoods, while too little water will have a significant impact on agriculture. Flash floods from GLOFs pose a particular risk, 24 GLOF events have been identified in or affecting Nepal (ICIMOD, 2011), while an increase in both magnitude and frequency of extreme events towards the end of the 21st century has been projected among others in the Hunza basin, resulting in both higher floods and increased dry conditions (Lutz et al., 2016; Wijngaard et al., 2017).

All the different changed states could have socio-economic impacts and present challenges, which can have differentiated impacts on women, children, and marginalized groups, ultimately impacting the wellbeing of all people.

Even though climate change impacts are unavoidable, their impact can be minimized through proper response, informed planning and management, and implementation of appropriate interventions at the local, national, and regional levels under an IRBM framework. A number of such responses are described in Module 8. For example, the community-based flood early warning system (CBFEWS) installed along two tributaries of the Koshi river – the Ratu Khola and Gagan Khola – show how communities can benefit from early warning, and the importance of cross border early warning to help them respond to floods (Section 8.2.3, and Annex 4 Information Sheet 10). Similarly, the Water Use Master Plan (WUMP) for local government, initiated by ICIMOD and developed in partnership with HELVETAS, can help in providing effective, efficient, and equitable water management at the local scale (Section 8.2.3, and Annex 4 Information Sheet 12). The WUMP was developed for the Koshi Basin with the aim of scaling out at river catchment and ultimately district levels. Another example is the solar powered irrigation pump (SPIP) for securing water for agriculture in the Terai districts of Nepal, which is considered to be a clean, climate resilient, and pro-poor solution (Section 8.2.3, and Annex 4 Information Sheet 11). At a larger scale, basin-scale water planning and flood information systems can help reduce the impacts of climate change (Section 8.2.2, and Annex 4 Information Sheet 4). More examples of responses, particularly at local level, are given in Module 6.

1.3.4. Challenges in IRBM implementation

Molle et al. (2008) have discussed the many challenges involved in implementing IRBM. The main points are summarized in the following.

The challenges in moving towards IRBM in a particular river basin depend on its scale (transboundary, national, local); the stage of basin development; the main water management challenges to be addressed; and the existing social, economic, political, and institutional environment. There are no universally applicable solutions, but it is possible to learn from experiences in river basins around the world. Several key lessons stand out:

- Some important challenges that institutional arrangements should address include coordinating decision-making between administrative levels and across scales, establishing water allocation mechanisms, reducing water pollution, and dealing with floods and droughts.
- Because different basins face different challenges and often involve different institutional environments, rolling out blanket country-wide reforms without adaptation to local specificities or directly copying institutional models from other countries as blueprints is seldom effective. What works for one basin may not work for its neighbour.
- Establishing institutional arrangements is a 'learning by doing' process – there must be enough flexibility to make adjustments and to adapt to changing conditions.
- Not all water-related problems can or should be solved at the river basin level. Some problems are best addressed at the sub-basin or local level. Others have solutions beyond the basin itself and even outside the water sector, for example in national or federal agricultural policies.

Water management is informed by a whole host of formal and informal institutions; attempting to impose a new more coherent structure for achieving IRBM – particularly a centralized structure – on this multiplicity can create conflicts with existing line agencies and loss of democratic and accountability mechanisms. It may be better to identify conditions under which existing organizations and institutions can play an effective role in addressing basin challenges, understand what can be done to strengthen them or adjust their mandates, and ensure effective coordination and negotiation mechanisms between them. Responsibilities among various organizations at different levels (national, basin, local) must be defined clearly to avoid overlaps and increase effectiveness.

Many water problems demand more local-level solutions – for example, soil and water conservation. These are often best managed at the sub-basin or local scale, but because these activities affect the flow of water, sediment, and nutrients through the basin, there need to be links between local-level decision-making and decision-making at the basin scale.

The challenge then is to define institutional arrangements that can coordinate between actors and decision-makers operating at different scales – local, basin, national, transboundary. However, the very diversity of physical and socio-political settings precludes defining universal guidelines for addressing this challenge.

In coordination-based, collaborative approaches to basin governance – common in Australia, the European Union, and the Western USA, but also emerging in countries such as Brazil, Morocco, Mexico, and South Africa – user and community organizations, government organizations, and stakeholder initiatives develop coordination and negotiation mechanisms at the basin or sub-basin level. This can mean a coordinating organization, for example, Mexico's Basin Councils, or it can be a mix of legislation, stakeholder platforms, and institutional linkages.

A coordination-based approach to governance can have several advantages:

- Legitimacy – if it recognizes existing institutions with good stakeholder representation and buy-in
- Participation – if it gives water users space, capacity, and power to participate in water management decisions that affect them

- Flexibility – because coordination-based arrangements involve diverse organizations and in general less rigid institutional structures, they are better able to adapt to changing needs and circumstances

Collaborative, multilevel governance can help to reconcile stakeholder values and objectives by ensuring that information becomes available to all stakeholders and that conflicting actions are flagged in advance and duly debated. However, this requires suitable processes, rules, and other institutions. It also works best when there is a culture of democratic debate and not too severe imbalances of power.

When creating new rules, roles, and rights, it is crucial to recognize that stakeholders have different levels of access to resources, knowledge, political representation, and institutions; otherwise, the institutional outcome can privilege the elite. Of course, if the goal is equity, just focusing on improving participation and coordination is rarely enough; there is a need to redistribute resources, entitlements, and opportunities – tasks that must involve the state. Overall, the following challenges arise in the implementation of IRBM:

- It may become more difficult to achieve as the size of the basin increases, and decision-making can be cumbersome and coordination costs high.
- Existing organizations must have legitimacy, relevant capacities, and adequate resources.
- Political changes in participating jurisdictions can upset agreements.
- Stakeholder participation in basin management is not straightforward, and including the poor and achieving substantive stakeholder representation have proven elusive in practice.
- In countries with strong, centralized government control, collaborative arrangements for IRBM may not be feasible.

Module 4 provides a more detailed description of governance, policy, and institutional frameworks.

1.3.5. Examples of IWRM implementation

UN-Water (2008) prepared a status report on IWRM and water efficiency plans for the Commission on Sustainable Development 16 (CDS16). The report highlights that at this time in the developed world, 16 of 27 countries (59%) either had fully implemented national IWRM plans (6 countries) or had plans in place or partially implemented. In the developing world, 20 of 53 countries (38%) had plans completed or under implementation. The impacts were also presented. For example, in China, after implementation of the IWRM approach in management of the Liao river basin at provincial level, upstream-downstream conflicts were reduced, deforestation halted, water quality in the river improved, and ecosystems along several stretches restored. Similarly, in Colombia, after the IWRM approach was implemented for conservation of the La Cocha Lagoon at a local level, threats to the lagoon and surrounding wetlands were reduced. The Lake Defense Committee formed under IWRM worked with the Ministry of Environment to have the area designated as a Ramsar site.

Table 1 shows some other examples of IWRM and IRBM implementation in different countries. It is important to remember, however, that IRBM is an ongoing and dynamic process, and a system that is initially successful may be less effective if it faces challenges in responding to a changing situation. For example, climate change is introducing new dynamics with a strong potential to affect water availability in space and time in any river basin (Lutz et al., 2014; Nepal, 2016). It is now imperative that IWRM (and thus IRBM) addresses climate change issues and responses the changing situation. In the field of water resources, one of the challenges for adaptation is how to integrate and mainstream it into the IWRM (and thus IRBM) concept (Giupponi & Gain, 2017).

IMPLEMENTATION OF IRBM IN NEPAL: CHALLENGES AND OPPORTUNITIES

In the 1980s, the Government of Nepal, in cooperation with the Japan International Cooperation Agency (JICA), prepared master plans for water resources development in Nepal based on a river basin approach. The Water Resources Strategy 2002 and National Water Plan 2005, which were prepared to guide water resources development and management in the country, adopted the integrated river basin approach as one of the policy principles for the management of water resources. Accordingly, sectoral policies like the Irrigation Policy 2003 and 2012 also adopted the integrated basin approach in the planning and development of irrigation and multipurpose projects.

A Water Resources Policy has now been drafted which has as its objective obtaining the maximum social, environmental, and economic benefit from the available water resources at the basin level by adopting the principle of IWRM. The policy emphasizes preparation of a basin plan for each river basin, and a sectoral master plan based on the basin plans, that would be prepared and executed by three levels of the government, as per the roles and responsibilities that will be defined in the legislation.

An Integrated River Basin Development and Management Plan for the Bagmati River Basin was prepared in 2018. It is a comprehensive development and management plan for the period up to 2035 and

TABLE 1 EXAMPLES OF IWRM AND IRBM IMPLEMENTATION

Country	Scale/river basin	Issue	IRBM significance	Improvement/Impact
Columbia	Local level: conserving the La Cocha Lagoon	Forest exploitation, soil erosion, loss of fertility, faster runoff, greatly reduced biodiversity	Partnerships established between the Network of Private Nature Reserves, Peasants' Development Association, and various community organizations	Improved economic status, improvement in meeting forest and food requirements
China	Provincial level: Liao River Basin Management	Severe water pollution	IWRM project comprising the institutional framework of Liaoning Cleaner Water Project Office, Liao River Basin Coordination Commission, EU-Liaoning Water Resource Planning Project Office	Reduction of pollution loads by 60%, improved river water quality, reduced upstream-downstream conflict, deforestation practices halted
USA	State level: NY City water supply	Deteriorating water quality, ecological degradation	Program launched in partnership between NY City; NY State; Environmental Protection Agency; watershed counties, towns, and villages; environmental and public interest groups	Implementation of best management practices within the watershed is reducing pollution loads
Morocco	National level: Management of scarce water resources and pilots on pollution control	Lack of access to potable drinking water	Improvement of institutions and policies for water resources management following IWRM principles	Procedures for allocation of water established together, Soussa–Massa River Basin Agency established and operating according to IWRM principles
Sri Lanka	National level: IWRM and water efficiency plan	Frequent water related disasters (floods, droughts, and others) associated with climatic change and inadequate water resources	Assessment of water resources, preparation of National Water Development Report, implementation of a disaster management plan and institutional setup	Menik Ganga Project, Weli Oya Diversion Project, and several others planned and implemented
Fergana Valley (Kyrgyzstan, Tajikistan, Uzbekistan)	International level: Improving water accessibility through IWRM	High soil salinization, widespread waterborne diseases, irrigation infrastructure inadequate, water use inefficient	Improved management of water resources based on IWRM principles emphasizing higher efficiency and more equity; demonstration of bottom-up approaches and increases in yields and water productivity	Partnership between all water management actors; ecological sanitation toilets constructed; water committees created and operating and maintaining water systems efficiently; improved irrigation practices and innovative solutions expanded
Pungwe River Project (Mozambique, Zimbabwe)	Transboundary level	Saline water intrusion, sedimentation	Sectoral studies of the water resources, scenario development, and formulation of a joint IWRM water strategy	Joint programme commenced between the Governments of Mozambique and Zimbabwe strengthening the capacity of key basin IWRM institutions

Source: UN, 2008

incorporates, among other things, water resources development in the upper and lower reaches, river environment improvement in the upper reaches, and water-induced disaster prevention in the lower reaches. The various components of the plans will be implemented by the related agencies of the government; however, coordination will be carried out by a river basin organization which is to be established.

In addition, WECS is preparing comprehensive basin plans for the other river basins in Nepal. The hydropower master plans will be prepared by WECS, simultaneously. In coordination with WECS, a sectoral master plan for irrigation is also under preparation. Thus, many important activities are ongoing for the implementation of IWRM in the country. However, there are challenges and opportunities in the implementation.

CHALLENGES

- Developing and executing a basin plan based on IWRM principles
- Defining the roles and responsibilities of the three levels of government in the development and management of water resources, as political boundaries differ from basin / sub-basin boundaries
- Constructing infrastructure considering the fragile geology, climate change, variation in water availability in time and space, and difficult topography

OPPORTUNITIES

- Plentiful water resources to meet the present and future demands of the country
- Opportunities to establish the right institutions and formulate policies related to water resources development and management, as these institutions are being established under the new Constitution and three-tier structure of federal government
- Opportunities to use the latest technology to construct environmentally friendly projects
- Possibility for bi/multilateral cooperation in the development of water resources, as the rivers of Nepal have an international dimension
- Good hydropower, irrigation, and navigation potential that can be exploited for economic benefit

IWRM IN AFGHANISTAN: PROCESS AND STRUCTURE

The Government of Afghanistan has adopted the IWRM approach for IRBM. The concept of IWRM emerged during the development of the new water law and water sector strategy in 2011. It encourages decentralization and attaches high priority to the participation of stakeholders in water resource management. The vision and goal of the water-sector strategy is to facilitate management of the nation's water resources efficiently (Shroder & Ahmadzai, 2016).

There are many challenges for water resources management in Afghanistan. According to Lashkaripour and Hussaini (2008), groundwater is being overexploited resulting in a fall in aquifer levels; similarly, irrigation schemes are less reliable than in the past. Heavily dependent on seasonal rain and snowfall, Afghanistan's water resources have become unstable. Glacial retreat and early snowmelt are having severe effects on seasonal water availability (King & Sturtewagen, 2010). In the context of the different water issues and associated challenges, IWRM is seen as an integrated approach for maximizing benefits and for risk reduction, disaster preparedness, and dealing with future climate change scenarios from watershed to river basin level (Shroder & Ahmadzai, 2016).

The planning process for water projects in Afghanistan involves 1) IWRM, 2) river basin management, and 3) participation by multiple stakeholders. IWRM is the preferred approach for dealing with the complex and difficult problems of all the different water management systems in Afghanistan (Shroder & Ahmadzai, 2016). The water management systems are designed to account for different types of water: the 'blue' water of precipitation and river flow; the 'green' water of evapotranspiration through plants; and the 'grey' water or wastewater from agricultural, industrial, and domestic use.

Amarkhail and Kakar (2011) noted that governance of the water sector in Afghanistan is complex and needs to focus on the four pillars of human and social development, economics, political dimensions, and environmental activities so that usages are equitable, efficient, equally democratic, and sustainable. CPHD (2011) proposed a complex organizational structure to implement the IRBM approach in Afghanistan (originally presented in the Panj-Amu River Basin Project (PARBP) Inception Report in 2010). Figure 6 shows the organogram of the river basin agency and highlights the

coordinated effort required by various agencies for water resource management.

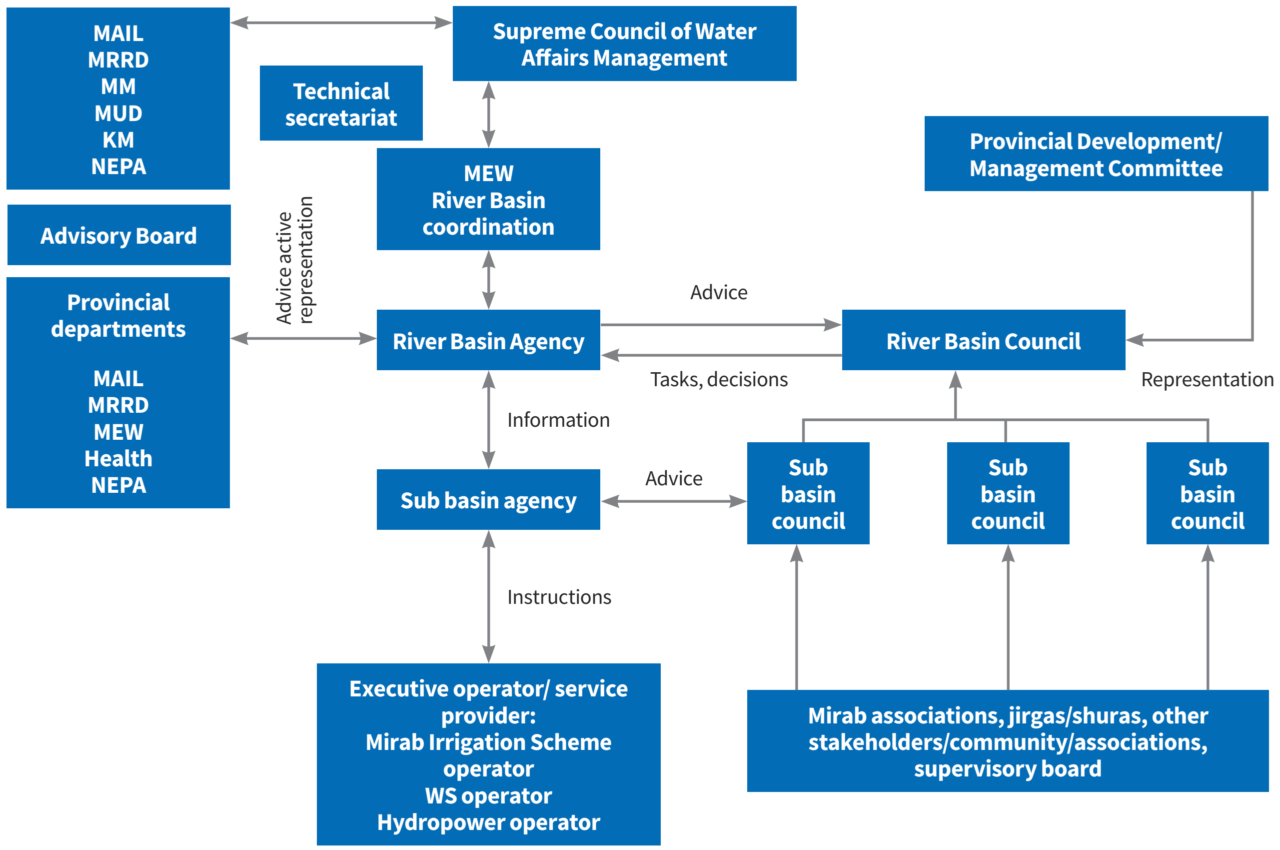
GENDER ISSUES

The access of the rural population to water from an improved source has been rising steadily, from close to 26% in 2001 to around 47% in 2015 (WHO/UNICEF, 2017). Nevertheless, 53% of the rural population still lack access to water and likely also to equitable participation in water management (Verne, 2017). Further, although Afghanistan's 2009 Water Law grants equitable rights to water to all, in practice not everybody enjoys the right to water equally. In many of Afghanistan's 32,000 rural villages, access to water is difficult, arduous, and time-consuming. Patriarchy is deeply-rooted in Afghan culture and the division of labour in the conservative, rural areas is rigid, hindering the equal participation of Afghan women in water management. Patriarchal attitudes and structures remain strong and affect gender relations in a way that can be detrimental to women's needs. Despite the Constitution granting equal rights to men and women, the situation in practice is very different: Women encounter many difficulties in the form of male prejudice, legal discrimination, and violence, which keep them from exercising their rights on equal terms with men.

PREPARATORY STUDIES FOR IRBM – CONCEPTUALIZING THE DPSIR FRAMEWORK FOR AFGHANISTAN

Participants In the course for Afghanistan professionals used a group exercise to explore how the DPSIR framework could be applied to the river basins in Afghanistan. The results provide an example of some ideas that could be used as a starting point in real world applications.

FIGURE 6 ORGANIZATIONAL STRUCTURE FOR IMPLEMENTATION OF IWRM IN AFGHANISTAN



Source: CPHD, 2011

Note: MAIL: Ministry of Agriculture, Irrigation and Livestock; MEW: Ministry of Energy and Water; MoM: Ministry of Mines; MRRD: Ministry of Rural Rehabilitation and Development; MUD: Ministry of Urban Development; NEPA: National Environmental Protection Agency

Participants were briefed to consider the major drivers of change in the context of a river basin they were familiar with; to include climate change as a (future) driver and the kind of pressures it will create; to discuss the pressures and impacts of the drivers and group these based on different themes/disciplines/sectors; to discuss some possible responses to reduce/mitigate the impacts; and finally to structure the discussions in a DPSIR framework. The results are shown as an example in Table 2. This step-wise approach helps those familiar with a more sectoral viewpoint to recognize the range of drivers of change, the relevance of impacts, and the interconnections with other river basin components, especially in the context of the potential future impact of climate change.

Some of the impacts and responses identified were subsequently observed in the transboundary Koshi river basin as described in Module 8.

TABLE 2 RAPID ASSESSMENT OF DRIVERS OF CHANGE IN RIVER BASINS IN AFGHANISTAN

Major drivers	Impact	Response
Physical		
Climate change	Snow cover, glacier melting, and GLOFs Drought Changing patterns of precipitation Increasing evapotranspiration	Capacity enhancement and public awareness Divert green energy Integrated policy making for fuel System and action Avoid deforestation
Infrastructure	Increasing groundwater usage Water pollution Disease, health Decreasing agricultural productivity Changing flow regime	Changing crop patterns Changing irrigation methods Water conservation in upper catchment
Population	Increasing water demand Increase in diseases Decrease in green area Water stress	Public awareness and efficient use of water Recycling and reuse of water Change of construction from horizontal to vertical Development of water supply Environmental protection system Biodiversity conservation
Socio-economic		
Agriculture	Irrigation infrastructure damage Water pollution Soil erosion	
Disaster (floods, landslides)	Sediment transport Migration Poverty	
Hydropower	Spiritual impact	
Other	Water pollution Air pollution	

1.4. Frequently asked questions

WHAT IS THE DIFFERENCE BETWEEN IWRM AND IRBM?

IRBM adapts IWRM principles to a river system or a lake basin context at different scales. Both of these management frameworks involve taking an integrated approach, looking not only at the water within the system, but also at the management, sustainable use, and environmental impacts of water and land resources for livelihoods, as well as DRR and the management of water-related hazards. But IWRM is essentially an approach which can be applied to a particular location, whereas IRBM looks at a whole basin including the full range of scales from local to basin level.

WHY IS MULTISCALE IRBM IMPORTANT IN THE HIMALAYAN RIVER BASINS?

River basin management approaches can be focused at local level (micro scale), watershed or catchment level (meso scale), or river basin and large river basin (macro scale) and also transboundary levels. IRBM can be implemented at a particular point/space along the scale or by integrating multiple scales. Although it may suit individual purposes to focus at only one point along the scale, it is useful to consider multiscale IRBM, which can link good practices identified at a micro scale to a larger scale, especially in terms of benefit and risk sharing related to water resources management decisions. This type of integration of multiple scales is very important in the Himalayan river basins due to the heterogeneity within the basins and interlinkages between upstream and downstream areas. Such integration supports regional collaboration and building of regional knowledge platforms to collate and share information promoting sustainable water resource management. Since the magnitude and nature of problems differ at different points along the scale, it is useful to consider scale questions when considering IRBM.

MODULE 1 | KEY TAKEAWAYS

Conceptual understanding of river basin drivers and their implications for Integrated River Basin Management

SECTION 1.1
INTRODUCTION

IWRM provides a framework in which water resource use is prioritized for cross-sectoral integration – for people, food, nature, industry, and other uses.

SECTION 1.2
LEARNING OBJECTIVES

The module laid out three specific objectives, with one being clarifying the need for IWRM and IRBM to address challenges in the Himalayan river basins.

SECTION 1.3
CONCEPTS AND PROCESSES OF IRBM

The IWRM approach is guided by many principles, and there are a number of multi-perspective frameworks that can be used to apply them.

SECTION 1.4
FREQUENTLY ASKED QUESTIONS

Learn about why multiscale IRBM is suited for the heterogeneous nature of basins and upstream-downstream interlinkages in the Himalayan region.

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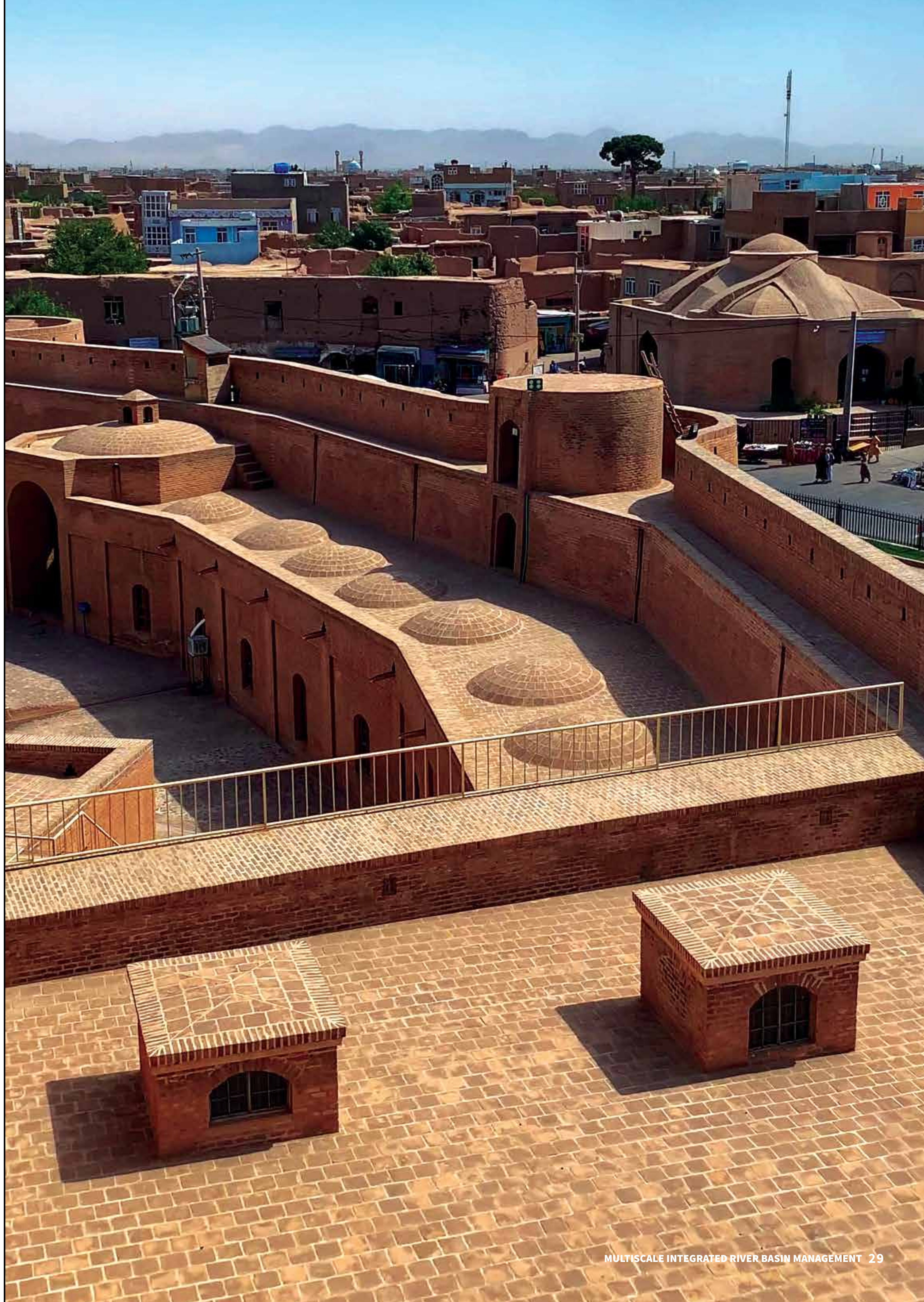

MODULE 2

Tools and approaches for understanding biophysical changes

Understanding and analysing the biophysical processes in river basins can aid effective planning and management.

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KEY MESSAGES

Understanding biophysical changes in the river basins is key to planning and implementing management options, and is an important aspect of the third pillar of IRBM – management instruments.

Recent developments in our understanding of biophysical processes, data availability – both ground and remote sensing based – and increased computational capacity have provided opportunities to implement complex analytical tools.

The selection of appropriate tools and models is a critical step and should be based on the question to be answered, human capacity, and resource availability, including data, time, financial resources, and computational facilities. Complex models and tools are not necessarily the most appropriate.

2.1. Introduction and relevance

IRBM relies on good governance mechanisms and legislation to plan, implement, monitor, and control actions. Strong databases and analytical tools help in each of these components. Understanding biophysical changes in the river basins is key to planning and implementing management options. Understanding of the socio-economic changes taking place is also crucial for developing management instruments (Figure 1 in Module 1). These are mentioned briefly in (Module 3). This module focuses on understanding and analysing the biophysical processes taking place within the geographic entities of concern (basin, sub-basin, or catchment). Gender and inclusion are not explicitly addressed in this module (they are discussed in Module 3), but it is important to recognize that gender and social equality in terms of participation in learning and implementation of the tools on the ground will be essential for achieving effective results.

The biophysical system contains many different components such as water, land, and other natural resources. The processes related to these components are dynamic, therefore we not only require information on the current status but also an understanding of how they are changing currently and how they might change in the future. The drivers of such changes could be natural (e.g. climate) or human induced (e.g. infrastructure, migration, land use change). In practice these drivers play together in a complex combination and thus the impacts are also complex. Understanding these interactions and impacts requires detailed analysis, quantification of changes, and scenario analysis. (See also Module 1, Section 1.3.8 for a discussion about using the DPSIR framework in the IRBM context.)

Ecosystems are an integral part of a river basin, and ecosystems and water have a strong interaction. Ecosystem change can have a marked impact on water availability and water quality (Laender et al., 2007). Equally, changes in water use and management can have a marked impact on the ecosystem. Changes in water resources are not gradual and consistent, they are marked by extremes such as floods and droughts. The IRBM approach should be able to take into account tools to analyse such extremes and devise mechanisms to forecast such events. Basin scale water budgeting and allocation models, which integrate or take inputs from process models, can provide an understanding of potential tradeoffs and synergies in water resources development in the basin.

Advances in the application of geographic information systems (GIS), the development of Google Earth Engine, availability of high resolution remote sensing data, and availability of other models mean that complex environmental analyses are now possible, with detailed analysis of status, quantification of changes, and analysis of scenarios. This module provides an overview of the types of analytical tools that can be used for assessing the biophysical drivers of change in a river basin and highlights a few in detail.

IRBM tools in practice – By their nature, the tools used in IRBM tend to be desk based and not directly apparent when travelling through a basin landscape. But some of the instruments that provide data, and the need for particular tools are often clear. As an example, Module 8, Section 8.2.1 (and Annex 4 Information Sheet 3) illustrates some impacts of flash flood events and the potential for preparing models to create a risk map that can be used in decision making and to support preparedness. Module 8, section 8.2.2 also highlights the importance of regional flood information as an input to models used in the management of risks from riverine floods and presents an automatic real time water level station that provides data for the system (see Annex 4 Information Sheet 4 for more details).

2.2. Learning objectives

IRBM depends heavily on understanding the drivers of change in a river basin and the impact they may have on the biophysical systems. Today, advances in our theoretical understanding of these processes, techniques such as GIS and remote sensing, availability of an array or reanalysis data, and cloud computing allow us to employ different analytical tools with a vast range of complexity to help understand these processes and current and future impacts. The module aims at

- Enhanced understanding of a range of analytical tools that can support IRBM
- Familiarization with a few selected tools

TABLE 1 SELECTION OF ANALYTICAL TOOLS USED TO STUDY DIFFERENT ASPECTS OF BIOPHYSICAL CHANGE

Issue	Approach	Tools/datasets
Climate change	Climate modelling and downscaling	General circulation models (GCMs); regional climate models; Statistical DownScaling Model (SDSM)
Water availability	Hydrological modelling	J2000; Soil and Water Assessment Tool; snow runoff models; HBV (Hydrologiska Byråns Vattenbalansavdelning) model; Spatial Processes in HYdrology (SPHY)
Drought	Modelling and analysis	Standardized Precipitation Index; Standardized Runoff Index; Soil Moisture Deficit Index; Normalized Difference Vegetation Index; Vegetation Condition Index
Flood	Hydrodynamic modelling	Global Flood Awareness System (GLoFAS), Mike-11, Integrated Flood Analysis System (IFAS), Hydrologic Engineering Center's River Analysis System (HEC-RASa), DELFT-FEWS
Ecosystem	Modelling, remote sensing, surveying	Ecomodeller, Ecopath models Global remote sensing products (e.g. GlobCover for land use)
Groundwater	Surveying, modelling, remote sensing	MODFLOW, hydrogeological mapping, hydrochemical analysis
Erosion and sedimentation	Soil erosion assessment modelling	Revised Universal Soil Loss Equation, Modified Universal Soil Loss Equation, Soil and Water Assessment Tool

2.3. Tools and approaches for assessing biophysical change

2.3.1. Assessment tools to support IRBM

Each analytical tool has its own strengths and weaknesses. Highly physically based tools provide detailed understanding but are demanding in terms of data and analytical resources and hence may not be suitable for large spatial coverage. The selection of tools depends on data availability, available computational resources, human capacity, and, most importantly, the key issues to be addressed.

Table 1 lists some of the analytical tools used to study various aspects of biophysical change. The table shows a selection of the more common or important tools; it is beyond the scope of this manual to describe all the tools available. For IRBM, the tools used to understand current and future water availability are particularly critical.

The selection and use of tools in assessments related to different issues is described briefly in the following sections, and is followed by a summary section that looks at the overall opportunities and constraints to using analytical tools and some of the factors and limitations that should be taken into consideration in interpreting and applying the information that they provide.

2.3.2. Information management for IRBM

IRBM requires the use of a range of scientific analytical tools (e.g. hydrological models and spatial models) to generate information useful for river basin management. These tools make use of different kinds of data (e.g. hydro-meteorological, climate, land cover, ecosystem, socio-economic.) depending on their nature, and generate results at appropriate spatial and temporal scales. IRBM thus involves administering a huge amount of data and data storage and it is essential to have a good data management mechanism for proper storage and use.

IRBM will also require a data management plan which describes and lists the data that will be produced or collated and how they will be managed and shared by all those concerned in the IRBM activities. A participatory needs assessment can lead to a better database management plan and a participatory data collection approach can result in better data quality. Further, a good database needs to be designed and developed to store all the data related to both the natural environment and human systems that is relevant to IRBM. The information system connected to the database is another key component of IRBM. It should offer an intuitive and user friendly interface and allow users to view data and information in different formats (e.g., charts, interactive maps, infographics). It may also offer decision support tools on various topics of river basin management, generating scenarios that are useful to managers in their decision making process.

As an example, ICIMOD has a regional database system (RDS) that acts as a central repository for all the data produced by the different initiatives at ICIMOD and provides access through a web-based RDS portal. ICIMOD has a data policy which is aligned with the philosophy of free and open access to scientific information and knowledge. All the data produced by ICIMOD are available to the public through the RDS portal. Within this, ICIMOD has developed a number of web-based applications which can provide a useful reference for developing an information system for IRBM. The Koshi basin information system (KBIS) provides a good example of a river basin information system which could be instrumental in implementing IRBM (http://geoapps.icimod.org/KBIS/). Figure 7 shows the interface. The KBIS provides a platform for

FIGURE 7 INFORMATION SYSTEM FOR THE TRANSBOUNDARY KOSHI RIVER

FIGURE 8 HKH CLIMATE AND HYDROLOGY VISUALIZATION AND ACCESS PORTAL

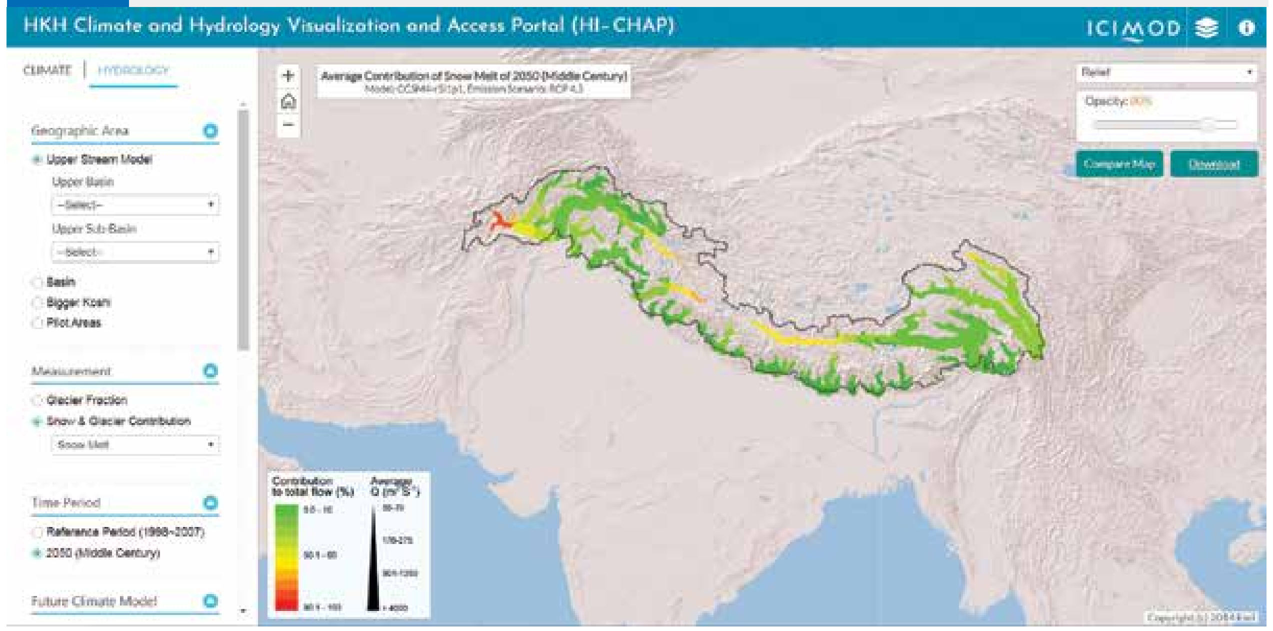


FIGURE 9 ICIMOD'S RESOURCES ACCOUNTING TOOL

collecting various types of data from all available sources, structuring the collected information, and storing the data in the regional database system. The system facilitates both data and information sharing and data visualization to promote interdisciplinary collaboration and communication among the stakeholders and general users concerned with the Koshi river basin.

Likewise, the HKH Climate and Hydrology Visualization and Access Portal (HI-CHAP) (http://geoapps.icimod.org/climate) shown in Figure 8 provides one stop access to climate change and water availability information for the various river basins of the HKH region derived from climate and hydrological models. The climate section contains data from two sources: data for five basins from the Himalayan Climate Change Adaptation Programme (HICAP) and data for the IGB basin from Himalayan Adaptation, Water, and Resilience (Hi-Aware). Annual and monthly maps are available for average temperature and precipitation and change between 1981–2010 and two future periods: 2035-2065 and 2071-2100. The hydrology section shows the results from the Hi-SPHY model on glacier fraction and snow and glacier contribution to total flow for the upper catchments of five river basins for RCP4.5 and RCP8.5 from the reference period 1998–2007 and the future period 2050s. Data can be downloaded for the time period and area of interest.

The advent of cloud computing platforms such as Google Earth Engine (GEE) has enabled quick and efficient environmental data analysis on a planetary-scale. ICIMOD's Resources Accounting Tool (http://geoapps.icimod.org/resourceinfo) shown in Figure 9 demonstrates the power of GEE for carrying out on-the-fly geospatial analyses and providing information about a number of biophysical and socio-economic parameters for a user-defined area. IRBM can use the GEE platform to develop online application modules where appropriate.

2.3.3. Role of hydro meteorological monitoring in IRBM

Hydro-meteorological monitoring stations are important for DRR and essential for planning, operation, and management of water resources. Hydro meteorological networks are generally established for a specific purpose. Spatial and temporal data are gathered for a range of variables such as precipitation, runoff, temperature, evaporation, water level, and sedimentation. Data on runoff, water levels, and precipitation support estimation of water availability in a basin using the tools listed in Table 1 . Hydro-meteorological data are also critical for monitoring and control of hydro-meteorological hazards (landslides, floods, droughts). The timescale of data is vital. Different purposes have different data requirements, with different timescales required for different applications. The data needs for early warning systems and peak flood estimation, DRR planning, infrastructure design, agricultural planning, water allocation, impacts of land use land cover (LULC) change, and so on are all very different.

Different applications require data with different levels of confidence and timescale. The network density also needs to be sufficient to reflect the variation in actual physio-climatic conditions (WMO, 2008), different network densities might be needed in mountains and plains areas, for example. The effectiveness of the tools applied in assessing biophysical change will depend on the data quality. Short-term (emergency) flood forecasting, for example, is largely dependent on the quality and availability of near real-time hydro-meteorological observations, whereas long-term flood forecasting for DRR planning depends on the availability of long-term data sets without gaps and with sufficiently dense coverage of the most relevant areas (e.g. high mountains).

2.3.4. Analysis of current and future water availability

Information on current and likely future water availability is important for proper river basin planning and management of water resources. This information is crucial for drought management, flood control, irrigation, and hydropower planning, among others. Water availability in a river basin is influenced by different basin characteristics such as physiography, climate, geology, and scale of the basin. In addition, land use and climate change are impacting water resources, and these changes need to be quantified.

Hydrological models help us to understand the relationships, make estimations, and project the hydrological variables under a range of climate and land use scenarios (Pandey et al., 2013). Hydrological models are a simple conceptualization of a watershed in which important hydrological processes are replicated through mathematical equations based on theoretical and field-based understanding. Different types of model (e.g. physical based-conceptual models and black-box models) have been developed based on the physical processes used to simulate hydrological behaviour and catchment distribution (distributed, sub-basin, or lumped). A model can provide very useful information about the hydrological characteristics of the basin. During the modelling process, the model is adjusted by tuning the calibration parameters in such a way that the model results are closer to the reality (measured values). For example, soil-moisture related parameters can be tuned to change the representation of infiltration, surface runoff, and sub-surface runoff in a model.

The modelling values obtained after tuning are checked against the measured data from the catchment such as observed streamflow and snow cover to validate the robustness of the model. If the model satisfactorily represents the different parts of the hydrograph (which can be checked against statistical evaluation), the model can be considered good for the catchment. The important information that hydrological models can provide includes, for example,

- the contribution of different runoff components (such as surface runoff and dry season flow) to streamflow,
- snow and glacier melt contribution,
- water balance components, and
- understanding of processes which affect the inter-annual and intra-annual variability in water availability.

Building on this, hydrological models play an important role in developing 'what-if' scenarios and the effect of different possible changes on water resources, which can be instrumental for water resources planning and management. Types of scenario include

- impact of land use and land cover change,
- change in water supply and demand,
- water resources development, and
- climate change.

Several models are in place globally that can be used to compare current and future water demand under different conditions. There are three prerequisites for applying a hydrological model:

1. Availability of data and information for the particular basin to address the research questions
2. Understanding of the typical dominant processes in the basin (e.g. glacier melt)
3. Computational facilities to run the model

EXAMPLE: THE J2000 HYDROLOGICAL MODEL

The J2000 hydrological model provides a good example of a model that is suitable for applications in the Himalayan region. It has been used by a number of authors to investigate changes in different areas (Nepal et al., 2013; Nepal, 2015). The J2000 is a process-oriented distributed hydrological model for hydrological simulations of catchments at different scales. It is implemented in the Jena

Adaptable Modelling system (JAMS), which is a software framework for component-based development and application of environmental models (Kralisch & Krause, 2006; Kralisch et. al., 2007). The simulation of different hydrological processes is carried out in encapsulated process modules which are to a great extent independent of each other. This allows changing, substituting, or adding single modules or processes without having to restructure the model from the start. The model is also able to replicate glacier melt processes.

Training in IRBM should include hands on training in the use of at least one hydrological model to understand water balance. The J2000 can be set up for a relevant river basin for training purposes (Box 1).

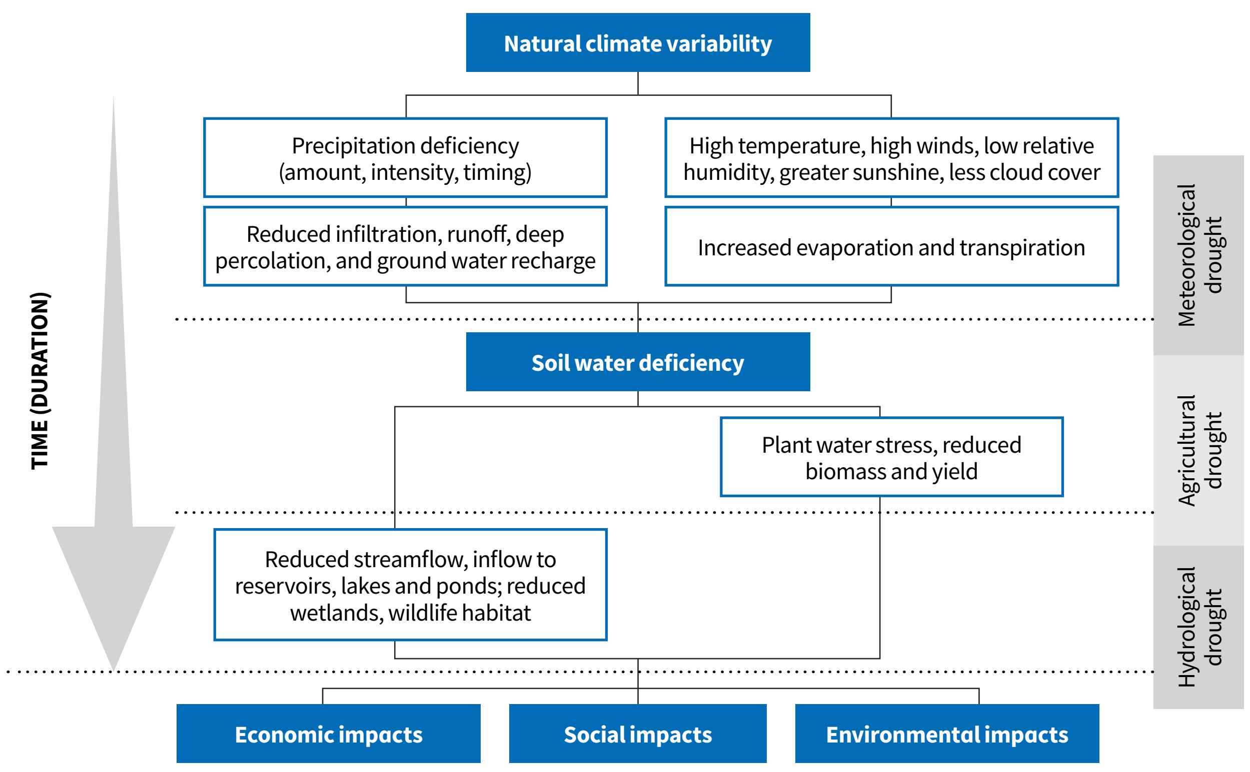
SOME LIMITATIONS OF HYDROLOGICAL MODELS

Hydrological models are forced using downscaled climate change scenarios to derive future water availability scenarios, which in turn provide important information for planning water resources management and infrastructure. There are various ways to downscale coarse GCM based scenarios to finer scales (e.g. Lutz et al., 2016; Themeßl et al., 2011a; Themeßl et al., 2011b). However, the large uncertainty in downscaling translates into large uncertainty in the water availability scenarios. The uncertainties associated with model projections should be clearly understood and incorporated in the planning process.

2.3.5. Drought monitoring and forecasting

In general, there are three common types of drought (NOAA, 2012): (1) meteorological drought – a deficiency in precipitation as compared to average conditions over an extended period of time; (2) agricultural drought – a reduction in soil moisture availability below the optimal level required by a crop at each growth stage, resulting in impaired growth and reduced yields; and (3) hydrological drought – when precipitation deficiencies begin to reduce the availability of surface and subsurface water resources, with either a substantial deficit in surface runoff below normal conditions, or a depletion of ground water recharge. The reduced precipitation and water availability can have an impact on human social and economic activities as well as the environment. This can result in 'socio-economic drought', when the weather-related deficit in water supply leads to the demand for an economic good exceeding the supply. Figure 10 shows the relationship between meteorological, agricultural, and hydrological drought and the impacts on society and the environment.

FIGURE 10 **DROUGHT TYPES AND ASSOCIATED SOCIO-ECONOMIC AND ENVIRONMENTAL IMPACTS**



(Source: Bunn and Arthington 2002).

Drought monitoring is mainly accomplished using drought indices. Drought indices are quantitative measures that characterize drought levels by assimilating data from one or several variables (indicators) such as precipitation and evapotranspiration into a single numerical value (Zargar et al., 2011). Drought indices are useful tools for providing information for decision-makers in business and government and to the public stakeholders. A drought index can be used to quantify (1) the moisture condition of a region, and thereby detect the onset and severity of drought events, and (2) the spatial extent of a drought event, allowing for comparison of moisture supply. Several drought indices have been derived in recent decades. Commonly, a drought index is a prime variable for assessing the effect of a drought and defining different drought parameters, which include intensity, duration, severity, and spatial extent (Mishra & Singh, 2010).

Monitoring drought is important for national agricultural and environmental planning (Box 2). Decision makers need timely and accurate information on the possible occurrence of drought so that they can prepare for it. The need for improved drought monitoring techniques is highlighted by widespread and severe droughts that have resulted in serious economic, social, and environmental impacts in many countries. The methods used to monitor drought can be categorized into two main classes: the traditional meteorological, agricultural, and hydrological based indices such as the standardized precipitation index, standardized runoff index, and Soil Moisture Deficit Index; and remote sensing-based indices, in particular satellite-based indices, such as the normalized difference vegetation index and Vegetation Condition Index.

Over the past two decades, a large amount of climate information has been made available by the scientific community, much of it derived from satellite remote sensing technologies, but this information is still little used for local level decision making. A drought advisory service that provides locally calibrated, easily accessible, decision-relevant, and user-oriented information can help communities to cope with drought-related vulnerabilities. Recent advances in seasonal prediction science and seasonal climate forecasting tools, together with improvements in the predictability of ENSO (El Niño-Southern Oscillation) impacts on regional climate patterns in South Asia, have the potential to provide reliable early warning to support farmers in climate related decision making.

BOX 1

EXAMPLE OF TRAINING IN THE USE OF A HYDROLOGICAL MODEL

For the training in Afghanistan, the J2000 model was set up for the Panjshir river basin under the SWaRMA initiative (http://www.icimod.org/SWaRMA). The model was validated using observed discharge data and MODIS-based remote-sensed snow cover data. Participants were allowed to run the model and see how it simulates discharge and snow cover. The model was set up with non-optimized calibration parameters. The modelling results were compared to the observed data and the calibration parameters adjusted to improve the modelling results. Participants then observed the changes that would resulted following a "what if" scenario with a 2 or 4°C increase in average temperature, and compared the results with the baseline values.

BOX 2

THE IMPORTANCE OF DROUGHT MONITORING – AFGHANISTAN EXAMPLE

There are roughly 3.9 million ha of cultivated land in Afghanistan of which about 1.3 million ha are rain-fed. Although the irrigated area produces more than 85% of all agricultural products in the country, the contribution from rain-fed areas is of significant importance in meeting the food and fibre requirements of the population living in these areas (NEPA, 2013). Afghanistan has a history of repeated droughts and will continue to experience them under future climate change scenarios. Future scenarios project reduced precipitation and increased evapotranspiration resulting in overall water scarcity (UNDP, 2012a). Decreased water availability will substantially limit growth in the agriculture sector. As a result, food security issues may be pronounced leading to malnutrition, high dependence on food aid, and reduced dietary diversity and consumption. Thus there is a strong need to develop an integrated framework of action for the management of drought in Afghanistan. Along with the use of modern agricultural technologies and improvements in socio-economic wellbeing, special attention will need to be paid to developing a monitoring and early warning system to support water management decision making and adaptation strategies.

2.3.6. Flow-ecology

River flow regimes are regarded to be the primary drivers of riverine and floodplain wetland ecosystems (Junk et al. 1989, Bunn and Arthington 2002, Poff and Zimmerman 2010). The flow regime is a major determinant of both biotic and abiotic components of a river system. Alteration of the natural flow regime can have serious consequences for the ecological sustainability of rivers and their associated floodplain wetlands (Bunn and Arthington, 2002, Poff and Zimmerman, 2010). Bunn and Arthington (2002) suggested four key principles that underpin the consequences of changing flow regimes. These principles are described below and illustrated in Figure 11.

Principle 1 states that flow is a major determinant of physical habitats in streams, and thus influences the biotic composition within the stream. Modified flow regimes can influence the distribution and abundance of a species at varying spatial scales because of an alteration in the physical habitats.

Principle 2 states that aquatic species have evolved life-history traits specific to the flow regimes they are subjected to. The adaptations can be manifested in high fecundity rates in boom-and-bust river systems, or specific cues by flows or water temperatures to initiate spawning. Modified flow regimes can influence a species' ability to complete its life cycle.

Principle 3 states that lateral and longitudinal connectivity is essential to the persistence of many aquatic species. Water development often entails impoundment infrastructure (e.g. dams, weirs), which can act as a barrier to movement within a stream or entirely divert flow to river reaches. Barriers to movement can have detrimental impacts on the range and distribution of species and can affect migratory species that require access to different reaches during their life cycle.

Principle 4 states that the invasion and success of exotic and introduced species in rivers is facilitated by the alteration of flow regimes. Introduced species can alter water-quality parameters, channel contours, and species assemblages.

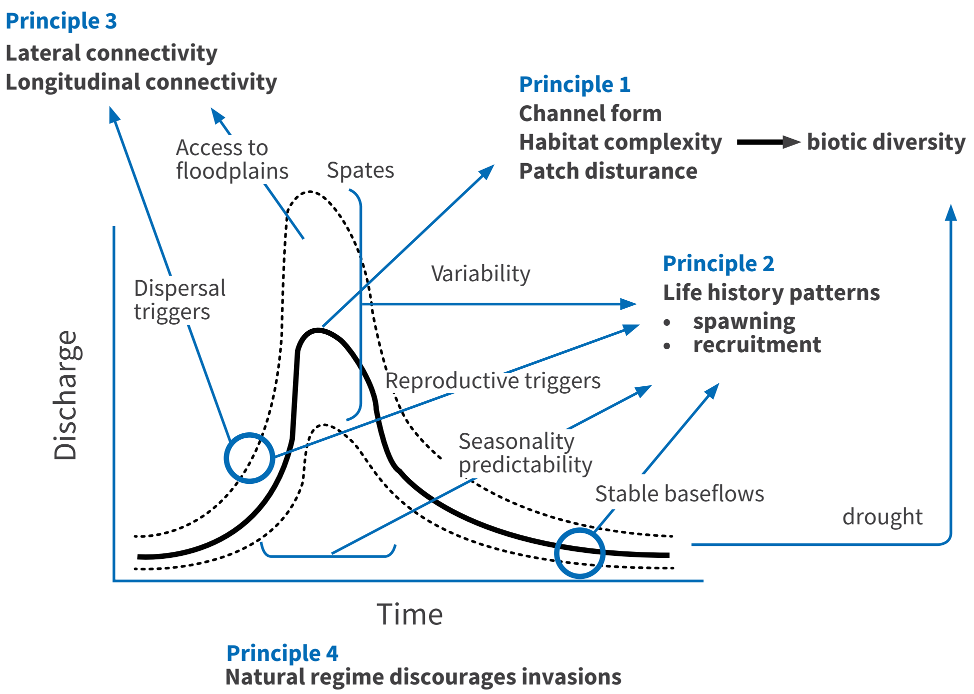
Several factors can change the natural flow regime. The key drivers of change include new and existing water infrastructure, land use change, and climate change, as described below.

New and existing water infrastructure: Water resource development often entails the construction of dams and reservoirs as a widespread way to control and facilitate irrigation for agriculture, control floods, support power generation, and provide reliable water sources (Poff et al., 2007). Infrastructure can reduce the extent of reaches or divert water entirely. Changing the flood extent of reaches can reduce both the lateral and longitudinal connectivity of a river system and coincides with Principle 3 above. Infrastructure also alters the natural flow regime of a system, which can disrupt cues for species to reproduce and migrate, coinciding with Principle 2.

Land use change – runoff: A change in land use in areas surrounding a river system can affect the natural flow regime. This can manifest in an increased demand for and use of water resources through irrigation, bores, and pumping. Land use change can also alter water quality parameters or entail the clearing of land for agricultural development. Clearing vegetation can increase the rate of runoff and sedimentation into a river system, which can affect aquatic species by reducing both the quality and quantity of available habitat. Disturbance associated with land use change and physical infrastructure can also promote the establishment of exotic species by disrupting environmental conditions (Poff et al., 2007).

Climate change: Climate change can have several effects on both the natural flow regime and freshwater biota. Climate change can affect aquatic systems by altering water temperatures and streamflow patterns and increasing the frequency and intensity of storms (Poff & Zimmerman, 2010). The changes associated with climate change are also likely to affect the distribution and timing of life cycle events of species and the productivity of aquatic systems (Parmesan, 2006).

FIGURE 11 **THE FOUR KEY PRINCIPLES THAT UNDERPIN THE ECOLOGICAL CONSEQUENCES OF CHANGING FLOW REGIMES**



(Source: Bunn and Arthington 2002).

2.3.7. Incorporating the environment into IRBM

The primary value of biodiversity lies in the tangible goods and services that it provides through functioning ecosystems. The most obvious are the direct uses of components of biodiversity such as traditional crops, fruits, forage, fuel and timber, fish, and animals (hunting). Less obvious are the indirect ecosystem services such as soil fertility, erosion control, crop pollination, and climatic stability (NEPA, 2014). Rural people cannot make a living from the land without the basic goods and services provided by biodiversity – poverty and emigration are their only options. Thus sustainable environmental management is critical for maintaining society (Box 3). This includes ensuring that the environment is taken into account as a user of equal importance in water resources management.

BOX 3

THE NEED TO INCORPORATE THE ENVIRONMENT INTO IRBM – EXAMPLE AFGHANISTAN

Afghanistan shares many of the challenges found across the Himalayan region and provides a good example of the need to integrate the environment into IRBM. The country has long been perceived as a barren and low biodiversity landscape, water scarce and devoid of any wildlife worth conserving. However, whilst decades of conflict have left environmental scars on the landscape, Afghanistan actually continues to be a uniquely biodiverse landscape. It lies at the centre of three biogeographic realms: the Palearctic, Indomalayan, and Afrotropic (Smallwood et al. 2011), each of which contributes to the unique ecology and assemblage of species, including snow leopard, Marco Polo sheep, grey wolf, brown bear, markhor, and a number of water birds.

As elsewhere in the HKH, biodiversity plays an important role in the livelihoods of many Afghans – 80% of the population depend directly on natural resources for their livelihoods. However, many agricultural practices have not advanced and remain unsustainable: grasslands are over-grazed, woody vegetation is overharvested, and unregulated water use and logging continues to threaten woodlands and aquatic systems (Smallwood et al., 2011). The main current threats to Afghanistan's biodiversity are conversion of land for agriculture and housing, illegal hunting, deforestation, overgrazing, shrub collection, dryland farming, water diversion, and climate change (NEPA 2014). These threats have become more serious over the last three decades and need to be considered during development planning.

Water, the environment, and the livelihoods that these sustain are inextricably linked. Afghanistan needs to manage its biodiversity well in order to develop into a vibrant and economically secure nation. This means integrating the needs of the environment and biodiversity into planning, and especially into IRBM. Without proper sustainable management of both aquatic and terrestrial systems, poverty is likely to continue and increase under scenarios of a growing population and climate change.

METHODS FOR INCORPORATING THE ENVIRONMENT INTO IRBM

A key step in basin planning to support sustainable management is identifying key environmental assets (e.g. protected areas, culturally/spiritually significant locations, ecosystems or processes, species), understanding their value in terms of the services they provide to livelihoods and the quality of life, and quantifying their water needs. In IRBM, we are most interested in assets that are directly connected to the river network (e.g. wetlands and floodplains) as these will be directly impacted under water resource development. Any environmental impact assessment associated with resource development will require this information, including consideration of the short and longer-term consequences of changes in the water regime.

There are numerous methods to incorporate the environment into IRBM including

- selecting environmental assets and looking at potential population changes as a result of flow changes;
- identifying critical habitat and species and actively avoiding development in these areas; and
- allocating water for the environment.

HOW MUCH, HOW LITTLE, AND WHAT IF WE DO NOTHING?

The environment needs water to sustain itself, but the needs of the environment are often neglected in the water allocation decision-making process. If too much water is allocated to other sectors, the impacts on ecosystems can be devastating. The agricultural sector is the largest user of water and impacts most heavily on ecosystems' 'water share'. Over extraction of water for agriculture can lead to dried-up rivers, falling groundwater tables, salinized soil, and polluted waterways. If not sufficiently treated, pollution from urban water uses can also damage downstream ecosystems (Leendertse et al., 2008). There are many instances globally where the 'do nothing' approach has resulted in immense social, environmental, and economic impacts.

Especially Afghanistan is a largely arid country and the provision of freshwater is essential. Agricultural production in Afghanistan is limited by the very high dependence on water from melting snow and ice and rainfall (NEPA, 2014). More than 80% of Afghanistan's water resources originate in the Hindu Kush Mountains at elevations above 2,000 metres. The mountains operate as a natural storage facility and source of water through the accumulation of snow during winter, snowmelt and rainfall during spring, and release of frozen water from glaciers in summer, sustaining vital flows in rivers. A similar situation exists in Pakistan in the Indus river basin. In other parts of the HKH, annual water availability is much higher, but similar problems exist with aridity in the long dry season (ICIMOD, 2009).

In all parts of the HKH, maintaining the natural functions of the watersheds is essential for future prosperity. Loss of vegetation, over extraction of water, and the potential impacts of climate change could have severe effects on the water cycle with severe direct impacts on communities living downstream. In addition, enhanced cross-border cooperation is required to ensure that any extraction from or construction on the water systems does not adversely impact local communities in neighbouring countries (NEPA, 2014).

BOX 4

THE NEED TO INCORPORATE THE ENVIRONMENT INTO IRBM – EXAMPLE AFGHANISTAN

A lack of awareness and concern for the environment and rapid development in the Liao River basin in China resulted in water shortages and severe water pollution. Untreated urban wastewater was being discharged into streams and in some cases it infiltrated the aquifers. In addition, deforestation took place in the upper parts of the catchments contributing to sediment and water quality issues (Leendertse et al., 2008). This had numerous adverse impacts: social, environmental, and economic.

Action was taken to establish an institutional framework under which the environment was incorporated into an IRBM framework. The implementation of this IRBM framework led to substantial improvements in the river basin. Pollution loads were reduced by 60% and the quality of river water improved considerably, upstream-downstream conflicts over water were reduced, groundwater pollution was reduced, and deforestation practices were halted. In addition, drinking water within the basin was safeguarded and ecosystems along several river stretches were restored. The project also achieved success in raising public awareness of demand management and pollution risks (Leendertse et al., 2008).

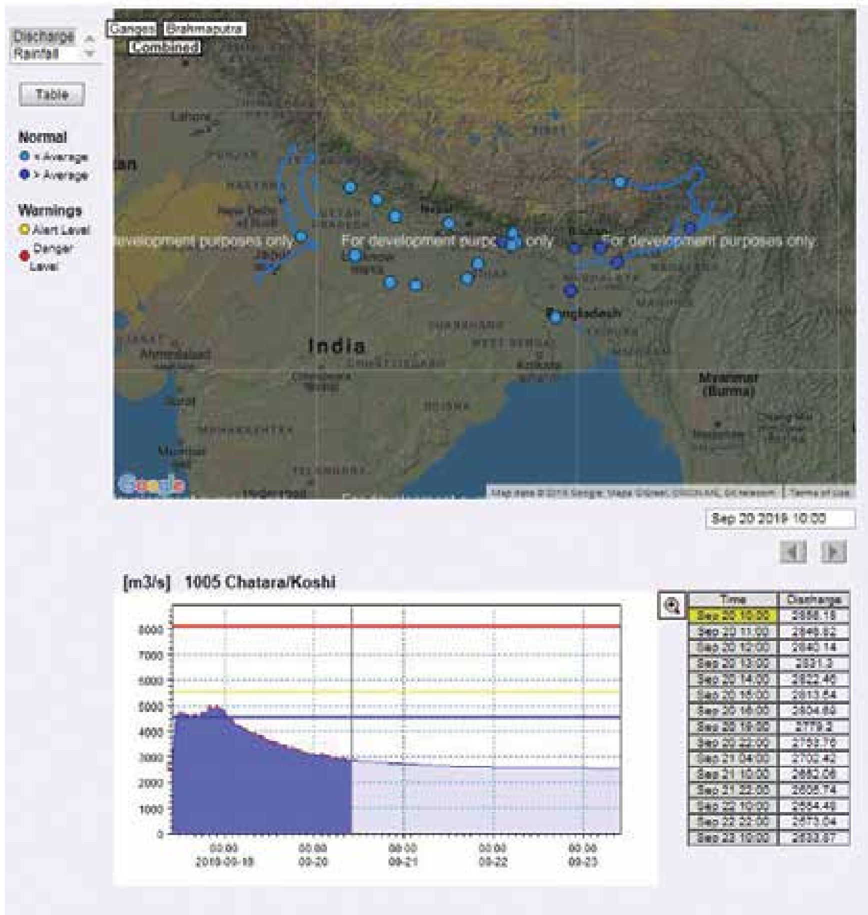
2.3.8. Flood modelling and forecasting

Floods are one of the most frequent and common hydro-meteorological hazards in river basins and not only affect those living in the mountains, they can affect the lives and livelihoods of hundreds of thousands of people residing in the floodplains. Annual flooding affects countries across the HKH region. Afghanistan is a good example. According to the EM-DAT disaster database, 78 flood events occurred in the country between 1978 and 2017, with notable events in 2005, 2006, and 2014, affecting many thousands of people, with 4,554 casualties and an estimated economic loss of about USD 396 million as result of damage to agricultural land and infrastructure. Flood impacts can be even higher in other parts of the HKH; an economic loss of 1 billion USD was estimated in Nepal, for example, over the same period.

Flood management is an important part of IRBM, and IRBM can help provide a holistic approach to addressing the problem. Modelling and forecasting of flood events plays a major role in reducing flood risk (e.g. Shrestha et al., 2015). Flood modelling helps in planning flood risk reduction, while flood forecasting helps in preparing and responding to floods.

There are several hydrodynamic models available that can be used to understand and forecast flood behaviour in a number of flood-prone river basins. The type of flood model selected depends on the particular application based on the processes that produce runoff and their spatial and temporal extent, geometry of river profile, spatial coverage, resolution of available data, and catchment features (Ranit & Durge, 2018). Flood forecasts are either based on the observed river water level with future values extrapolated using river routing models, or observed rainfall yields are coupled into flood models (Alfieri et al., 2013). The increased availability of remote sensing data has strengthened flood detection techniques and helps in producing an overview of affected areas (Alfieri et al., 2013). For example, Global Precipitation Measurement provides a real time precipitation product which can

FIGURE 12 **MIKE-11 PORTRAYAL OF THE KOSHI FLOOD OUTLOOK INTERFACE AT CHATARA, KOSHI RIVER**



be very useful for flood forecasting with increased lead time. Table 1 shows some of the tools available for flood forecasting. One of the most widely used is MIKE 11; this is the model used by ICIMOD and its partners for flood forecasting and flood outlook generation. The Regional Flood Outlook http://www.icimod.org/?q=14181 (Figure 12) is one of the similar platforms of ICIMOD, promoting the timely exchange of flood data and information for the reduction of flood vulnerability within and among the countries.

There is always uncertainty in model results, and identification of these is important as it will influence decision making, particularly the choice of whether and when to issue a flood warning. There will always be some uncertainty in longer term flood forecasting resulting from the uncertainty in precipitation forecasts (Dietrich et al., 2009) and estimation of model parameters. In addition, the sparse meteorological network at high altitudes generally doesn't capture snowfall, leading to underestimation of precipitation, while limited station density across the mountains, with the few stations often limited to valley locations, can lead to inaccurate estimates of catchment rainfall. When communicating flood warnings based on modelling applications it is important to consider uncertainty.

2.3.9. Groundwater

Groundwater is widely used for drinking and irrigation across the HKH region in all except the highest elevations. In Afghanistan, it is the major source of water. Over extraction is an ongoing threat. Groundwater recharge mainly occurs in the rainy season in countries affected by the summer monsoon, or in the spring in countries like Afghanistan that are more dependent on snow and ice melt. Groundwater availability is also strongly affected by groundwater management approaches (see Module 6). For example, destruction by the Mongols of the ancient groundwater management system used in Afghanistan in the early 13th century was arguably the most catastrophic event in Afghan history; while in the present day, excessive pumping for irrigation and cropping is resulting in a shortage of groundwater in many parts of the HKH (ICIMOD 2009).

Groundwater is found at different depths and amounts depending on the location. It is important to have information about the groundwater in a catchment as it plays an important role in the movement of water. However, aquifer depletion and drying of wetlands, with increased land subsidence

and ground cracks, are frequently reported at the basin scale (Zhou and Li, 2011). Thus it is crucial to have knowledge about the aquifer levels across a basin, the interaction with surface water, and likely response under existing and potential future conditions (e.g. infrastructure construction and management interventions). Projection of future behaviour is important for determining sustainable use levels and formulating management strategies. This information will be instrumental for implementing new projects or establishing interventions.

Table 1 shows some of the analytical tools available for groundwater assessment. Groundwater models help us to understand the relationship between natural interactions and human interventions and assess recharge, discharge, and aquifer storage processes (Zhou and Li, 2011). Among others, models of groundwater flow are used to investigate groundwater system dynamics and understand flow patterns; provide simulation tools to estimate potential response to interventions; and to help evaluate groundwater development scenarios. Model selection depends on the objective. For example, the MODFLOW model has a flexible structure with complete coverage of hydrogeological processes and is widely used to simulate and predict groundwater conditions and the interaction with surface water.

It is only possible to use models, however, when the appropriate data are available. This data needs to be obtained (or generated) before IRBM planning can start. In countries like Afghanistan, data may be quite limited geographically. For example, groundwater studies, including depth to water measurements, have been carried out in the Kabul basin since 2001 (Mack et al., 2010), and measurements on water-level and water quality have been conducted at some time in most wells (Broshears et al., 2005). The flow is known to be through saturated alluvium and other basin sediment (Broshears et al., 2005). However, similar studies remain to be made in other parts of the country.

2.3.10. What does a basin plan let you do?

A river basin management plan allows a manager to take decisions towards sustainable resource use, reducing development in over allocated rivers and planning development in under allocated rivers. It also helps you understand the risks associated with a variable, including a changing climate; share water resources between competing users (people, environment, irrigation, towns, industry, and so on); and define water security and rights. This facilitates investment and inter basin transfers and helps maintain a healthy basin and manage conflicts.

There are a number of examples of basin management plans in different countries using different approaches and with different levels of success which provide a good idea of the possibilities. They include, for example, the Murray-Darling basin plan in Australia (Box 5) and the Colorado Compact for the Colorado river in the USA (SERC, 2017). In Europe, the EU Water Framework Directive 2000/60/EC requires all member states to develop IRBM plans (see, for example, UKGOV 2016 for plans for different river basins in the UK). Climate change has highlighted some of the challenges for plans when precipitation becomes less reliable. A revision was agreed very recently to the Colorado Compact, which is now being updated in response to climate change (Schwartz 2019), while the Murray Darling plan still minimizes climate as a management issue (Box 5).

BOX 5

BASIN PLANNING EXPERIENCE FROM AUSTRALIA

Australia provides some comprehensive examples of the development and application of a basin management plan. Here, a basin plan refers to an agreement between stakeholders (individual states) on how to share and manage the water resources of the basin. It is a risk-based plan that considers both surface and groundwater resources and social, environmental, and economic aspects. It is based on an adaptive approach which is evaluated based on changing views and understanding. However, it does not prescribe how to operate the basin infrastructure or manage local/regional water allocation and sharing arrangements.

The Murray-Darling Basin Plan (MDBP) is one of the most comprehensive plans in existence (https://www.mdba.gov.au/basin-plan/plan-murray-darling-basin). The Water Act 2008 Legislative Mandate provides the broad philosophy of how to share and manage water for the benefit of the nation. The Basin Plan must comply with the Water Act. It reflects the particular needs and issues of the basin, provides the broad philosophy of how to share and manage water for the benefit of the basin, and defines the level of use. It also provides guidance on how to manage the basin's water resources. The Murray-Darling Agreement defines the agreed operational rules for the system within the context of the Basin Plan. The Water Allocation Plan reflects the particular needs and issues of each state/region within the basin. It must be consistent with the Basin Plan; it prescribes how the water resource is to be allocated and shared within each region (within the bulk allocation determined in the Basin Plan), provides licence, operational, and allocation rules at the state level, and is negotiated with all relevant water users in the region.

The MDBP is not without challenges. According to the Productivity Commission (2018) report, there is a conflict between the implementation roles of the basin authority and the basin governments. While the 2016 State of the Environment Report outlines some underachievements in ecosystem function and inland water flows in the basin (Jackson et al., 2017). More importantly, it may not be practical to implement a similar type of plan in the HKH context where there is a radically different policy and governance environment.

In general, a successful basin planning process focuses on stakeholder engagement. The first attempt to formulate a basin plan for the Murray-Darling basin in Australia (Box 5) was carried out without adequate stakeholder engagement. It was based on science, but did not take account of the issues relevant to water users and communities and thus failed. The second attempt had extensive stakeholder engagement. Issues were clearly defined and understood before the plan was publicly released, and the plan responded to user concerns. The outcomes were evidence based and accepted by all parties.

Although the destination of the process is a formal 'basin plan', much of the value is achieved by the journey required to get there. Development of a plan should recognize both social and technical processes and allow stakeholders to negotiate the trade-offs required. The planning process itself should be iterative and underpinned by science. The key to success in Australia was innovative leadership to drive the agenda and build trust.

2.3.11. Scenario based planning in IRBM

Traditional IRBM practices rely on learning from the past to extrapolate to the future, and/or for developing a consensus about what the most desirable future might be. Planners and managers look at records of historical climate, water, infrastructure development, and management regimes to predict a set of likely futures and choose actions and projects to reach the most desirable future. The future is thought of as something 'singular' – a target to forecast accurately or an aspirational vision to bring into being.

Increasingly, many planners realize that predictions based on extrapolations from the past or on aspiration may be misleading due to a number of factors that introduce uncertainty. Climate change and the 2008 global financial crisis (and its impact on the global supply chain) are just two examples that illustrated dramatically how our decisions and actions to manage water in basins may not cope with sudden or very drastic changes in the drivers of water availability and use.

Contemporary IRBM is increasingly embracing scenario-based planning that combines a range of facts and stakeholder perceptions on a wide range of disciplines and interests, including economics, politics, and demographics, to draw up a list of priorities, including things that will have the most impact on water availability, demand, and use, and whose outcomes are the most uncertain. These priorities then form the basis for decision making on river basin management. Decision makers in the HKH will need to work to understand the sources of uncertainty related to contemporary drivers of change related to water resources management issues in river basins, to learn to identify and prioritize key planning uncertainties through a structured process, and to acquire the skills for strategic decision making based on basin exploratory scenarios. Support can be found in a recently published guide on Climate Risk Informed Decision Analysis (CRIDA) (UNESCO and ICIWaRM, 2018), which provides stepwise planning guidance for water resources planners, managers, and engineers to implement robust water management. CRIDA is specifically designed to support technical staff, stakeholders, and decision makers in implementing effective decisions under conditions of deep uncertainty.

The scenario planning approach often employs a multi-step process designed to define the range of future uncertainty by generating multiple plausible scenario futures. Each scenario credibly describes a longer-term future-planning environment that reflects a unique combination of uncertain outcomes and conditions. These scenario futures are evaluated both individually and collectively to develop flexible, strategic action plans that are applied in the near and mid-terms.

Even though scenario planning generates longer-term scenario futures to conduct strategic assessments, the main objective is not to plan for the long term – a time that may be several decades away. The primary motivation is much more practical and immediate. Scenario futures are developed to establish a longer-term planning context in order to put in place an implementable, action-based plan in the near and midterms – usually over the next five to 10 years.

Given the forward-looking nature of the process and periodic planning updates, an evolving strategic action plan will continue to be compatible with a diverse set of plausible future planning environments that could emerge over time. A scenario-based strategic action plan can operatively enhance the adaptive flexibility of a country and its preparedness for whatever future lies ahead.

However, reframing IRBM planning as continuing, deliberative practice among multiple actors is not easy. Tools and practices such as qualitative scenario thinking are used to identify strategic issues confronting the basin (scenario focal question) and the forces that drive the planning environment at multiple levels (scenario issue, basin, national, regional, and international. These drivers are then ranked in accordance with uncertainties to create the scenario matrix. Scenario planners develop the scenario narratives from the matrix and formulate actions common to multiple scenarios which they group into 'high-regret' must-do actions to offset potential big risk, robust 'no-regret' (near-term) actions, and adaptive (longer-term) actions. Experts then conduct quantified analysis (model, sensitivity analysis, optimization, cost-benefit analyses, and so on) and refine identified actions to make final recommendations.

Integrating climate change and variability in basin planning is of critical importance. Both long-term scenarios and short term variabilities have to be incorporated. Long-term scenarios are important for large infrastructure planning, whereas short-term variabilities are important for agriculture and preparedness for flood and other natural hazards.

2.4. Opportunities and challenges in implementing analytical tools

Recent advances in technology have made possible several complex numerical environmental analyses which were rather challenging in the past. This includes advances in space-based information and increased capacity of GIS applications. Now, many more high resolution environmental remote sensing datasets are available at reasonably low cost. Further, a massive amount of reanalysis data are available for various climatic variables that can to some extent bridge the chronic data scarcity in the HKH. In addition, cloud computing possibilities such as Google Earth Engine enable analyses to be conducted remotely with minimum computational resources. However, several challenges remain. All analytical tools have uncertainty due to various factors. The uncertainties should be understood and acknowledged when making decisions based on the results. Equally, the level of confidence required is different for different types of decisions, and can be altered by the relevant scenarios. For example, much higher levels of confidence are required for decisions on long-lived infrastructure, where there is a high risk of locking in poor decisions in the face of large uncertainties over the operational lifetime of the infrastructure. Lower levels of certainty may be acceptable for shorter timescale decisions – over a season or a few years – since most of these decisions are reversible. As discussed in the previous section, Climate Risk Informed Decision Analysis (UNESCO and ICIWaRM, 2018) provides a comprehensive methodology for water resources planning and management if significant uncertainty exists about future conditions.

It is also important to be careful in the selection of appropriate tools. The most complex tool is not always the most appropriate. Tools should be selected based on the specific need and the kind of question to be answered, including the level of confidence required. Tool selection is also governed by the availability of data, capacity, and human and financial resources. For decisions that require a high level of certainty, it is particularly important to take into account the uncertainty involved in using tools with scenarios based on the results of downscaling from GCMs. The resolution of GCMs is too low to provide really useful information at the level of a river basin in areas with complex topography like the HKH.

Finally, the importance of proper communication of analysis results cannot be overemphasized. Successful implementation of results is highly dependent on strategising the communication based on the targeted recipients of the information.

HOW CAN WE ENSURE SUCCESSFUL APPLICATION OF TOOLS AND MODELS IN IRBM?

Successful development and use of tools and models in IWRM depends on several factors, including

- awareness of, and access to, appropriate models and tools (see section 2.3);
- availability of qualified staff to undertake the analyses;
- availability of reliable data to create a model which can provide good decision support; and
- appropriate guidelines/agreements for accepting the results.

It is important to emphasise that the results and findings to be used in IRBM must be accepted by all parties involved, i.e. both decision-makers and stakeholders. This requires openness and transparency in all phases of the model development and application in which the modelling principles, procedures, and criteria are established. Furthermore, it is important to assess the model responses in relation to the data quality and availability and the associated uncertainties.

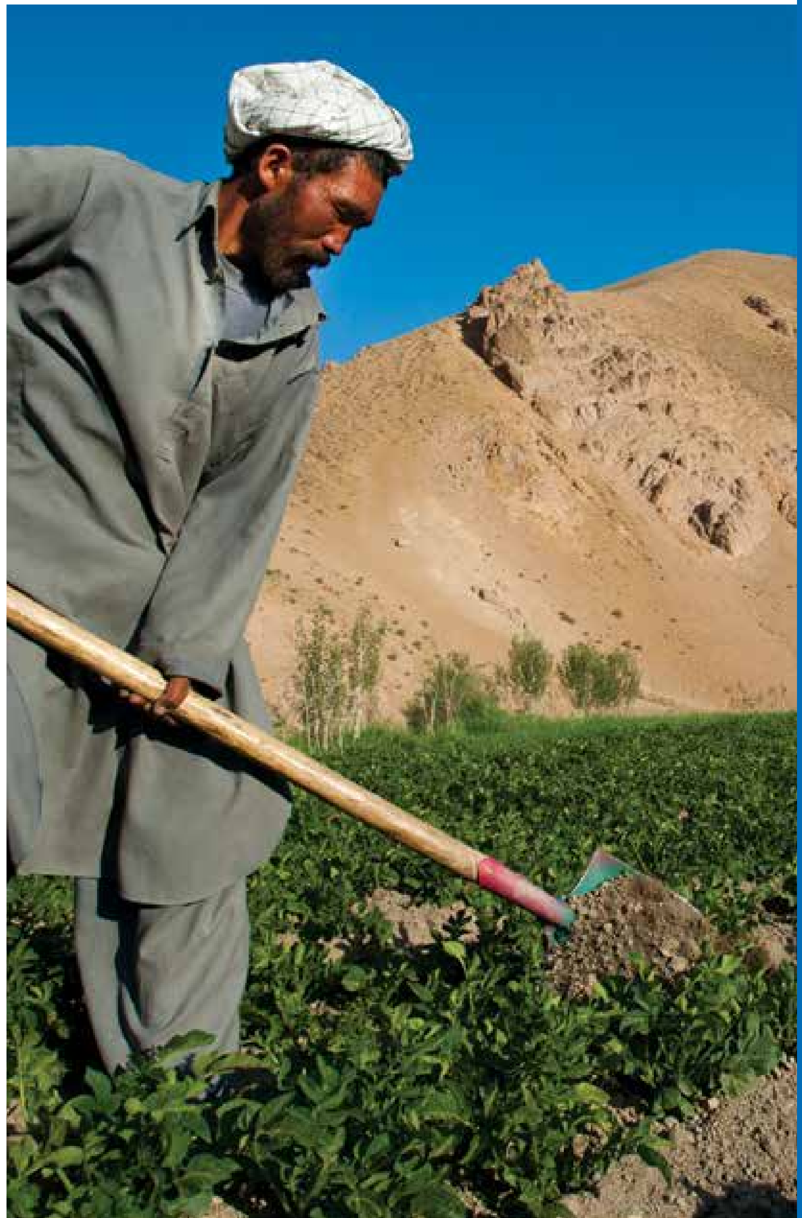
2.5. Frequently asked questions

WHAT ARE TOOLS AND MODELS?

A tool is something one uses to get a job done. For example, Microsoft Excel is a tool that is commonly used to conduct simple models. Similarly, the Internet is used as a tool to host an information system or the results of models. A model is a simplified representation of a system, construct, device, or idea. For example, the map of an underground train system is a model representing the route of the train and the stops along that route.

WHAT TYPES OF MODELS ARE USED IN BIOPHYSICAL ANALYSIS?

All biophysical models are simplified representations of parts or all of the processes occuring in river basins. Models can be physical (e.g. laboratory scale models such as wind tunnels), electrical analogue (such as the stream depletion factor (SDF) model for groundwater analysis), or mathematical (computer-based models such as MIKE). Physical and analogue models were very important in the past. However, mathematical models have now become the most important. They are the easiest to use, the most universally applicable, the most widespread, and undergoing the most rapid development with regard to scientific basis and application. This module focuses on this type of model.



MODULE 2 | KEY TAKEAWAYS

Tools and approaches for understanding biophysical change

SECTION 2.1
INTRODUCTION AND RELEVANCE

The IRBM approach should be able to take into account tools to analyse extreme events and devise forecasting mechanisms.

SECTION 2.2
LEARNING OBJECTIVES

The module focuses on a wide range of analytical tools can be used to support IRBM.

SECTION 2.3
TOOLS AND APPROACHES FOR ASSESSING BIOPHYSICAL CHANGE

IRBM involves considerable data analysis and storage, and it is essential to have a good data management mechanism.

SECTION 2.4
OPPORTUNITIES AND CHALLENGES IN IMPLEMENTING ANALYTICAL TOOLS

Tools should be selected based on the specific need, data availability, capacity, and human and financial resources.

SECTION 2.5
FREQUENTLY ASKED QUESTIONS

Mathematical biophysical models are the easiest to use and most universally applicable.

2.6. References and further reading

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MODULE 3

Gendered vulnerabilities and socioeconomic drivers of change

Integrating gender and social aspects into IRBM could help reduce gender gaps, social inequality, and vulnerability of specific gender and social groups.

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KEY MESSAGES

Gender is an issue emanating from power relations. It is reflected in resource access and control as well as governance and hence is an important element of river basin management.

River basin management is a multi-stakeholder process in which gender and social inclusion issues become crucial in terms of who participates, whose concerns are addressed, and who influences the ultimate decision.

The major discussions in river basin management are on water, land, and other bio-resources and about access to these resources and DRR, all of which have gender and social implications.

3.1. Introduction

River basin management is about managing land, water, and other ecosystem services for the wellbeing of heterogeneous populations living within and dependent on a river basin. It covers a range of different dynamics both social and biophysical and at different scales. Gender and social differences are critical aspects to be considered at different scales of river basin management. If gender and social aspects are omitted from the discussions, river basin management can widen gender gaps, increase social inequality, and increase the vulnerability of specific gender and social groups – thus hindering development. The different needs, interests, barriers to participation, and capacities of different gender and social groups need to be addressed while formulating and implementing IRBM policies and programmes.

This module looks at human/social interlinkages with the environment, key gender terms and concepts, paradigm shifts in understanding vulnerability, gendered and social vulnerability, the relevance of gender and socioeconomic drivers of change to sustainable river basin management, and gender analysis frameworks and tools. The module also explores how differential vulnerabilities and wellbeing among heterogeneous populations are shaped along the axis of gender and other social fault lines. The module mostly uses the terms gender and gender discrimination, but the considerations should be interpreted as applying equally to other forms of social discrimination, for example on the basis of ethnicity, caste, age, class, physical abilities, and geographical locations, among others.

Gendered vulnerability and IRBM in practice – A field trip of the type described in Module 8 provides a good way of looking at some of the outward indications of the different roles, responsibilities, and access to and control over resources of women and men from different social groups. What are the different gender roles and responsibilities? Who has access to and control over resources? Talking to local women and men at points of interest can help understand the differential vulnerability.

3.2. Learning objectives

Professionals working in river basin management often come from diverse disciplinary backgrounds, which at times can act as a hurdle to working together to address the complexity of resource management at a basin scale. This module highlights the need for inter-disciplinarity and trans-disciplinarity to promote the multi-stakeholder processes that are inherent to river basin management in an inclusive manner. This is even more important when the resources are perceived through a gender and social lens. Technical professionals from sectors such as water, land, and forest may fail to visualize gender issues due to the lack of integration of this topic in their professional training, and also personal biases emerging from the cultural context. The overarching goal of this module is to move from a gender neutral or even gender-blind approach to a gender sensitive, gender responsive, and gender transformative approach, both at individual and institutional levels. It aims to cultivate a gender sensitive attitude among participants by enhancing their understanding of gender issues and concepts, to open them to cross disciplinary ideas, to highlight the differential vulnerabilities caused by the interaction of social, environmental, political, and technical conditions and drivers, and to introduce some gender analytical frameworks and tools.

The module will help participants to

- understand the concepts of gender, social inclusion, and inclusive development;
- have clarity on gendered vulnerabilities and their drivers;
- understand the interlinkages between the human/social dimension and the environment;
- understand why and what gender and social issues need to be considered while developing plans; and
- link these concepts with their work on water management at different scales, including at river basin scale.

3.3. The impact of gender and social inclusion issues on IRBM

3.3.1. Society, gender, and natural resource management

The IRBM approach considers resource availability, social and gendered needs, resource uses, and associated governance issues with the aim of achieving higher wellbeing for the different groups of people living within the basin as well as sustainability of the resources. Thus gender forms an integral part of IRBM. The gender division of roles found in much of the HKH, as elsewhere, means that women and men often have different roles and responsibilities. Furthermore, the gender discriminatory practices followed in many different cultures and religions mean that women and men have different levels of access to and control over resources. It is important that IRBM is sensitive to and respects the cultural needs, and gender and social issues, and does not discriminate against catchment users because of their position in the decision-making process.

IRBM is about maintaining the capacity of nature to support life by ensuring optimal use of water for both economic and environmental sustainability. At the same time, a fair share of water benefits and responsibilities should be given to women and men, poor and rich, and young and old. This means that opportunities to access, use, and control water resources, must take gender and social equity into account to achieve sustainable use of water.

By recognizing and integrating gender in natural resources management, the water sector will benefit by

- improving the efficiency of resource use – e.g. reduced water loss and maintenance of the resource, adaptability to water shortages, and increased access;
- improving the sustainability of resources – e.g. acceptable, cost efficient, and sustained operation of technology, dealing effectively with conflict;
- improving health conditions – e.g. positive economic and health outcomes; and
- reducing gender discrimination.

Access to resources implies that individuals can use and benefit from specific resources (material, financial, human, social and political), while control over resources implies that individuals can not only obtain access but can also make decisions about a resource. For example, control over land means that the individual can not only use the land, they can also own the land (as legal title holder) and can make decisions about whether to sell or rent it. The vulnerability and capacity of individuals is shaped by who has access to and control over a resource. Therefore, to manage resources effectively and sustainably, it is essential to understand the differential needs and priorities of women and men, which are based on their roles, responsibilities, and their access to and control over resources.

The module starts by introducing key gender terms and concepts as a basis for understanding. This is followed by sections on paradigm shifts in understanding vulnerabilities; the conditions and drivers of change; gender, social inclusion, and governance at scale in a river basin; and gender mainstreaming and analysis tools.

3.3.2. Key gender terms and concepts

Patriarchy: Patriarchy refers to a social system in which men hold primary power and control resource allocation and decision-making and masculine characteristics have a higher value than feminine characteristics. The patriarchal mindset fails to recognize gendered needs and women are kept subordinate in many ways.

Gender: Gender refers to qualities or characteristics, roles and responsibilities, resource access and control that society ascribes to each sex, which becomes the basis for and shapes differentiated wellbeing among different gender groups. In all cultures, gender determines power and resource allocation for women and men. Gender is generally associated with unequal power and access to choices and resources.

Gendered division of labour: Gendered division of labour refers to different labour roles being allocated to women and men. Three areas of labour are distinguished.

1. **Reproductive roles:** These roles involve childbearing, and care services within households that support a household's wellbeing such as cooking, cleaning, fetching water, washing, and attending to the sick and elderly. These responsibilities are performed primarily by women and children and have low value.
2. **Productive roles:** These roles are related to activities that produce goods and services for consumption or trade (growing crops for sale or household consumption). Both men and women can be involved in these activities. However, women often carry out these roles alongside their reproductive roles in a household farm or home garden, which makes their contributions less visible and less valued than men's productive work.
3. **Community roles:** These roles involve community work, such as holding social events, activities to improve or care for community resources (land or irrigation ditches), and/or participating in groups or farmer organizations. These activities are often voluntary. Men tend to participate more often in the political affairs of the community (e.g., serving as chair of the farmers' association), whereas women tend to contribute their time more for free for a social good (e.g. cleaning the school backyard) (Moser, 2012).

Practical gender needs (PGNs) and strategic gender needs: PGNs are gender needs that women and men can easily identify, as they relate to living conditions, are practical in nature, and are usually related to inadequacies in living conditions such as water provision, health care, and employment. They include such things as provision of taps, health posts, and schools. PGNs are a response to immediate and perceived necessity, identified within a specific context. They do not challenge gender divisions of labour or women's subordinate position in society.

Strategic gender needs (SGNs) are the needs women identify because of their subordinate position in society, and tend to challenge gender divisions of labour power and control, and traditionally defined norms and roles. These needs and interests vary according to context and may include such issues as legal rights, domestic violence, equal wages, and women's control over their bodies. SGNs target change in the position of women, thus meeting these helps women to achieve greater equality and change existing gender roles, thereby challenging their subordinate position. SGNs are more long term and less visible than PGNs (Moser, 2012; March et al., 1999).

Condition and position: Condition refers to the material state in which women and men live, and relates to their responsibilities and work. Improvements in women's and men's condition can be made by providing, for example, safe water, credit, seeds, food and nutritional requirements, and security policies, (i.e. PGNs). Condition can be changed by fulfilling these practical needs.

Position refers to women's social and economic standing in society relative to men, for example, male/female disparities in wages and employment opportunities, unequal representation in the political process, unequal ownership of land and property, vulnerability to violence. Position refers to status and is linked to the possibility of making decisions and gaining power. Position can be changed by targeting strategic gender needs and interests (UNDP, 2001).

Gender relations: Gender relations refers to the specific subset of social relations uniting men and women as social groups in a particular community. Gender relations intersect with all other influences on social relations such as age, ethnicity, race, and religion to determine the position and identity of people in a social group. Since gender relations are a social construct, they can be changed (Christodoulou & Zobnina, 2009).

Gender equity: Gender equity implies fairness of treatment for women and men according to their respective needs. This can be equal treatment or treatment that is different but considered equivalent concerning rights, benefits, obligations, and opportunities, for example, reservation of seats for women in different institutions. In the development context, a gender equity goal often requires built-in measures to compensate for the historical and social disadvantages of women (Christos, 2009).

Gender equality: Gender equality entails the concept that all human beings, both women and men, are free to develop their abilities and make choices without limitations set by stereotypes, rigid gender roles, or prejudices. Gender equality means that the different behaviours, aspirations, and needs of women and men are considered, valued, and favoured equally. It does not mean that women and men have to become the same, but that their rights, responsibilities, and opportunities will not depend on whether they are born male or female (Christos, 2009).

Gender norms: Gender norms are the accepted attributes and characteristics of male and female gendered identity at a particular point in time for a specific society or community. They are the standards and expectations to which gender identity

generally conforms, within a range that defines a particular society, culture, and community at that point in time. Gender norms are ideas about how men and women should be and act, for example, that women should be responsible for household work and should not travel alone, and that men should be the wage earners. Internalized early in life, gender norms can establish a life cycle of gender socialization and stereotyping (Christodoulou & Zobnina, 2009).

Gender bias: Gender bias means making decisions based on gender that result in favouring one gender over the other, which often results in contexts that favour men and/or boys over women and/or girls, for example, family decisions that boys should get preference over girls for education (Christodoulou & Zobnina, 2009).

Gender discrimination: Gender discrimination refers to "any distinction, exclusion, or restriction made on the basis of sex which has the effect or purpose of impairing or nullifying the recognition, enjoyment, or exercise by women (or men), irrespective of their marital status, on the basis of equality of men and women, of human rights and fundamental freedoms in the political, economic, social, cultural, civil, or any other field" [United Nations, 1979. Convention on the Elimination of all forms of Discrimination Against Women, Article 1]. Discrimination can stem from law (de jure) or from practice (de facto).

Gender based violence: Gender based violence (GBV) is violence directed against a person because of their gender identity and is a phenomenon deeply rooted in gender inequality. GBV is mostly, but not only, inflicted on women and girls because of the power inequality in relation to men (EIGE, n.d.).

Gender disparities: Gender disparities refer to statistical differences (often referred to as 'gaps') between men and women, and boys and girls that reflect an inequality in some quantity (Christodoulou & Zobnina, 2009).

Gender gap: A gender gap is a proportionate difference between men and women and boys and girls, particularly as reflected in the attainment of development goals, access to resources, or levels of participation. A gender gap indicates gender inequality (Christodoulou & Zobnina, 2009).

Gender parity: Gender parity is a numerical concept describing relative equality in terms of numbers and proportions of men and women, girls and boys. Gender parity addresses the ratio of female to male (or male to female) values for a given indicator (Christodoulou & Zobnina, 2009).

Empowerment: Empowerment describes both the process and the outcome of people – women and men – taking control over their lives: setting their own agendas, gaining skills (or having their own skills and knowledge recognized), increasing self-confidence, solving problems, and developing self-reliance. Empowerment implies an expansion in women's (or men's) ability to make strategic life choices in a context where this ability was previously denied to them (Kabeer, 2001). The

Gendered vulnerabilities refer to gender-differentiated vulnerabilities with respect to stressors. Not all women and men are equally vulnerable. Gender-differentiated practices and the possibility to respond and cope shape vulnerabilities. Planning therefore needs to integrate gender aspects, recognizing the different needs and roles of women and men in society.

gender norms that shape current unequal relations and practices can be changed through this process, replacing the norms with more equitable relationships between men and women through a system of gender transformative change.

Stereotypes and implicit bias: Stereotypes are a generalized set of traits and characteristics attributed to a specific ethnic, national, cultural, racial, or gender group which gives rise to false expectations that individual members of the group will conform to these traits. Gender stereotypes are over-generalizations about the characteristics of an entire group based on gender (e.g., farmers are male; men do the work while women care for the family). Stereotypes result in implicit biases against certain gender or social groups (MIGS, 2009). Most often stereotypes and implicit biases are found in the sayings and proverbs of society (e.g., 'In childhood a female must be subject to her father… in youth to her husband…and when her lord is dead to her sons'; 'women must never be independent'; 'women should not crow').

Social inclusion: Social inclusion refers to the removal of institutional barriers and the enhancement of incentives to increase access by diverse individuals and groups to development opportunities. This requires a change in policies, rules, and social practices, and shifts in people's perspectives and behaviour, towards excluded groups (ADB, 2010). For example, women and other marginalized groups are often excluded from decision-making processes in water institutions as a result of structural issues that assign authority and power to certain groups only. These structural issues constitute the rules, norms, beliefs, and practices that define social relationships between different groups in a society (Kabeer, 2010).

Gendered vulnerabilities: Vulnerability refers to the propensity or predisposition to be adversely affected by something. It encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt (IPCC 2012). Gendered vulnerabilities refer to gender differentiated vulnerabilities with respect to stressors. Not all women and men are equally vulnerable. Gender differentiated practices and the possibility to respond and cope shape vulnerabilities (Denton, 2002; Kakota et al, 2011).

Gender analysis: Gender analysis is a tool for examining differences in women's and men's lives and the ways in which those differences, whether real or perceived, have been valued, used, and relied upon in assigning roles and responsibilities to them. It examines the multiple ways in which women and men, as social actors, engage in strategies to transform existing roles, relationships, and processes in their own interest and in the interest of others. There are multiple gender analytical frameworks that can be used to help in understanding the social and economic conditions of women and men and identifying the gender gaps and inequalities that affect them (March et al., 1999). (For further details see section 3.3.6 below on 'Gender mainstreaming and gender analysis tools and techniques'.)

Gender mainstreaming: Gender mainstreaming is a strategy for making the concerns of women and men belonging to different groups, and their experiences, an integral dimension in the design, implementation, monitoring, and evaluation of policies and programmes in all political, economic, and social spheres, such that inequality between men and women is not perpetuated. It includes the process of assessing the implications for women and men of any planned action, including legislation, policies, or programmes, in any area and at all levels (March et al., 1999; UNDCP, 2000).

Gender planning: Gender planning is a planning approach that recognizes the different roles that women and men play in society and the fact that they often have different needs (Christodoulou & Zobnina, 2009).

3.3.3. Paradigm shifts in understanding vulnerabilities

The word vulnerability gives a sense of someone being in a state of risk. Until the 1980s, vulnerability was only associated with biophysical vulnerabilities related to natural disaster. Natural disasters were considered to have a homogenous impact on people living in an area, and the area affected by a disaster was considered to be the unit for designing programmes aimed at supporting the victims of a disaster event.

A paradigm shift began with Wisner (1978) and Hewitt (1983) leading to a growing recognition that the impacts of hazardous events, even within small geographic areas, are not homogenous. There are deep social features affecting vulnerability, in addition to the vulnerability determined by the biophysical characteristics of an event. Gender is a crucial facet of social vulnerability, and it was realised that women and men may experience events differently (Aguilar, 2009 & 2013; Hemmati & Rohr, 2009; Lambrou & Piana, 2006; Terry, 2009).

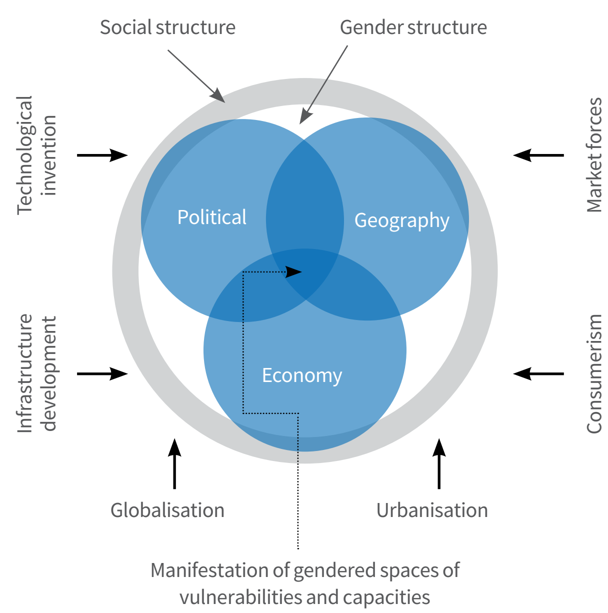
For example, if women are unable to leave their house due to social norms, they will be more at risk from flood and earthquake events than men. Furthermore, the impacts of change can further exacerbate already existing inequalities, and these in turn can compound the vulnerabilities of those who are in a subordinate position in the social and gender structure. Hence it is important to have a gender perspective when analysing vulnerabilities and to design programmes to respond to the vulnerabilities of the most affected groups.

3.3.4. Conditions and drivers of gender vulnerabilities

Vulnerability describes a set of conditions of people that arises from the historical and current cultural, social, environmental, political, and geographical context. These contextual conditions interact with each other and with other socio-economic drivers of change such as market forces, urbanization, globalization, infrastructure development, and technological interventions to shape the vulnerabilities of people (Figure 13) (Goodrich et al., 2019).

Gender and social vulnerability reflects pre-existing internal conditions and structures in a society that determine social and gender positioning relative to drivers of change that result in differential impacts of a hazard or climatic and socioeconomic stressors on a population according to gender or social position (Dow, 1992; Gerlitz et al., 2014; Hewitt, 1983).

FIGURE 13 CLIMATE CHANGE AND GENDERED VULNERABILITIES



Source: Goodrich et al., 2019

3.3.5. Gender, social inclusion, and governance at different scales in a river basin

The gender issues in a river basin vary at different geographical levels (i.e. upstream, midstream, and downstream), and at different scales of social unit (i.e. individual/household, community/watershed, and basin) and of governance.

The physical structure and resource availability in a basin differ in the upstream, midstream, and downstream sections leading to differences in mobility and livelihood opportunities. Upstream areas in the HKH tend to be characterized by steep slopes, less fertile land, and snow cover. In the midstream, the land is generally more fertile but still sloping, while in the downstream, land tends to be flatter and low-lying. Gender issues also tend to vary with elevation as a result of the different types of livelihoods available as well as socio-cultural norms and practices. The different gender issues at different elevations require special consideration in the design and implementation of basin level plans and programmes.

Gender differential needs also need to be considered using a scale sensitive perspective when constructing or promoting water systems. For example, at household level, an irrigation system that was designed to incorporate gender needs by including multiple use elements such as setting up a place to wash clothes and supplying water for livestock in addition to providing irrigation met women's practical needs and reduced their workload (Shah & Memon 2018). In contrast, an irrigation management system that promoted night irrigation had a negative impact on the productivity of women-headed households, as women could not go to irrigate their fields at night (Udas, 2014). At community or watershed level, addressing issues such as prioritization of resource use and protecting water sources used by the most vulnerable communities can have a positive impact on gender equity and social inclusion, while ignoring them can result in negative impacts. For example, a new drinking water system was designed which destroyed an existing source used by women to maintain privacy, and created further problems for women when a public tap was built next to a road to make water accessible to travellers; women could not use this source for bathing or for sanitation purposes during menstruation as the tap was placed in a publicly visible area (Regmi, 2000). At the basin level, decisions on allocation of funds for the most vulnerable and excluded groups could help bridge the gap between the haves and the have nots.

3.3.6. Gender mainstreaming and gender analysis tools and techniques

As described in Section 3.3.2, gender mainstreaming is a strategy for making the concerns of women and men belonging to different groups an integral dimension in the design, implementation, monitoring, and evaluation of policies and programmes.

PRINCIPLES OF GENDER MAINSTREAMING

The main principles of gender mainstreaming are:

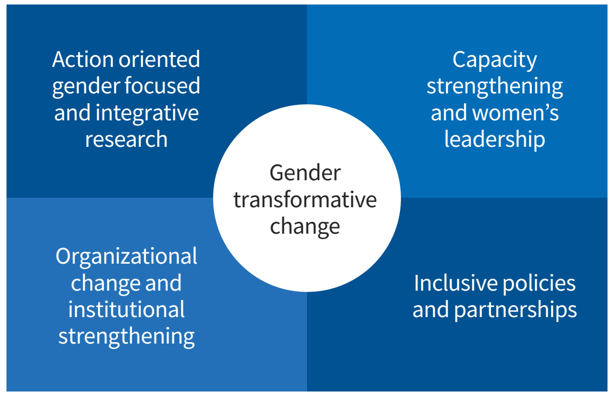
1. forging and strengthening the political will to achieve gender equality and equity, at the local, national, regional, and global levels;
2. incorporating a gender perspective into the planning processes of all ministries and departments of government, particularly those concerned with macroeconomic and development planning, personnel policies and management, and legal affairs;
3. integrating a gender perspective into all phases of planning cycles, including the analysis development, appraisal, implementation, monitoring, and evaluation of policies, programmes, and projects;
4. using sex and socially disaggregated data in statistical analysis to reveal how policies impact differently on women and men of different groups;
5. increasing the numbers of women in decision-making positions in government and the private and public sectors;
6. providing tools and training in gender awareness, gender analysis, and gender planning to decision-makers, senior managers, and other key personnel; and
7. forging linkages between government, the private sector, civil society and other stakeholders to ensure a better use of resources.

APPROACHES TO GENDER INCLUSION

In practice, the level of gender mainstreaming will differ depending on the approach adopted by a programme or project. Typical types of approach can be recognized.

- A gender negative approach reinforces gender inequalities to achieve desired development outcomes and uses gender norms, roles, and stereotypes that reinforce gender inequalities.
- A gender neutral approach does not consider gender to be relevant to development outcome. Gender neutral projects or programmes neither worsen nor improve gender norms, roles, and relations, but maintain the status quo.
- A gender sensitive approach considers gender as a means to reach the development goals. This approach addresses gender norms, roles, and access to resources, but only so far as needed to reach project goals.
- A gender responsive approach considers gender as central to achieving positive development outcomes. Changing gender norms, roles, and access to resources are a key component of project outcomes.
- A gender transformative approach is one that considers promoting gender equality and achieving positive development outcomes as central to the programme/project. Transforming unequal gender relations to promote shared power, control of resources, decision-making, and support for women's empowerment is integral to this concept (Figure 14). The approach challenges gender discriminatory norms and practices and promotes actions and strategies to change these (ICIMOD, 2013).

FIGURE 14 **FOUR PILLARS OF GENDER TRANSFORMATIVE CHANGE**



Important points for gender sensitive, responsive, and transformative approaches

1. Equal participation of women and men in considering demands, expectations, experiences, involvement, and knowledge in resource utilization and management
2. Equal gender consideration of water and other resource allocation and prior planning – who needs what and how much
3. Recognize different abilities to pay, and understand who pays the water bills within a community
4. Recognize the multiplier effects of water – e.g. gender sensitive irrigation can improve food security and income generation and, as a result, increase young girls' access to education
5. Recognize that caste, class, and ethnicity are integral to gender discrimination in access and control over resources
6. Provide gender sensitivity training both to technical and managerial professionals and to the male members in the community
7. Gather gender disaggregated data on who does what, women's and men's tasks, who participates, who benefits, who is most affected and how, to facilitate gender analysis to inform policies and programmes

FRAMEWORKS FOR GENDER ANALYSIS

Gender analysis is a tool for examining differences in women's and men's lives and the ways in which those differences have been valued, used, and relied upon in assigning roles and responsibilities (see Section 3.2.2). The following list summarizes some of the different frameworks used for gender analysis. March et al. (1999) provides more detail of the individual frameworks. Table 1 shows a comparison of their different features.

- Harvard Analytical Framework: useful in diagnosis; effective in identifying gender division of labour and gendered needs
- Moser (Triple Roles) Framework: used to explore division of labour between women and men, and practical and strategic gender needs)
- Gender Analysis Matrix (GAM): useful in monitoring and evaluation; can be used to explore the gender impact of disaster risk management (DRM) programmes at community level
- Capacities and Vulnerabilities Framework (CVA): used for humanitarian disaster preparedness issues; looks into capacities and vulnerabilities or existing weaknesses
- Women's Empowerment Framework (Longwe): useful in monitoring and evaluation; to assess the contribution of interventions in all sectors to the empowerment of women
- Social Relations Framework (SRF): used to explore gender aspects of sustainable development and institutional change and the concept of social relations (in relation to resources), and for institutional analysis (state, market, community, family/kinship)
- Levy (Web of Institutionalization) Framework: used to explore gender mainstreaming in institutions (Levy, 1996)

TABLE 1 COMPARISON OF DIFFERENT FRAMEWORKS USED IN GENDER ANALYSIS IN THE WATER AND SANITATION SECTOR

Aspect	Framework						
	Harvard Analytical	People-Oriented Planning (POP)	Moser	Gender Analysis Matrix (GAM)	Capacities and Vulnerabilities Framework	Women's Empowerment (Longwe)	Social Relations Approach
Participation							
Quality of process (i.e. gender balance in participation)	x	x	✓	x	x	x	✓
Quality of representation (representation resulting in gender sensitive decisions)	x	x	x	✓	x	x	✓
Networks (women's access to formal or informal networks)	x	✓	✓	x	✓	x	✓
Inclusion (demographic composition of population)	x	✓	x	x	✓	✓	✓
Community power dynamics (in relation to gender)	✓	x	x	✓	✓	✓	✓
Access to services							
Hardware (toilets, taps)	✓	✓	✓	x	x	✓	✓
Coverage (extent to which people are reached)	x	✓	x	x	✓	x	x
Distance (time to access services)	x	✓	x	x	✓	x	x
Control over							
Source	✓	✓	✓	✓	✓	✓	✓
Land (where source rights belong to land owner)	✓	✓	✓	✓	✓	✓	✓
Household decision-making (on procurement, management, and distribution in household)	x	x	✓	✓	x	✓	✓
Benefits to women							
Livelihoods	✓	✓	✓	✓	x	✓	✓
Health	✓	✓	x	x	x	✓	✓
Education	✓	✓	✓	x	x	✓	✓
Time (how much time is saved, more work and less people involved)	x	✓	x	✓	✓	x	x
Governance							
Institutional strengthening in terms of gender (formal institutions at local and district level)	✓	✓	✓	x	✓	✓	✓
Voice (gender empowerment, especially with reference to decision-making)	x	✓	x	✓	x	✓	✓
Operation, Maintenance, and Management							
Participation	x	✓	x	x	x	✓	✓
Contribution (in terms of time, labour and/or money)	x	x	x	x	✓	x	✓
Monitoring	x	x	x	x	✓	x	x

Modified from Lala et al., 2015

When applying these frameworks, it is important to be aware that they may require customization depending on the gender scenario at a particular place and particular time. A combination of frameworks may be applied in the process.

3.4. Frequently asked questions

WHY CONSIDER GENDER AND SOCIAL INCLUSION IN RIVER BASIN MANAGEMENT?

Gender and social exclusion is an issue that can deny access to or control over resources that are crucial for an individual, family, or community to enhance their wellbeing. The resources available in a river basin are important livelihood assets, hence access to and control over these resources is contested and exclusion is often the outcome of power relations. Considering gender and social inclusion issues becomes important in IRBM in order to avoid or minimize the politics around resource access and control and make it more inclusive and equitable.

HOW CAN WE ADDRESS GENDER AND SOCIAL INCLUSION ISSUES IN RIVER BASIN MANAGEMENT?

Gender inclusive policy and programme design guided by gender and social inclusion/exclusion analysis is the first step towards addressing gender and social inclusion issues in river basin management. In order to do this, it is important to understand the linkages between gender and environmental sustainability, gender and economic efficiency, and gender and social equity. For example, to establish gender and environmental sustainability linkages, we need to understand how women and men use and access water, land, and ecosystem resources in different ways (understand women's and men's tasks), identify the differences, understand communities' ideas suited to local natural and social conditions on how to respond to challenges (work with affected communities to find creative solutions), and adopt targeted actions in a transparent manner handling the trade-offs through dialogue and negotiation, wherein the process is empowering for marginalized women and men. Similarly, to establish gender and economic efficiency linkages, consider women's and men's demands (technology choice and priorities for investment), expectations, experiences, involvement, and knowledge in planning (water allocation and affordability) and management, and promote their roles in water management in an equitable manner (allocation of tasks). Further, to achieve social equity goals in water management, establish the gender linkages by taking into consideration the effects of water allocation on women's and men's welfare and the whole economy. It is important to understand the multiplier effect of water on welfare (e.g., gender sensitive irrigation can help improve food security and income-generation), reduce social/opportunity cost, and target the gender differentials to reduce the burden on those who are more vulnerable. Recognition of gender differentials using gender analytical frameworks would help in addressing gender and social inclusion issues in river basin management.

MODULE 3 | KEY TAKEAWAYS

Gendered vulnerabilities and socioeconomic drivers of change

SECTION 3.1
INTRODUCTION

Talking to local women and men at points of interest can help understand gendered vulnerabilities.

SECTION 3.2
LEARNING OBJECTIVES

This module highlights the need for inter-disciplinarity and trans-disciplinarity to promote inclusive multistakeholder processes inherent to river basin management.

SECTION 3.3
THE IMPACT OF GENDER AND SOCIAL INCLUSION ISSUES ON IRBM

It is essential to understand the differential needs and priorities of women and men to manage resources effectively and sustainably.

SECTION 3.4
FREQUENTLY ASKED QUESTIONS

Gender inclusive policy and programme design guided by analysis is the first step towards addressing gender and social inclusion issues in river basin management.

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MODULE 4

Governance, policy, and institutional framework

Developing institutional interfaces allow for smooth, transparent, conflict-free interactions among key stakeholders for IRBM.

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KEY MESSAGES

Crisis in the water sector is often a crisis of governance. Good governance – in terms of both process and outcome – needs to be a fundamental part of IRBM.

Adaptive management is now recognized and advocated as the preferred type of governance for the water sector. At the heart of the adaptive governance paradigm is effective stakeholder engagement for developing shared interests and coordinated actions.

Capable river basin organizations and institutions (RBOs) create effective response systems to changes in basin dynamics – they incorporate new knowledge and conditions as they arise and respond with improved functioning. In this way they are adaptive organizations.

A blend of traditional and modern institutional arrangements is often the best form of governance system. Social network analysis can be used as a tool to identify the most appropriate blend in a given river basin context.

4.1. Introduction

Since the beginning of this millennium, the crisis in the water sector has come to be recognized as a crisis of governance (GWP, 2000). The Ministerial Declaration that emerged from the Second World Water Forum committed the signatory governments "to ensuring 'good governance', including effective public involvement in decision-making to protect stakeholder interests" (WWC 2000 cited in Turton et al., 2007).

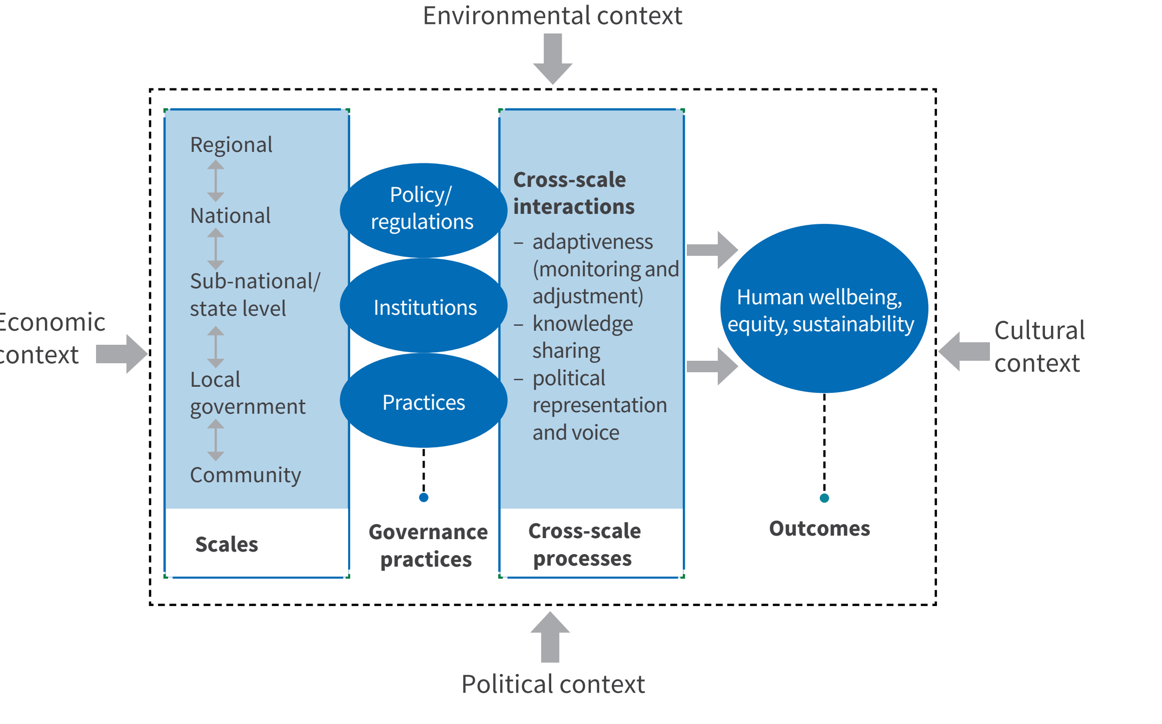
But what is good governance, especially in the context of water resources management? The GWP has defined water governance as: "the range of political, social, economic, and administrative systems that are in place to develop and manage water resources, and the delivery of water services, at different levels in society" (Rogers & Hall, 2003:7). The OECD has laid out a set of 12 principles on water governance focussing on allocation, governance, and depth of knowledge about conditions (OECD 2015). Governance is a fundamental part of the IRBM process of coordinating conservation and development activities across sectors for all types of natural resources within the river basin system (Jones et al., 2003). The governance goal in IRBM is to maximise the net economic and social gains resulting from sustainable resource utilization in the basin. Hence, the good governance outcome in IRBM is multi-dimensional and includes effective coordination, maximization of social welfare, and optimal resource conservation- and development for the water resource system.

At the heart of governance are the norms and values of society that define relationships and structure interactions among key stakeholders through institutional interfaces. Thus developing these institutional interfaces to allow for smooth, transparent, conflict-free interactions among stakeholders is also a governance mandate. Public participation and stakeholder engagement thus become central to good governance systems. But challenges arise when it comes to institutionalizing appropriate stakeholder engagement mechanisms.

While engaging with society, governance systems cannot ignore the traditional rules and norms of resource management that are deeply embedded in many societies. A blend of traditional and modern institutional arrangements is often the best form of governance system. Here again the challenge is to identify which elements to blend from the different systems of governance, and most often this is defined by the socio-ecological context. It can be useful to consider developing a basin-wide vision with stakeholders as a first step. A shared vision of what is healthy and what can be achieved can help create a more positive, aspirational vision of a basin. For example, the Institute for Water Resources of the US Army Corps of Engineers has developed a detailed methodology – Shared Vision Planning (SVP) – for formulating water management solutions through integration of traditional planning processes with structured public participation and collaborative computer modelling (USACE, n.d.).

Figure 15 shows a multi-scalar and multi-dimensional framework for environmental governance prepared by Ojha et. al. (2019) that can also be used in the river basin context.

FIGURE 15 **CONCEPTUAL FRAMEWORK FOR MULTIDIMENSIONAL GOVERNANCE**



Source: Ojha et al., 2019

IRBM governance in practice – The entire landscape of a river basin is affected by governance systems from local to national and beyond. Module 8 section 8.2.3 provides a good example of governance in practice in the form of the local level Water Use Master Plans for the Koshi river basin (and more details in Annex 4 Information Sheet 12). The plans involve multi-level strategies which are discussed and implemented in managing the water resources.

4.2. Learning objectives

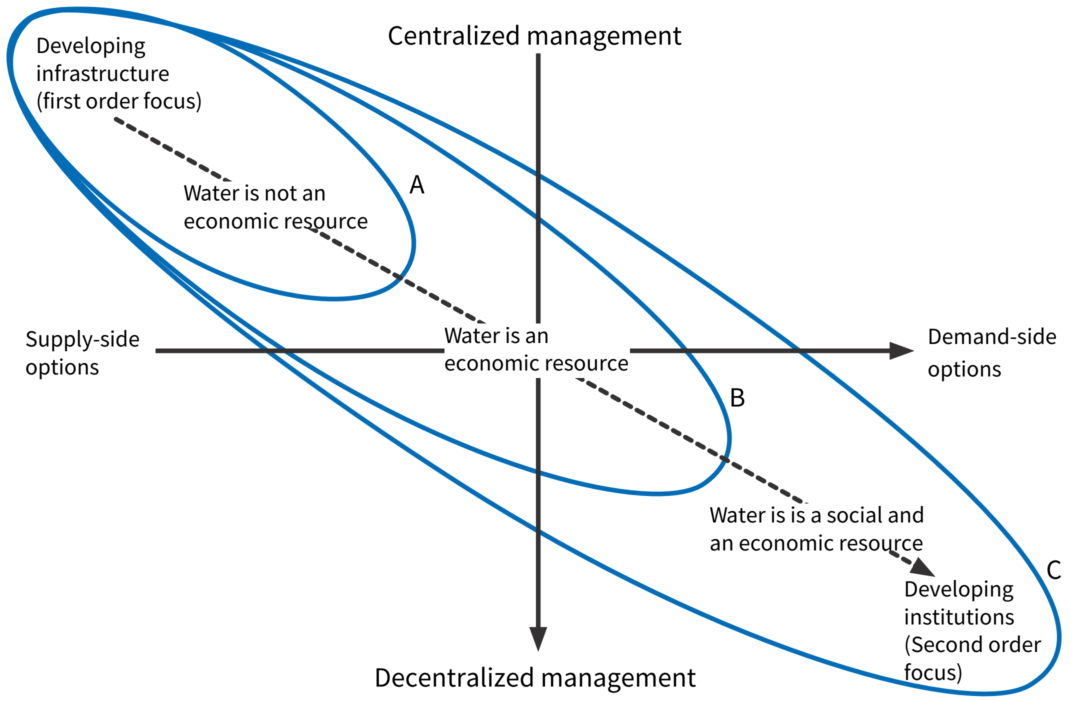
This module is intended to develop understanding of the concept and principles of adaptive governance and its application possibilities in the context of HKH river basins, using the example of Afghanistan, while keeping in mind the existing policy framework and organizational arrangements in a country. The module also seeks to introduce some tools and techniques for effective stakeholder engagement that can help bring some key elements of adaptive governance into river basin management. We place special emphasis on understanding the relevance and role of traditional water management systems in the adaptive governance paradigm for IRBM.

4.3. Governance in the context of IRBM

4.3.1. River basin governance – needs and challenges

All over the world, approaches to water resources management have changed from centralized to decentralized, and from a preference for supply-side options to more interest in demand-side options. The management tasks are no longer exclusive to engineers and hydrologists, experts from other disciplines are increasingly becoming involved. There is also more civil society participation in water resources management, especially when democratic systems in a country become more established and 'mature'. Figure 16, based on Turton et al. (2007), illustrates the trend.

FIGURE 16 CONCEPTUAL MODEL ILLUSTRATING THE GENERAL TREND OF CHANGE IN WATER RESOURCE MANAGEMENT APPROACHES



Source: Turton et al., 2007

TABLE 1 CHARACTERISTICS OF RIVER BASINS AT DIFFERENT STAGES OF DEVELOPMENT IN AFGHANISTAN

	Stage 1: Development	Stage 2: Utilization	Stage 3: Reallocation
Allocated flow, %	Low 0–40	Medium 40–70	High 70–100
Dominant activity	Construction: supply and storage infrastructure	Managing supply	Managing demand
Value of water	Low	Increasing	High
Groundwater	Development	Conjunctive use	Regulation
Conflicts	Few	Within the subsector	Cross-sectoral
Typical Institutional tasks	Construction: planning and implementation	Operation, maintenance, expansion and rehabilitation	Intersectoral planning
Based by allocated flow	Panj-Amu Kabul Indus	Harirod-Murghab Helmand	Northern

Source: Adapted from Molden et al. (2005), as cited in CPHD (2011)

Water resource governance involves "decision making about water storage, types of water use, regulation of extraction from aquifers, regulation of discharges, and allocation between competing uses, including allocations to maintain basic environmental services" (Bucknall, 2006). More importantly, the governance needs of a river basin depend on what phase the resource system is in. For example, a basin system in which water is becoming increasingly scarce relative to demand can undergo transition across a phase spectrum – from 'shortage' to 'over-exploitation' and finally 'basin closure'. From the governance point of view, institutional transitions need to occur as water becomes scarcer; the first when water abundance turns to water shortage and the second when water shortage turns to water over-exploitation (Turton & Ohlsson, 2000). It is this need for responsive institutions that calls for the adaptive governance paradigm to be adopted in river basin management. Table 1 shows the typical characteristics of river basins at different stages of development using the example of Afghanistan (CPHD, 2011). Afghanistan Human Development Report 2011 -- Forgotten Font: Water Security and the crisis in sanitation. Kabul: Center for Policy and Human Development, Kabul University).

Natural resources in river basins are often common pool resources shared by multiple users, which in the absence of effective governance can fall victim to the 'tragedy of the commons'. Decision-making must address complexity and uncertainty because of basin and resource dynamics that have significant cross-scale linkages – both in space and time – for which there is often little science-based evidence to guide the making of choices. Coordination challenges can arise when there are many rule-enforcing agencies at different administrative levels. Challenges to basin governance can also arise because of externalities that are likely to result from public investments in basin infrastructure, presence of vested interests and the possibility of elite capture, and uncertainty created by global drivers like climate change. Addressing these challenges calls for knowledge generation and sharing by different actors at various basin scales, polycentric decision-making that is well coordinated through networks, and institutional diversity and flexibility accompanied by an enabling environment for social

BOX 1
GOVERNANCE NEEDS OF IRBM

Basin-wide planning: Need to balance all user needs for water, both in present and future, and to incorporate spatial developments; special attention to vital human and ecosystem needs.

Participation in decision-making: Need to ensure local empowerment and stakeholder participation in decision-making (including representing the ecosystem as a stakeholder).

Demand management: Need to be part of sustainable water management.

Compliance: Need for compliance monitoring and assessment of commitments under river basin agreements and arrangements.

Human and financial capacities: Need for long-term development of sufficient human and financial capacity.

Source: Adapted from Anonymous (1999) cited in Hooper (2005)

Natural resources in river basins are often common pool resources shared by multiple users. The absence of effective governance could lead to the tragedy of the commons.

learning and experimentation – all of which are intrinsic to the notion of adaptive governance. Box 1 shows a summary of the main governance needs of IRBM.

ASSESSING WATER GOVERNANCE NEEDS

It is useful to consider all the different activities involved in water governance when assessing the experience and competencies of course participants and/or the need for trained personnel when developing plans. A 'water governance menu' derived from USAID (2009) was prepared for participants in the training course for Afghan professionals to help them assess the extent of their own work experience in functions and activities related to water governance (Table 2).

ANALYSING PROBLEMS IN IRBM

It is also important to identify and analyse potential problems facing IRBM in the context of a particular basin and country using a simple 'problem, possible causes, potential solutions' approach. Hooper (2005) listed several common, critical problems based on a number of studies and the author's discussions on river basin management during field missions in a wide range of both developed and developing countries (Table 3). The results provide a good indication of the type of issues that may emerge.

GOVERNANCE DECISION TREE

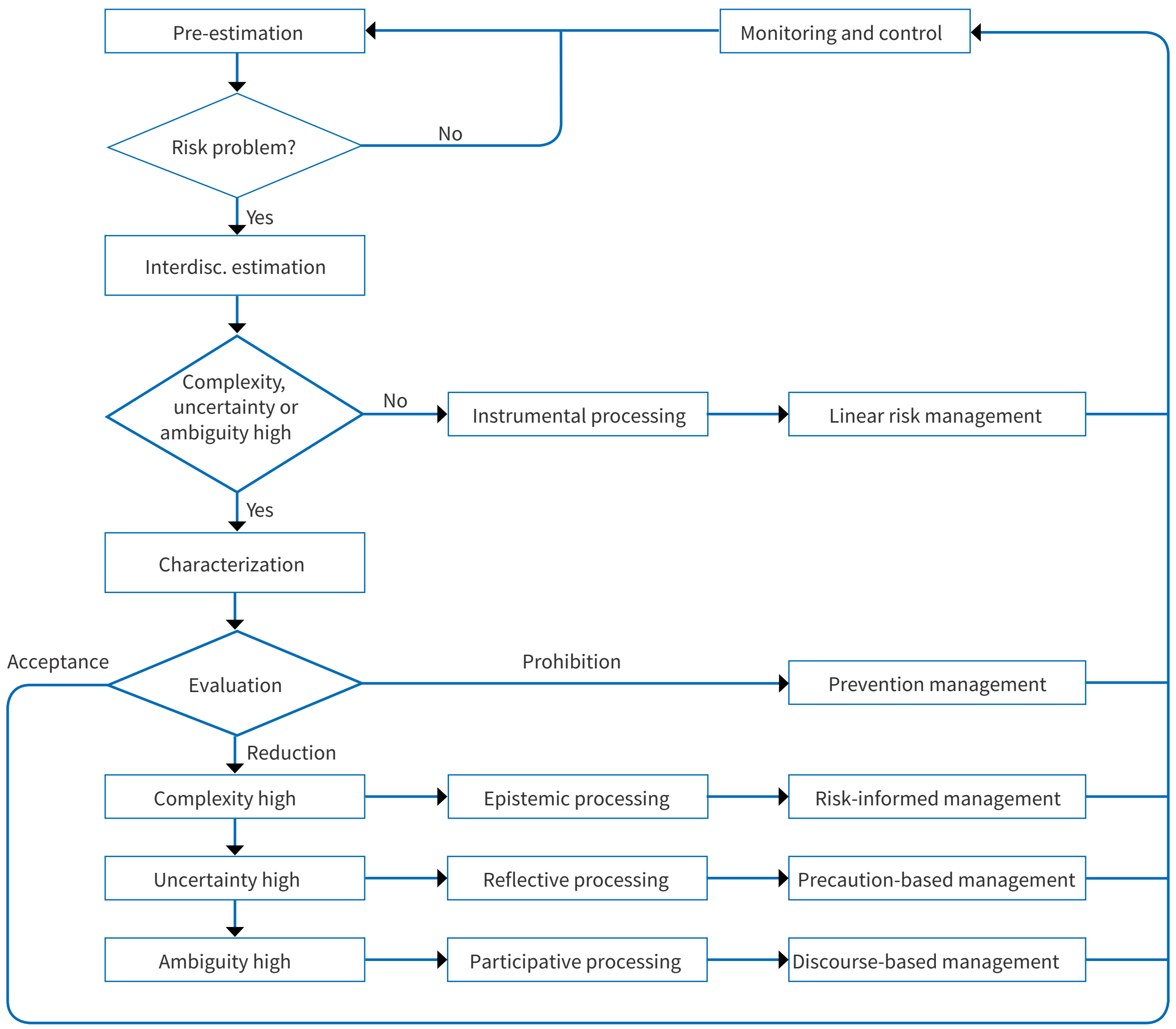
The governance decision tree given by Klinke and Renn (2012) provides a good framework for discussing the problems and solutions for IRBM in a particular river basin (Figure 17). The tree provides a way of classifying problems in terms of the three major categories of high complexity, high ambiguity, and high uncertainty, and thus selecting the appropriate route for seeking a solution.

TABLE 2 THE WATER GOVERNANCE MENU

Activities	Always	Sometimes	Never
Policy-making and law-making and their implementation			
Developing a long-term framework for water resources and services			
Setting a strategy and priorities			
Budgeting and fiscal transfer			
Regulating water resources and services			
Monitoring public and private service providers			
Economic regulation (setting water fees)			
Monitoring water permits and their implementation			
Protecting ecosystems			
Monitoring and enforcing water services standards			
Applying incentives and sanctions			
Organizing and building capacity in water			
Building awareness of water issues and priorities			
Developing and utilizing skilled water professionals			
Tendering and procurement			
Facilitating coordinated decision-making			
Planning			
Collecting, managing, storing, sharing and utilizing water-relevant data			
Projecting future supply and demand for water			
Designing strategies for long-term planning of water resources			
Developing planning and management tools			
Facilitating stakeholder participation			
Developing and managing water resources and delivering services			
Constructing public infrastructure and authorizing private sector infrastructure development			
Operating and maintaining infrastructure			
Forecasting and managing the effects of floods and droughts			
Tendering and procurement			
Organizing water services delivery			
Organizing stakeholder participation			
Treating wastewater			
Monitoring and evaluation			

Source: Modified from USAID (2009)

FIGURE 17 GOVERNANCE DECISION TREE



Source: Klinke and Renn, 2012

4.3.2. Adaptive governance and its relevance to IRBM

ADAPTIVE GOVERNANCE PARADIGM FOR THE WATER SECTOR

Adaptive governance of a river basin can help realize the goal of 'integration' in IRBM – across scales, across resource systems, and across multiple stakeholder interests. Institutional flexibility is inherent to the adaptive governance paradigm since it involves the continuous improvement of management strategies and policies by learning from the outcome of already implemented management (Pahl-Wostl, 2004). This may include learning from trial and error management, from lessons from the past, and even from certain policy and technological interventions (Raadgever & Mostert, 2006). The paradigm allows for social learning by engaging with diverse knowledge systems, including the experiential and indigenous (Varma et al., 2014).

The term 'adaptive governance' was coined by Dietz et al. (2003) who argued for its need in the case of complex multiscale socio-ecological systems. Chaffin et al. (2014) define adaptive governance as "a range of interactions between actors, networks, organizations, and institutions emerging in pursuit of a desired state for socio-ecological systems". There is a large body of literature that discusses the criteria associated with adaptive governance, its characterization, core principles, and so on. More relevant here is the practical diagnostic approach suggested by Rijke et al. (2012) that allows us to assess whether existing governance structures and processes are fit to address the three key challenges that are central to putting adaptive governance into practice. These challenges are ambiguity in governance goals, unclear contextual conditions, and uncertainty about the outcomes of different governance strategies. The operational framework proposed by Rijke et al. (2012) has identification of purpose, mapping of the context, and evaluation of the governance outcomes as three key steps for achieving adaptive governance. For training purposes, a tool can be developed that takes participants through the three steps. The participation of stakeholders takes a central role in each step, and hence, the outcome depends on the mix of stakeholders' value systems and interests (Sud et al., 2015).

RIVER BASIN ORGANIZATIONS (RBOS) AS ADAPTIVE ORGANIZATIONS

A necessary prerequisite at the institutional level for putting the adaptive management strategy into practice is the creation of appropriate river basin agencies to coordinate the interactions among all the actors involved at all levels.

The Third World Water Forum at Kyoto recognized RBOs as "the basic institutional entities for implementing IWRM". Many types of river basin organizations (RBOs) have emerged: advisory committees, authorities, associations, commissions, councils, corporations, federations, tribunals and trusts. They are summarized in Hooper (2005). For national and international basin organizations, functions tend to fall into one of three categories (Millington 1999, cited in Hooper 2005): monitoring, investigating, and coordinating basin committees (oversee conditions and trends in the use and quality of basin resources and suggest methods to coordinate management for improved governance); planning and management commissions (more prescriptive than the first); and development and regulation authorities (regulatory bodies and enforcement agencies).

Hooper (2005) has analysed the practices of well-developed river basin organizations which have had considerable experience in the implementation of IWRM. The conclusion is that capable basin organizations and institutions create effective response systems – they incorporate new knowledge and conditions as they arise and respond with improved functioning. In this way they are adaptive organizations. They evolve from stage to stage with a mature, auto-adaptive basin organization or institution having a highly advanced responsive capability.

SOCIAL NETWORK ANALYSIS (SNA) AS A TOOL

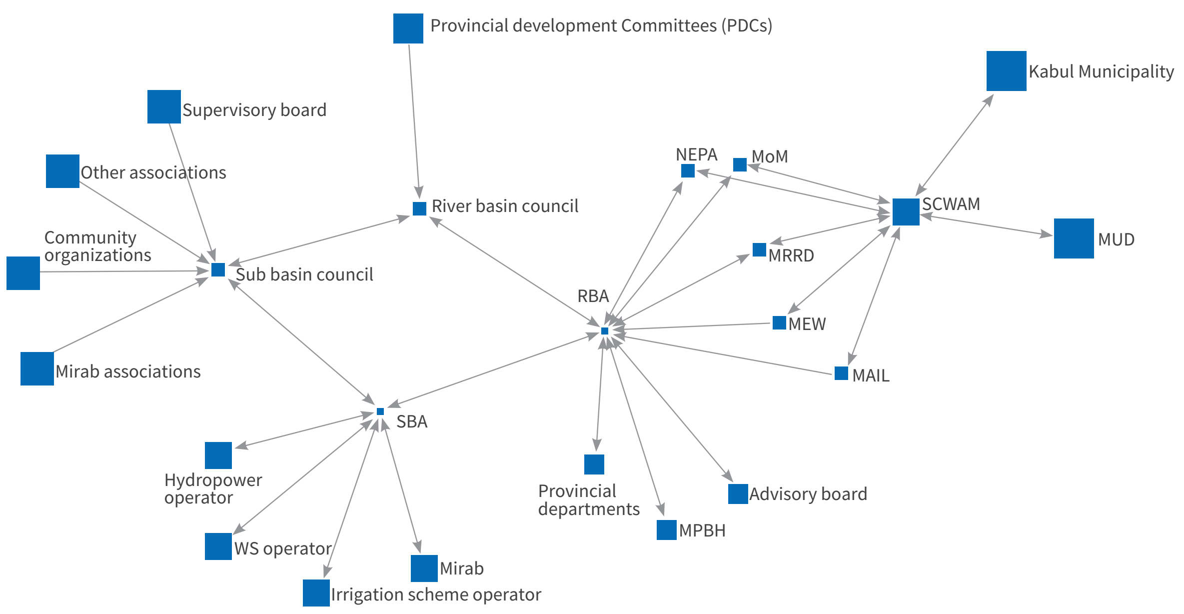
Adaptive governance is an emergent phenomenon (Chaffin and Gunderson, 2016) often involving a shift away from exclusive hierarchical control by government toward a more diffuse governance of resources through the activation of cross-scale and cross-level networks (Chaffin et al., 2014). According to Chaffin et al. (2014), the characteristics of networks – polycentricity, trust, communication, collaboration, learning, participation – contribute to the adaptive capacity of a governance system, and transitions toward adaptive governance are facilitated by high levels of adaptive capacity.

Social network analysis (SNA) is a useful method to mathematically evaluate network structure in terms of nodes (actors, organizations, events) and ties (linkages between nodes). SNA is

- useful for assessing relative position, power, influence, and legitimacy among nodes involved in governance; and
- some of the SNA metrics can be used to characterize aspects of adaptive capacity in a governance network.

The NetDraw feature in UCINET software (www.analytictech.com/archive/ucinet.htm) can be used to generate visual maps of social networks based on an understanding of the institutional arrangements in a given context. As an example, Figure 18 shows the initial social network developed by the participants in the course for Afghan professionals based on the organizational structure for implementing IWRM in Afghanistan shown in Module 1. An initial draft of this type can then be further developed using the experience and knowledge of those involved in the activities and can used to identify critical gaps and weaknesses in the network of relationships among existing organizations.

FIGURE 18 **THE INITIAL SOCIAL NETWORK GENERATED TO SHOW THE NETWORK AMONG INSTITUTIONS INVOLVED IN THE IMPLEMENTATION OF IWRM IN AFGHANISTAN**



4.3.3. Developing river basin governance structures in the HKH – the example of Afghanistan

THE POLICY AND INSTITUTIONAL CONTEXT FOR AFGHANISTAN'S WATER SECTOR

In Afghanistan, irrigation systems are largely informal (90%) (Thomas et al., 2012). The majority of these systems are managed by community-based service providers called mirabs and operated through indigenous infrastructure. These systems have been influenced throughout their history by external stakeholders (including the state) and interests beyond the realm of the community communities.

Table 3 shows the main developments in the water sector and related institutional context from the 1960s to 2011. At the state level, there was an era of water resource development and engineering during the period from the late 1940s to the early. At institutional level, the Ministry of Agriculture and Irrigation (MAI), later Ministry of Agriculture, Irrigation and Livestock (MAIL), was fragmented in the early 1970s, leading to the transfer of irrigation and water management responsibilities to the Ministry of Water and Power (MWP). The MWP mainly emphasized engineering and infrastructure development, and identified large-scale multipurpose infrastructure projects with a focus on both hydropower and irrigation (Thomas et al., 2012). The activities not only aimed at developing new irrigated areas, but also to improving the existing informal systems. In the late 1980s, the Ministry of Irrigation, Water Resources and the Environment was created. However, civil war hindered progress while weakening the influence and capacity of government institutions. Many state projects were left partially completed after the onset of war. During the 25 years of civil war, canal systems in Afghanistan (both formal and informal) turned into farmer-managed systems with support from a few non-governmental organizations (NGOs).

In 2002, there was a strong shift towards good water governance principles, driven by the support and influence of international donors (Table 3). In May 2002, the 'Kabul Understanding on Water Resource Management and Development in Afghanistan' laid the foundations for an ambitious attempt at water sector reform (Thomas et al., 2012). In February 2008, a Water Sector Strategy (WSS) was officially completed and set short- and long-term goals, including the development of sustainable water resources management policies and structures through the progressive implementation of IWRM. the Afghanistan Water Law was officially published on 26 April 2009 setting an important legislative milestone. The process of development of this law involved various ministries (including both MEW and MAIL), national and international consultants and advisors, and, to a much lesser extent, NGOs and civil society. Overall, the new Water Law attempts to find a balance between respecting traditions and introducing new governance and water allocation procedures at the local, sub-basin, and river basin levels. The new water governance approach followed in the Water Law follows the river basin approach as a core principle for land and water management (Thomas et al. 2012).

Furthermore, the Water Law provides a legal framework that defines the duties of decentralized multi-stakeholder platforms at the river basin level in the form of river basin agencies and river basin councils. At the local level (i.e. within irrigation canal command areas), the Water Law promotes the formation of water user associations (WUAs) and irrigation associations.

TABLE 3 **MAIN DEVELOPMENTS IN THE WATER SECTOR AND RELATED INSTITUTIONAL CONTEXT IN AFGHANISTAN FROM THE 1960s–2011**

Timeline	Main development
1960s–1970s: Ministry of Agriculture and Irrigation (MAI)	Creation of Ministry of Agriculture in 1948 and renaming to Ministry of Agriculture and Irrigation (MAI) in 1960. Construction and establishment of formal and large multi-purpose irrigation schemes including the development of hydropower.
1971-1972: Split within the MAI between agriculture and irrigation; a 'survey for soil and water' department is created, then becomes a general directorate, which finally becomes an independent Ministry of Water and Power (MWP).	To the end of the 1970s, MWP was in charge of administering the irrigation and hydropower sub-sectors, the Rural Development Department was responsible for the water supply and sanitation sector and traditional irrigation systems, and the Ministry of Public Works controlled urban water and sanitation. The Ministry of Agriculture, Animal Husbandry and Food (MAAHF) continued to influence research on irrigation and water management topics within its research department.
1981: Formulation and adoption of the first Water Law.	The Water Law combines traditional Islamic laws or principles with new principles and inputs brought in by the Soviet regime.
1988: The Ministry of Irrigation, Water Resources and Environment (MIWRE) was created alongside the MWP to manage hydrological networks, the development of water resources, and large-scale irrigation facilities.	The MIWRE and MWP had a mandate focusing mainly on hydraulic infrastructure/ civil engineering development. During the 1980s the MAAHF lost influence and was relieved of any role in irrigation and water management
1991: Formulation and adoption of a new Water Law.	
2002: Kabul Conference 'Kabul Understanding'	During the 2000s, water sector reform pushes for the introduction of 'good water governance' concepts including IWRM, RBM, and decentralization/participation, largely at the instigation of international donors and advisers.
2004: Strategic Policy Framework for the Water Sector	
Mid 2004: Start of the Kunduz River Basin Programme (KRBP) seen by MEW and at institution level as a pilot project for the implementation and development of the river basin/IWRM approach that forms the basis for the new water policy	
December 2004: Merger of MIWRE and MWP into the Ministry of Energy and Water (MEW).	
2004/05: Water Resource Management Policy and Strategy and Irrigation Policy.	Development and adoption of a Water Law led by the Ministry of Energy and Water (MEW), with the Ministry of Agriculture, Irrigation and Livestock (MAIL) effectively marginalized from the process.
2005: Formation of the Supreme Council for Water Affairs and Management.	
2008: Water Sector Strategy	
2009: Water Law	
2011: Regulations on WUAs	

Source: Thomas et al., 2012, adapted from Rivière, 2005

BOX 2

STAKEHOLDERS' ENGAGEMENT IN THE TRADITIONAL MIRAB SYSTEM

In Afghanistan most of the irrigation systems are managed and supervised in a three-tier system: primary canals are managed by a water bailiff, secondary canals by a mirab, and tertiary ditches by a chakbahi (Lee, 2003). The three-tier system is not present in all irrigation systems, it depends on the size, geography, and water availability in the canal. Wegerich (2009) reviewed the mirab system and found it to be equitable at the community level in terms of water distribution and maintenance work. Further, the study illustrated that the system is not isolated but is linked to administrative units at the district or province levels.

Other studies have shown that the method of choosing a mirab differs from basin to basin, especially in the summer where water is scarcer, with none appointed if there is enough water. Often a mirab is appointed for downstream communities where water scarcity is more common, but not upstream which generally has more water available (Lee, 2006). The system is intended to promote equitable and fair allocation of water resources. If there are serious conflicts or disputes over equitable sharing of water resources between irrigators, a shora or water master intervenes to reconcile them. The mirab is supported by an elder representing the communities when determining the sharing of maintenance work to make sure that labour responsibilities are apportioned fairly (Lee, 2006).

INTEGRATING THE TRADITIONAL WATER MANAGEMENT SYSTEM INTO MODERN IRBM

Box 2 describes the traditional water management system in Afghanistan. A basin council was formed under the Kunduz River Basin Program (KRBP) which included stakeholders from all sectors to further strengthen and understand the mirab system. The aim was to include all the mirabs from the different areas in the basin to discuss the water resource allocation strategy. Unfortunately, the local mirabs were barely represented due to the high transaction cost, lack of direct relevance of the meetings, and their fear of losing water rights (Wegerich, 2009). However, some informal agreements were made in which mirabs and shoras from downstream went to upstream areas to ask for extra water. However, the equitability of the arrangements is questionable and there is no technology in place to measure the quantity of water being diverted. The draft water law for the KRBP faces the dilemma of deciding whether individual farmers or the WUAs hold the permits for water use. There has also been an increase in non-farm consumptive use of water resources in the form of micro-hydro and mills, which is increasing the complexity of the decisions to be made (Wegerich, 2009).

Participatory management of the irrigation system (PMIS) was launched to address these complexities in two canals in Takhar province. The aim was to better understand and improve the collective water management practices through canal level WUAs and building of linkages between the water users and external agencies such as the basin councils (Wegerich, 2009). The PMIS involved government stakeholders, farmers, mirabs, and shoras. Technology was introduced to quantify the water distribution between the head, middle, and tail ends of the canals. Research under the PMIS found that in two canals there wasn't just one mirab unifying the canal communities, rather there were multiple mirabs representing different ethnicities and upstream and downstream communities. Using this knowledge, the PMIS was able to focus on the issues that were considered important by the communities rather than following a WUA blueprint. Consensus was reached among the various stakeholders on electing a committee to control and support the mirabs in equitable water allocation to farmers, mills, and micro-hydro power plants.

ROLE PLAYING TO ILLUSTRATE THE IMPORTANCE OF STAKEHOLDER ENGAGEMENT

To be effective, natural resources management should involve as wise a range of stakeholders as possible in planning and decision making. Role playing games are a useful way to help participants understand the importance of stakeholder involvement. Participants in the course for Afghan professionals played a game based on one developed by Bichai and Ferrero (2017) of IHE Delft Institute for Water Education for practising stakeholder collaboration in the preparation of Water Safety Plans (see Box 3). Water quality issues had been identified by the participants as a major management challenge. The role-playing game helped to illustrate the importance of stakeholder participation in leading to more efficient decision-making on investments in drinking water safety for public health protection, and highlighted the need for stakeholder participation in all aspects of IRBM.

4.4. Frequently asked questions

What is governance and what is 'good' governance in the IRBM context?

Governance is "…a suite of decision processes in natural resources management within the basin and external to the basin which impact on the basin's natural resources management." (Hooper, 2005). Good governance is based on the elements of transparency, integrity, predictability, accountability, and legitimacy.

What is adaptive governance?

Adaptive governance means "Institutional and political frameworks designed to adapt to changing relationships between society and ecosystems in ways that sustain ecosystem services; it expands the focus from adaptive management of ecosystems to address the broader social contexts that enable ecosystem-based management." (https://www.resalliance.org/glossary)

What are river basin organizations?

According to the Global Water Partnership (GWP), "the term basin organisation refers to any formal or informal entity that manages water resources at the basin scale." (https://www.gwp.org/en/learn/iwrm-toolbox/Institutional_Arrangements/coordination_and_facilitation/Basin_organisations/) The Third World Water Forum at Kyoto recognized river basin organizations (RBOs) as "the basic institutional entities for implementing IWRM". Many types of RBOs have emerged: advisory committees, authorities, associations, commissions, councils, corporations, federations, tribunals, and trusts. They are summarized in Hooper (2005).

BOX 3

ROLE PLAYING GAME FOR STAKEHOLDERS IN IMPROVED WATER QUALITY

Materials

Trainer's guidance manual (Bichai &Ferrero, 2017); participant's guidance material; printed materials for participants; flipcharts/blackboard

Steps

- Form teams of seven participants. Allocate roles – each group has one stakeholder representative each from the catchment authority (CA), farmers' association (FA), industry (I), water supply company (WC), local government (LG), Ministry of Health (MH), and consumers (Co). [The game could also be adapted to include a representative for the ecosystem.]
- Describe an imaginary city on the shore of the river that serves as the main water supply source. Due to industrial and agricultural development the water quality has drastically deteriorated and the water supply company is urgently required to supply drinking water that meets basic standards of the Ministry of Health. Consumers are dissatisfied with the boil-water advisories issued by the ministry and the water company is struggling to implement the raised tariffs to meet the water quality standards. A development agency has agreed to donate 3 million BE$ (currency of the imaginary city) to invest in improving the water quality. The fund is administered by the local government. The water supply company also has a budget of 1 million BE$ to improve the water supply.
- Round 1: Divide each team into two sub-groups, (A) with the CA, FA, I and LG representatives, and (B) with the WC, MH, and Co representatives. Group A discusses the stakeholder engagement and fund allocation of the donated 3M BE$; Group B discusses the stakeholder engagement and fund allocation of the WC's 1M BE$. Subgroup B also discusses the risk reduction factor, which is provided to them forehand. The subgroups should not interact.
- Round 2: The sub-groups come together to discuss how to spend the total budget of 4 million BE$ and which stakeholders to involve in implementing the activities according to the investment decision and allocated amount. The investment decision should ensure that all stakeholders are involved as well as proper allocation of budget.
- If there are a number of teams, they can then come together to discuss the similarities and differences in their decision-making.

MODULE 4 | KEY TAKEAWAYS

Governance, policy, and institutional framework

SECTION 4.1
INTRODUCTION

Governance is crucial to the IRBM process of coordinating multi-sector conservation and development activities for all types of natural resources within the river basin system.

SECTION 4.2
LEARNING OBJECTIVES

This module focuses on understanding the relevance and role of traditional water management systems in the adaptive governance paradigm for IRBM.

SECTION 4.3
GOVERNANCE IN THE CONTEXT OF INTEGRATED RIVER BASIN MANAGEMENT

Decision-making must address complexity and uncertainty because of basin and resource dynamics that have significant cross-scale linkages.

SECTION 4.4
FREQUENTLY ASKED QUESTIONS

Adaptive governance refers to institutional and political frameworks designed to adapt to changing society–ecosystem relationships in ways that sustain ecosystem services.

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MODULE 5

Water diplomacy and transboundary cooperation

Tools to understand how peaceful negotiations can be conducted and agreement reached within the framework of conflict management and regional cooperation.

Prakash, A., & Pandey, A. (2019). Module 5: Water diplomacy and transboundary cooperation. In S. Nepal, A. B. Shrestha, C. G. Goodrich, A. Mishra, A. Prakash, S. Bhuchar, L. A. Vasily, V. Khadgi, & N. S. Pradhan (Eds). *Multiscale Integrated River Basin Management from a Hindu Kush Himalayan perspective* (pp. 84–93). Kathmandu: ICIMOD.

KEY MESSAGES

Water diplomacy allows countries to negotiate agreements on the allocation and management of shared waters based on science and societal needs. It is an active process intended to pursue sustainable, peaceful, and win-win solutions to water allocation and management while promoting or influencing regional cooperation and collaboration.

The practice of water diplomacy provides practical tools of action on how to govern water across geo-political boundaries. It tries to understand and reflect on why and how countries do or do not cooperate for managing a shared resource. Water diplomacy opens up the cooperation dialogue to multiple stakeholders, including municipalities, provinces, and civil society.

Transboundary water management is based on a concept of IWRM that emphasizes management of a shared river as a single unit across political boundaries for planning, distribution, and allocation of water. The concept promotes a dynamic, interactive, iterative, and integrated approach to water resources management that combines technological, socio-economic, environmental, and human considerations and is based on agreed international laws and institutional frameworks.

5.1. Introduction

Conflicts produce disorderly impacts on the security, economy, and social wellbeing of increasingly interconnected societies. Of the many conflicts, sharing of water is becoming a particularly contentious issue between riparian countries. In a time when conflicts are becoming more complex, better understanding of their dynamics and of the means to address and solve them are important for people involved in resource management. Water diplomacy and transboundary water management are tools to understand how peaceful negotiations could be conducted and agreement reached within the framework of conflict management and regional cooperation. This module offers the opportunity to develop the analytical skills to understand water diplomacy and aspects of transboundary river basin management. It not only aims to provide a better understanding of how to address and solve contemporary water conflicts and disputes, but also to develop assessment techniques that can be useful for understanding and analysing how to manage shared rivers through cooperation and management.

The module looks at the issue of water diplomacy, regional cooperation, and negotiation of water share within a broader framework of water conflict management. It offers a brief insight into river basin management issues as highlighted in the Framework for Water Diplomacy, and looks at the way in which the Framework challenges conventional thinking about water management and helps overcome cooperation issues resulting from the dynamics of upstream and downstream water use. The key principles of international water laws and international negotiations in a transboundary river basin context are summarized. Finally, some water cooperation issues are showcased in two examples.

Water diplomacy in practice – Module 8, Section 8.2.3 offers a real-life example of water diplomacy in the HKH region. The section looks at some of the opportunities and challenges associated with the Koshi Barrage, which was constructed as an outcome of a bilateral treaty signed by the governments of Nepal and India. The treaty focussed on the use of the water resources of the Koshi river for irrigation, flood control, and sediment control. The Barrage illustrates many of the complexities of transboundary river management and the challenges for water diplomacy; further details are given in Annex 4 Information Sheet 13. The video on river basin management for the Nile introduced in section 5.3.3 also provides a good introduction for understanding the challenges in river basin management and the need for water diplomacy.

5.2. Learning objectives

- To develop critical thinking on water diplomacy in the framework of regional cooperation and to identify key principles and challenges
- To understand the issue of water related conflicts and cooperation and the interlinkages and interdependencies (such as climate change, poverty, food and energy, gender and social inclusion, and others)
- To identify different conflict resolution mechanisms and apply an analytical framework to resolve latent or actual water-induced disputes
- To recognize the cooperation potential of water and the benefits from collaborative transboundary water management

5.3. Water diplomacy and IRBM

5.3.1. Water diplomacy, regional cooperation, and conflict management framework

Water diplomacy is a dynamic process that works under the premise that the shared benefits of water cooperation will result in mutually acceptable benefits for riparian states (Nishat, 2014). Regional cooperation is a part of water diplomacy in which water is a means for goals beyond the resource to achieve stability, peace, and cooperation between two or more countries (Schmeier, Gerlak, & Blumstein, 2016). Water diplomacy includes all measures by state and non-state actors that can be undertaken to prevent or peacefully resolve present or emerging conflicts and facilitate cooperation

FIGURE 19 WATER DIPLOMACY FRAMEWORK

Acknowledge key assumptions	Theory: Characterize water networks properly	Practice: Manage water networks properly
Water is a flexible resource Science, policy and politics combine to create water networks Assumption #1: Water networks are open and continuously changing Assumption #2: Water network managers must take account of uncertainty, non-linearity and feedback Assumption #3: Water networks need to be managed using a non-zero sum approach to negotiation	Distinguish among simple, complicated and complex water networks Identify appropriate domains, levels and scales Recognize that the natural, societal nd political domains (NSPD) are interconnected Locate problems on the certaintyuncertainty and aggreement disagreement continua Understand what it means to operate in the zone of complexity	Recognize that simple, complicated and complex water networks require different management approaches Ensure appropriate stakeholder representation Engage in scenario planning and joint face-finding Emphasize value creation Mediate informal problem-solving and seek consensus Common to adaptive management (AM) and organizational learning Implement an appropriate management strategy for each water network

Source: adapted from Water Diplomacy (n.d.)

related to water availability and allocation or use between and within states and among public and private stakeholders (Swain et al., 2016). An example of regional cooperation is the International Commission for the Protection of the Rhine (IPCR) in Europe where nine states in the river catchment and the European Commission cooperate in order to harmonize the many interests in use and protection of the Rhine river (Rohn-Brossard & Stötter, 2018). Further, as per the principle of the European Floods Directive in the Rhine basin, the states should avoid taking measures which affect flood risks in other countries upstream or downstream.

Islam and Repella (2015) have developed a Framework for Water Diplomacy. The framework is based on the modern approach of recognizing a river basin as a complex system, and that complex problems require negotiated solutions (Water Diplomacy, n.d.). The Water Diplomacy approach diagnoses water problems, identifies intervention points, and proposes sustainable solutions that are sensitive to diverse viewpoints and values, ambiguity, and uncertainty as well as changing and competing needs. The framework makes a distinction between values, interests, and tools and suggests ways of thinking about these issues before prescribing a solution. Values are deeply held beliefs that shape how people view the world. These values include economic, political, cultural, religious, and ethical considerations. The Water Diplomacy Framework (Figure 19) addresses boundary-crossing water management problems (Islam & Susskind, 2012). The Framework challenges conventional thinking about water management in three important ways: (1) it assumes water is a flexible not a fixed resource; (2) science, policy, and politics combine to create water networks; and (3) water networks are complex and need to be treated as open-ended and unpredictable rather than closed and predictable systems. The three key assumptions embedded in the Framework have important consequences for how water disputes should be approached.

Table 1 shows the key elements of the Framework compared to conventional conflict resolution approaches for common pool resources (Islam & Susskind, 2012).

Water diplomacy plays an increasingly important role in preventing, mitigating, and resolving current and future water conflicts. Conceptually, water diplomacy is defined differently by different academics and organizations. However, the

TABLE 1 WATER DIPLOMACY FRAMEWORK VS CONVENTIONAL CONFLICT RESOLUTION APPROACHES

	The Water Diplomacy Framework	Conventional conflict resolution theory
Domains and scales	Water crosses domains (natural, societal, and political) and boundaries at different scales (space, time, jurisdictional, institutional)	Watershed or river basin within a bounded domain.
Water availability	Embedded water, blue and green water, virtual water, technology sharing, and negotiated problem-solving to arrange for re-use can 'create flexibility' in water for competing demands.	Water is a scarce resource and competing demands over fixed availability will lead to conflict, if not war.
Water systems	Water networks are made up of societal and natural elements that are open and cross boundaries and change constantly in unpredictable ways within a political system.	Water systems are bounded by their natural components; cause-effect relationships are known and can be readily modelled.
Water management	All stakeholders need to be involved at every decision-making step including problem framing and formulation; heavy investments in experimentation and monitoring are key to adaptive management; the process of collaborative problem solving needs to be professionally facilitated.	Planning is usually expert driven; scientific analysis often precedes participation by stakeholders; long-range plans guide short-term decisions; the goal is usually optimization given competing political demands.
Key analytical tools	Stakeholder assessment, joint fact finding, scenario planning, and mediated problem-solving	Systems engineering, optimization, game theory, and negotiation support systems
Negotiation theory	The Mutual Gains Approach (MGA) to value creation; multiparty negotiation keyed to coalitional behaviour; mediation as informal problem-solving	Hard bargaining informed by Prisoner's Dilemma-style game theory; principal-agent theory; decision-analysis (Pareto Optimality); theory of two-level games

Source: Water Diplomacy (n.d.)

different definitions share a common understanding of the importance of integrating the interests of the multiple dimensions and stakeholders in the cooperation process. Practice shows that water-related conflict prevention and resolution is largely the outcome of processes of research and fact finding, negotiation, mediation, and conciliation that are rooted in an in-depth understanding of the social, cultural, economic, and environmental conditions and the political context. This should be supported by a sound assessment and integrated analysis of the water system. The practice of diplomacy is carried out along different pathways or tracks:

- government to government
- official and non-official actors work together to resolve conflicts
- unofficial dialogues involving influential academic, religious, and NGO leaders and other civil society actors who can interact more freely than high-ranking officials
- people-to-people diplomacy undertaken by individuals and private groups
- affected communities such as farmers, women, indigenous peoples

Multi-track diplomacy is the term used for operating on several tracks simultaneously.

5.3.2. Key principles of international water laws and international negotiations in transboundary river basins

International law provides an overarching framework for addressing water-related challenges and concerns that span across scales, sectors, and disciplines. International law refers to the "system of legal rules, norms and general principles, and substantive and procedural rules that govern inter-state relations in various areas of human activities such as international trade, maritime and outer space activities, and environmental protection, as

BOX 1

EXAMPLE – NILE RIVER BASIN MANAGEMENT: IDENTIFYING RIVER BASIN CHALLENGES (DOCUMENTARY)

The Nile river basin provides a useful example both of historic tensions and modern-day diplomacy approaches.

The longest river in the world, the Nile flows north towards the Mediterranean Sea fed by two main tributaries, the White Nile and the Blue Nile. The river drains 10% of the African continent and is considered a lifeline for Africa. It flows through 10 countries and is the primary source of water for both Egypt and Sudan, as well as other riparian countries. The Nile river has been a source of conflict from historic times. In 2011, Al Jazeera produced a documentary titled "Struggle over the Nile – Legacy of Dispute" (Al Jazeera, 2011) which looks at the source of the tensions from the beginning of the 19th century, the present day disputes among the nations controlling and using the river water, and the diplomatic efforts to achieve a resolution. The documentary stresses both the political realities on the ground and the uncertainties over control of the river. The documentary provides a useful introduction to, and basis for discussion of, the concepts related to international disputes and negotiations on river basins.

well as access to and use of transboundary natural resources" (Wouters, 2013, p. 13). For example, the United Nations Economic Commission for Europe (UNECE) Water Convention, after its amendment allowing non-UNECE countries to accede, promotes cooperation on transboundary surface and ground water and strengthens their protection and sustainable management (UN-Water, 2013). This kind of convention fosters cooperation through Meetings of Parties, working groups, and a Secretariat with exchange of experience and good practices, elaboration of guidelines and recommendations, and development of legally binding protocols. Together with INBO, UNECE has also provided practical guidance on transboundary freshwater adaptation, with many examples from across the globe, to help address the need to consider the impacts of climate change and the need for adaptation (UNECE & INBO, 2015). Timmerman, Matthews, Koeppel, Valensuela, and Vlaanderen (2017) provide a short synthesis of selected aspects focused on transboundary cooperation.

It is important to understand the principles of international water law related to transboundary water resources management and the extent to which these principles are incorporated in recent international conventions and treaties.

Transboundary water cooperation is vital to prevent conflicts and for effective and sustainable use and management of shared resources. Water resources are under stress as a result of global population growth, rapid urbanization, increasing industrialization, agricultural intensification, and tourism, among others, and the problems are further aggravated by climate change and an increase in hydrological extreme events (droughts and floods). Projections indicate that 1.8 billion people will be living in regions with pressing water-scarcity problems by 2025. Cooperation between countries is, and will continue to be, essential to manage water resources judiciously. The key principles of international water laws and international negotiations in a transboundary river basin context are equitable and reasonable utilisation, obligation not to cause significant harm, cooperation, information exchange, notification, consultation, and peaceful settlement of disputes. These are widely acknowledged by modern international conventions, agreements, and treaties, such as the Convention on the Protection and Use of Transboundary Watercourses and International Lakes (Water Convention) (opened in Helsinki in 1992, brought into force in 1996), UN Watercourses Convention (1997), Indus Waters Treaty, India-Nepal Water Treaties, and India-Bangladesh Farakka Barrage Treaty. These principles can facilitate effective transboundary management of shared watercourses involving riparian countries and hence promote sustainable development around the world. As a part of this, IBRM offers a useful approach for integration of conservation, management, and development of water, land, and other resources in a particular river basin. The approach can provide a basis for negotiation that serves the interests of both upstream and downstream countries and can help maximize the socio-economic benefits while managing a river basin in a sustainable manner.

5.3.3. Examples of transboundary (and other) cooperation

There are many examples of transboundary basins where an integrated management plan is needed, is being developed, or is in place. These examples provide a good basis for learning about potential challenges and successful approaches. Boxes 1 and 2 offer two examples, one transboundary, of the issues involved in IRBM in terms of the need for cooperation and thus for water diplomacy to achieve it.

BOX 2

EXAMPLE – COOPERATION IN RIVER BASINS IN AFGHANISTAN

Participants in the training programme for Afghani professionals used the ideas introduced in the module to identify issues thought to be enabling cooperation and issues thought to be barriers to cooperation in river basins in Afghanistan. They also looked at what might be perceived as a loss as a result of cooperation, and future issues and possibilities. They identified the following issues.

Factors enabling cooperation

- Implementation of IRBM approaches
- Improvement in irrigation practices and increase in agricultural production
- Economic improvement
- Security and friendly relations
- Factors hindering to cooperation
- Lack of trust and cooperation among different stakeholders
- Lack of data sharing
- Lack of infrastructure security
- Water demand not considered
- Environmental flows not maintained
- Climate change
- Migration

Potential losses due to cooperation

- Loss of ownership of all the available water resources
- Development of water resource related infrastructure
- Insecurity/security
- Inter-relations among neighbouring countries (Iran and Afghanistan)

Future issues and potentials

- Irrigation development industry
- Climate impact reduction
- Gain benefits even in drought years
- Power production
- Joint projects in the future
- Conflict resolution
- Water demand increase

5.4. Frequently asked questions

WHAT IS WATER DIPLOMACY?

Water diplomacy is defined as the use of diplomatic tools to overcome present or evolving disagreements and conflicts over sharing of water within or outside national boundaries. The aim is to achieve mutual benefit through cooperation. The term is largely used when two or more countries share a river and there are, as always, different views on how this resource needs to be shared. In many regions of the world, water sharing results in conflict and water diplomacy can help in achieving regional stability and peace through increased cooperation. Water diplomacy is about how diplomatic instruments such as negotiations, dispute resolution mechanisms, and establishment of joint working groups or fact finding missions are applied to mitigate issues such as water sharing, data and basin management, and transboundary cooperation for shared resources such as water.

WHAT IS TRANSBOUNDARY RIVER BASIN MANAGEMENT? WHAT ARE ITS BENEFITS AND CHALLENGES?

Transboundary river basins are rivers that flow across political boundaries and are shared between two or more countries. Transboundary river basin management (TBRM) is about managing rivers across political boundaries for the benefit of all countries that have riparian rights over the river water. Riparian rights refer to a system for allocating water among all those who possess land along the path of the river. In an era of increasing water stress, it is important to manage rivers for the benefit of all those who rely on them. TBRM is necessary for managing the data needed to inform policy decisions. Depleted and degraded transboundary rivers have the potential to cause social unrest and spark conflict within and between countries. In recent years, the changing climate has led to an increase in events such as floods and these have transboundary implications. TBRM provides a legal and institutional framework for sharing the benefits and costs of managing a river across political boundaries. For example, integrated and cooperative management of a dam upstream on a transboundary river can provide greater hydropower generation or flood control benefits for both upstream and downstream countries. There are many challenges for TBRM. In general, each country wants to utilise more water and share less in their own national interest. Data sharing across countries that have a history of conflict is also a huge challenge.

MODULE 5 | KEY TAKEAWAYS

Water diplomacy and transboundary cooperation

SECTION 5.1
INTRODUCTION

Better understanding of the dynamics of conflict and of the means to address and solve them is important.

SECTION 5.2
LEARNING OBJECTIVES

The module offers the opportunity to develop analytical skills to understand water diplomacy and aspects of transboundary river basin management.

SECTION 5.3
WATER DIPLOMACY AND IRBM

Water diplomacy plays an increasingly important role in preventing, mitigating, and resolving current and future water conflicts.

SECTION 5.4
FREQUENTLY ASKED QUESTIONS

Diplomatic instruments and the establishment of joint working groups are applied to mitigate issues concerning shared resources.

5.5. References

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FURTHER READING

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MODULE 6

Operational aspects of water and land management

There is high potential for water development if planned and managed in a basin-wide approach and through regional cooperation.

Bhuchar, S., Shrestha, F., Joshi, S., Sinisalo, A., Khadgi, V., Pradhan, N.S., Shrestha, M., Shakya, D., Dhakal, M., Pokhrel, G., Khadka, K., Sthapit, K.M., Wester, P., & Sherpa, S. (2019). Module 6: Operational aspects of water and land management. In S. Nepal, A. B. Shrestha, C. G. Goodrich, A. Mishra, A. Prakash, S. Bhuchar, L. A. Vasily, V. Khadgi, & N. S. Pradhan (Eds). *Multiscale Integrated River Basin Management from a Hindu Kush Himalayan perspective* (pp. 94–111). Kathmandu: ICIMOD.

KEY MESSAGES

Interventions related to the use and management of water resources at different scales in mountainous regions should establish upstream and downstream and water and land interrelationships for IRBM.

A multi-stakeholder approach involving communities, government, non-governmental organizations, the private sector, and academia is essential for IRBM.

Water resource management requires a focus on both surface and groundwater management. The latter has received less attention in policy and practice in the past.

Sustainable water resource development and allocation requires a combination of technical, social, environmental, economic, and institutional solutions, together with risk and benefit sharing.

6.1. Introduction

The river basins in the HKH region have a high potential for water development if planned and managed in a basin-wide approach and through regional cooperation. Water resource management is vital for shaping the wellbeing of the 240 million people living in the mountains and hills of the HKH region as well as the 1.65 billion people living downstream. It is also critical for maintaining diverse ecosystem structures and functions and ecosystem services (Xu et al., 2009). In the HKH region, water resource management has also gained importance due to hydropower and communications development and inland navigation.

There are many issues related to water resource management in the HKH that are at river basin scale, such as increasing risks of sedimentation and erosion, glacial lake outburst floods (GLOFs) and flash floods, riverine floods, changing patterns of flood and drought due to climate change, changing gender and social patterns (including upstream-downstream migration), increasing demand for water and other ecosystem services, and institutions and governance. All of these issues have strong upstream-downstream relationships (Nepal, Flügel, & Shrestha, 2014), and there are a number of solutions and opportunities available for addressing them at local to river basin scale. The science, policy, and practice environment in the HKH region is becoming more conducive for IWRM as many countries have adopted an IWRM approach for river basin management, including Afghanistan, Bhutan, and Nepal. Due to administrative decentralization, opportunities for engaging local communities in resource management to enable water use for different purposes have also increased over the years.

The key objective of this module is to share some solutions which can be applied at regional to local scales for operationalizing IRBM. The solutions are provided as examples and can be configured to a specific context, while the approaches used can be extrapolated to other topics.

IRBM in practice – The field trip described in Module 8 provides a good practical introduction to operational IRBM with illustrations of many of the approaches and interventions used in the field to implement the approach. They include warning systems for flash floods in the upper reaches (Section 8.2.1), collection and sharing of hydrometeorological data for riverine flood forecasting in the middle reaches (Section 8.2.2), and community based local flood-warning systems in the lower reaches (Section 8.2.3). Practical interventions being made to manage the competing claims on water resources are also visible in the form of plans for inter basin water transfer, changing agricultural practices, changing ways of water harvesting and accessing groundwater, and piloting of a Resilient Mountain Village (RMV) approach to address climate change adaptation and preparedness.

6.2. Learning objectives

The main aim of the module is to facilitate understanding of the broad range of potential solutions (technical, social, and institutional) for water resource management at local, watershed/catchment, and basin level, taking into account the upstream-downstream linkages, and to share good practices on water resource management which are also gender-sensitive.

6.3. Examples of management approaches in operational IRBM at different scales

The module looks at four examples of management approaches that can be used in operational IRBM – groundwater and springshed management, sediment management, IFM including forecasting and warning services, and GLOF risk reduction – together with the role of institutions in operationalization and sustainability of water resource management in river basins of the HKH. A full IRBM plan will integrate, or suggest, many more areas of management at different scales. The four described here provide examples of how IRBM can be implemented in practice.

6.3.1. Groundwater and springshed management –Operationalizing water resource management at a local scale for improving access to water

Groundwater provides drinking water to at least 50% of the world's population (UNESCO, 2009) and 43% of all irrigation water used (Siebert et al., 2010). Springs are one of the major groundwater resources in the hills and mountains of the HKH and the main source of water for millions of people in the mid hills. Most water supply schemes in the HKH are linked to springs, and rural and urban communities depend on springs for their drinking, domestic, agricultural, and cultural water needs (Shrestha et al., 2018). Nearly every river in India has its origins in springs (NITI Aayog, 2018), while in Afghanistan, groundwater systems such as kareez (an intricate subsurface water conveyance system), springs, and shallow wells are vital sources of water for drinking and irrigation (Sinfield & Shroder, 2018). Qureshi (2002) identified 5,558 springs in Afghanistan used for irrigating about 188,000 ha of land.

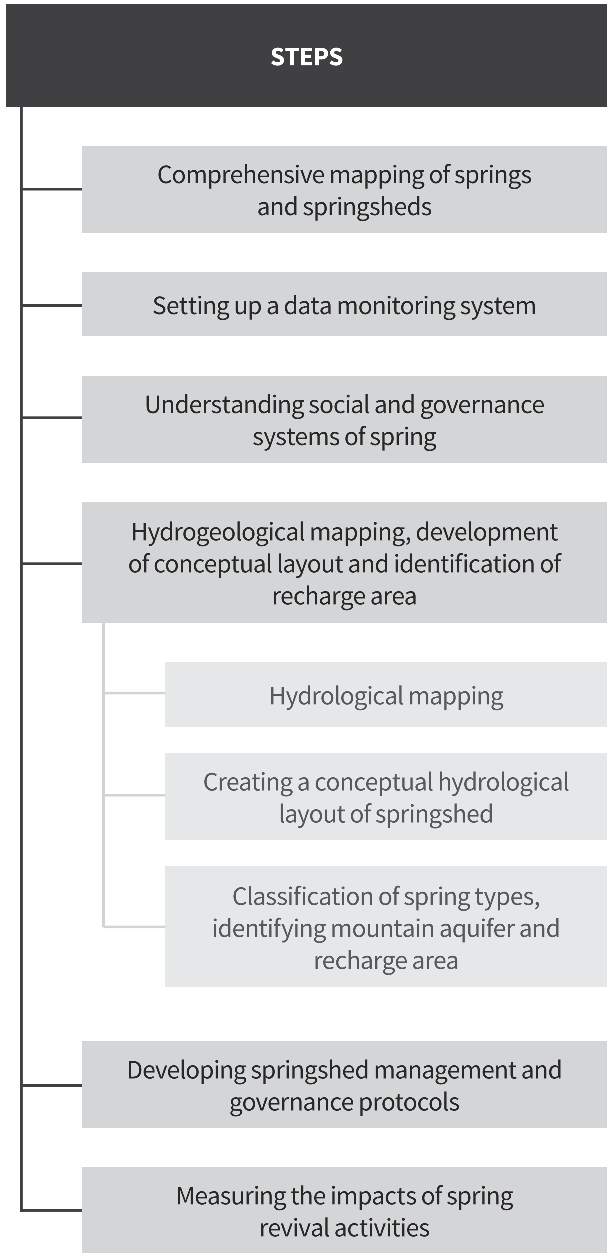
There is increasing evidence that springs are drying up or their discharge is reducing throughout the HKH. As a result, communities are facing unprecedented water stress, particularly women and girls who bear the burden of fetching water daily. The exact extent of this problem is not well known due to a lack of scientific studies on springs. However, changes in climate and the biophysical landscape (e.g. land use and vegetation) is widely implicated in the drying of springs.

As springs are a part of the groundwater system, the science of hydrogeology needs to be understood for spring revival. Hydrologically, springs are groundwater systems. Any reduction in groundwater level due to drought leads to a reduction in spring discharge. Therefore, spring revival work should be accompanied by drought risk reduction practices which include soil-moisture and watershed management measures. Local knowledge and practices should be valued.

A detailed methodology for spring revival has been developed and tested in Sikkim, a mountainous Himalayan state in north India. Many springs in the state have been revived using this hydrogeological approach (ACWADAM, 2011; Tambe et al. 2012) and the methodology is now being taken up elsewhere in the region. The basic geology, hydrogeology, and springshed management concepts are described in detail in the 'Protocol for Reviving Springs in the Hindu Kush Himalaya: A Practitioner's Manual' developed together with the Advanced Center for Water Resources Development and Management and published by ICIMOD in 2018 (Shrestha et al., 2018). The main steps are summarized below.

Spring revival is based on a six-step protocol (Figure 20). Briefly, the location of existing and dried springs in an area is mapped in detail using a field survey and used to delineate the springshed and demarcate spring types. Long-term spring discharge data, water quality information, and rainfall data are collected with the help of the local community by setting up instruments and data monitoring systems. Participatory assessment is used to gain an understanding of current water use patterns and their socio-economic implications, and the institutions and governance systems that are in place for managing springs. Detailed hydrogeological mapping enables identification of spring types, and type(s) of aquifer, and demarcation of the recharge area for the springs of concern.

FIGURE 20 THE SIX-STEP PROTOCOL FOR SPRING REVIVAL IN THE HINDU KUSH HIMALAYA



Source: Shrestha et al., 2018

There are many methods available for increasing infiltration in a spring recharge zone. They mainly focus on structural measures aimed at retaining water for longer on the slope, such as digging pits and ponds and constructing terraces, and vegetative measures to reduce runoff and increase soil uptake, such as afforestation and planting hedgerows. Introducing sustainable agriculture, together with management measures for wetlands, grazing, and road construction further contributes to spring maintenance and revival. The measures to be implemented are selected to suit the particular context and combined in a comprehensive springshed management plan. They can be complemented with other measures to reduce the dependence on recharge areas for ecosystem goods and services, for example introduction of solar energy technologies, improved stoves, fodder cultivation on private land, roof rainwater harvesting and other solutions which combine social, economic and environmental dimensions of sustainable development with climate change adaptation, resilience and preparedness for future risks (see Module 8: Resilient Mountain Solutions Framework).

Good governance is essential in spring management and should be based on involvement of and ownership by the local community at all stages. Spring water user groups provide the backbone of good management, but to be successful they need to include representatives of all castes and groups of different social/economic status, with a focus on ensuring full participation of women. The planning and implementation of springshed management and governance protocols requires good community mobilization for motivating and convincing land users to invest in, and maintain, spring recharge measures. Three-dimensional springshed models can be used to familiarize local users with spring formation principles and increase understanding of the reasons for spring decline and how measures can contribute to revival. Social mobilization is also necessary for ensuring gender and social equity and for conflict resolution during the process of designing and implementing protocols. Moreover, the effectiveness and efficiency of the recharge measures will be ensured if the technical measures are selected and applied based on proper survey, design, and cost estimations, and when there is coordination between the relevant programmes of agriculture, horticulture, forestry, animal husbandry, infrastructure development, soil and water conservation, and others.

It is important to have local water planning and development systems based on good governance principles that facilitate and control decision making with regards to spring water use, spring resource management and overall water resource development (see, for example, Annex 4 Information Sheet 12 on making local water planning gender and socially inclusive).

6.3.2. Sedimentation management – Operationalizing water resources management at basin scale

Soil erosion and sedimentation are natural hydro-geological processes in all river basins. They are influenced by climate, slope, altitude, soil, land management practices, stream density, rock strength and mass wasting, and erosion intensity. Human interventions such as deforestation, wetland degradation, excessive grazing in rangelands, unsustainable agriculture on steep slopes, haphazard infrastructure development (such as road construction) in the mountains, and removal of riparian vegetation for socio-economic reasons intensify the natural erosion and mass wasting processes leading to higher sediment yields. The impact of high sedimentation is felt most in downstream locations due to intense flooding, and damage to waterways, irrigation canals, river banks, and aquatic ecosystems such as wetlands. Sedimentation is also an important issue in hydroelectric production, especially for reservoirs where sedimentation can limit the level of production and life of a project (Asif, 2009).

Himalayan rivers are known for their high sediment loads, with the Indus having one of the highest sediment loads in the world (Laghari, Vanham, & Rauch, 2012). The Koshi river, which flows into the Ganges, is a good example of the upstream-downstream linkages. Sediment produced in the upstream reaches of the Koshi river basin is transported and deposited downstream in the rivers and plains of southern Nepal and northern India. The high sediment load and riverbed aggradation lead to frequent flooding and bank erosion in the downstream reaches (see, for example, Section 8.2.3 in Module 8, and Annex 4 Information Sheets 13, 14). Amplified bank erosion heightens the risk of water-induced disaster during the monsoon and increases the likelihood of the river shifting course. The alluvial fan of the Koshi river is witness to the dynamic nature of the river channel which has moved more than 113 km over the past two centuries across the Bihar plains of India. Because the river is transboundary, soil erosion control and sediment management require collaborative and integrated multi-disciplinary assessment and management by stakeholders across the region (Sinha, Nepal, & Uddin, 2018).

BOX 1

OPERATIONALIZING SPRINGSHED MANAGEMENT – AFGHANISTAN AS AN EXAMPLE

Participants in the training programme for Afghani professionals considered the likely challenges and opportunities for operationalizing springshed management in Afghanistan, and the key stakeholders involved. They identified the following:

Key challenges

- Deforestation
- Decrease in agricultural production affecting livelihoods
- Expanding urbanization
- Climate change
- Overuse and insufficient water use for domestic water supply
- Unplanned road construction and retaining structures

Opportunities

- Afforestation and expansion of greenery for flood control and sediment management
- Improvement in agricultural and environmentally friendly practices
- Improvement in water and sanitation hygiene (WASH) sector
- Freshwater access in rural areas
- Establishment of ponds and groundwater recharge

Key stakeholders

- Multinational agencies: JICA, WB, GIZ, UNFAO
- Governmental agencies: Ministry of Rural Rehabilitation Development (MRRD), Ministry of Energy and Water (MEW), Ministry of Agriculture, Irrigation and Livestock (MAIL), National Environmental Protection Agency (NEPA)
- Associations/NGOs: Aga Khan Foundation (AKF), UNDP, JICA
- Village institutions: community development councils (CDC), CFA, CRA
- Academic institutions: Kabul Polytechnic University (KPU), Kabul University (KU)
- Social cooperation: Provincial Development Council (PDC)

SEDIMENT MANAGEMENT

The nature of the landscape in a river basin means that on balance soil erosion due to water occurs at higher elevations and sedimentation at lower elevations. Watershed degradation produces sediment which is deposited downstream. How far the sediment load is transported, depends on a number of factors including the speed of flow of the water and the particle size of the sediment. The sediment load in a river reduces the river's capacity to accommodate the flow and causes the river to meander and shift as the sediment is deposited. At the same time, annual silt deposition is the natural basis of fertility in many plains areas, and loss of this source of nutrients can also be problematic.

All river basins in the HKH face challenges related to erosion and sedimentation, thus sediment management plays an important role in IRBM. In Afghanistan, for example, high sedimentation resulting from poor vegetation coverage and intense rainfall is a key challenge in the river basins. In IRBM, it is important to understand the way in which sediment is produced, how it is transported and deposited, and how it can be managed. Annex 1 provides an overview which can be used as a basis when preparing an outline plan. It describes the source, pathway, and deposition of sediment and introduces the basic principles of sediment management. Approaches include reducing soil erosion and production of sediment through soil and water conservation measures at watershed scale; stabilization of stream and river banks and neighbouring slopes using nature-based and engineering solutions; and sediment management in the downstream/receptor location. Low cost techniques, including bioengineering, for soil and water conservation and other multiple local benefits (fodder, timber, others) are also shared. This learning should be deepened through field visits to observe the impacts of erosion and sedimentation together with effective control measures (see, for example, Module 8).

Sedimentation management provides a useful example of the need for integrated approaches in a river basin, as the main source of sediment lies far from the main area of impact. Actions undertaken upstream can have a marked negative impact or can mitigate problems experienced downstream. At the same time, the causes and impacts of sediment production, and many control measures, are closely interlinked with the causes, and control, of flooding, as well as many other activities and interventions in a basin. Only by taking a holistic view that takes all of these into account and integrates activities across the basin will it be possible to maximize impact and benefit.

6.3.3. Integrated flood risk management – operationalizing water resource management at watershed, sub-basin, and basin scale

Floods are among the most common natural disasters in the Himalayan river basins, and experienced on an annual basis, often leading to widespread loss of life and property (Wester, Mishra, Mukherji, & Shrestha, 2019). In the HKH, water-related disasters, especially floods, are likely to have cascading transboundary impacts. The impacts of floods originating in the upstream are experienced downstream.

There is a growing perception that natural disasters, in particular flash floods and droughts, are more frequent and intense than in the past and that the level of destruction has increased. Water is the primary medium through which the effects of climate change are expected to manifest and it is generally expected that climate change and increased climate variability will result in an increase in both the number and scale of flood events through a range of different processes. Climate change is predicted to exacerbate existing vulnerabilities to land degradation, floods, and drought across the HKH, including in Afghanistan (HELVETAS-Afghanistan, 2010; Shrestha et al., 2015).

In order to manage flood risk, it is first necessary to have an understanding of the different types of flood that can occur, and how they arise.

TYPES OF FLOOD

There are two main types of flood: riverine floods and flash floods. Riverine floods are characterised by a slow increase in the volume of water in a river leading to widespread inundation of low-lying areas that can last for considerable periods of time. Flash floods are sudden and intense surges of water that rise and fall very rapidly along a water course with an intensity that can destroy river banks, wash away or damage infrastructure, and cause loss of life. Table 1 shows the major characteristics of the two types of flood.

Riverine flooding is generally more common from larger rivers and occurs following prolonged intense rainfall with high runoff, or occasionally from rapid snowmelt. Although the increased flow may primarily originate from runoff upstream, the impacts tend to be greatest downstream with inundations common during the summer monsoon in all the downstream floodplain areas of the HKH and to a lesser extent in the transition zone Siwalik regions. Floods lead to considerable loss of life and property in the HKH countries, accounting for 17% of people killed and 51% of damage caused by disasters annually, and displacing thousands of people from their homes (Wester et al., 2019, chapter 11).

Infrastructure failure in the floodplain areas can also lead to flooding even when river levels are not especially high, as happened in August 2008, when a flood control embankment along the Koshi river in the Nepal Terai was breached. The breach and subsequent floods caused unexpected devastation and heavy damage in India and Nepal, including the deaths of 235 people and 787 livestock. A population of 4.8 million was affected by the flood, with 322,169 houses destroyed and more than 338,000 ha of agricultural land damaged (Mishra, 2008). Even a decade after the disaster, it is still possible to observe the extent of the damage as most of the land remains barren. More details are given in Module 8 Section 8.2.3, and Annex 4 Information Sheet 14.

TABLE 1 **CHARACTERISTICS OF FLASH FLOODS AND RIVERINE FLOODS**

	Flash floods	Riverine floods
Features	Rapid water level rise above natural channels Reaches peak flow within minutes up to a few hours Rapid recession (within minutes to a few hours) Often dissipate quickly Not necessarily related to base flow levels Short lag times	Slow water level rise beyond natural channels Reaches peak flow within days to weeks Slow recession (within days to weeks) Mostly coinciding with high base flow levels Medium to long lag times
Causes	Very high intensity rainstorms/cloudbursts Rapid snow/glacial melt due to rapid increase in temperature Dam (both artificial and natural) breaks	Prolonged seasonal precipitation of low to high intensity Seasonal snow and glacial melt
Associated problems	Often carry high sediment and debris loads Very high hydraulic force and erosive power	Inundation
Frequency	Occasionally, any time during the year	Annually during rainy season
Affected areas	River plains and valleys Alluvial fans Mostly local extent Generally small to medium areas are affected	River plains and valleys Local to regional extent Large areas can be affected
Predictability	Very difficult to forecast	With appropriate technology and measures in place, forecasting is easily possible
Potential mitigation measures	Early warning systems Community preparedness and awareness Appropriate emergency measures	Real-time flood forecasting Community preparedness and awareness Appropriate emergency measures

Source: Xu et al. (2006)

Flash floods are common across the HKH region and can occur at any time of year. They have a variety of causes including excessive high intensity rainfall (cloudbursts), most commonly during the monsoon; collapse of landslide dams formed across rivers as a result of slope failure following heavy rainfall or earthquakes (landslide dam outburst floods, LDOFs); and glacial lake outburst floods (GLOFs). Flash floods generally originate in the mountain and hill areas of a river basin and have a mostly local impact as their force dissipates as the river flows downstream. Nevertheless, the impacts can be devastating, and they can be transboundary. In Nepal, a massive landslide created a high dam across the Sun Koshi river on 2 August 2014. Within 13 hours, a lake formed and rapidly grew to hold an estimated 7 million cubic metres of water; the backwaters extended three kilometres upstream and submerged a hydropower station and forced the relocation of an entire village. Two hydrometeorological stations from the Department of Hydrology and Meteorology which had been upgraded to telemetric real-time stations by the Establishment of a Regional Flood Information System in the HKH Region (HKH-HYCOS) project (Annex 4 Information Sheet 5), were instrumental in continuously monitoring the flows upstream and downstream of the landslide site and determining the volume of water held by the lake. Nepal's security forces used controlled explosions to release some of the stored water and prevented a LDOF. For more details see Section 8.2.2 in Module 8 on the Jure Landslide, and Annex 4 Information Sheet 5.

Communities living in the flood plains of river tributaries are equally vulnerable to floods. On 12 August 2017, a flood originating in the Siwalik hills in Nepal affected the river tributaries. The heavy rain resulted from a monsoon trough – an elongated area of low pressure that formed parallel to the foothills of the Himalaya. A local-level community-based flood early warning system implemented in the cross-border area of the Ratu river between Nepal and India successfully detected the water level rise and informed downstream communities, giving them close to eight hours of lead time to prepare. For more details see Section 8.2.3 in Module 8 and Annex 4 Information Sheet 10.

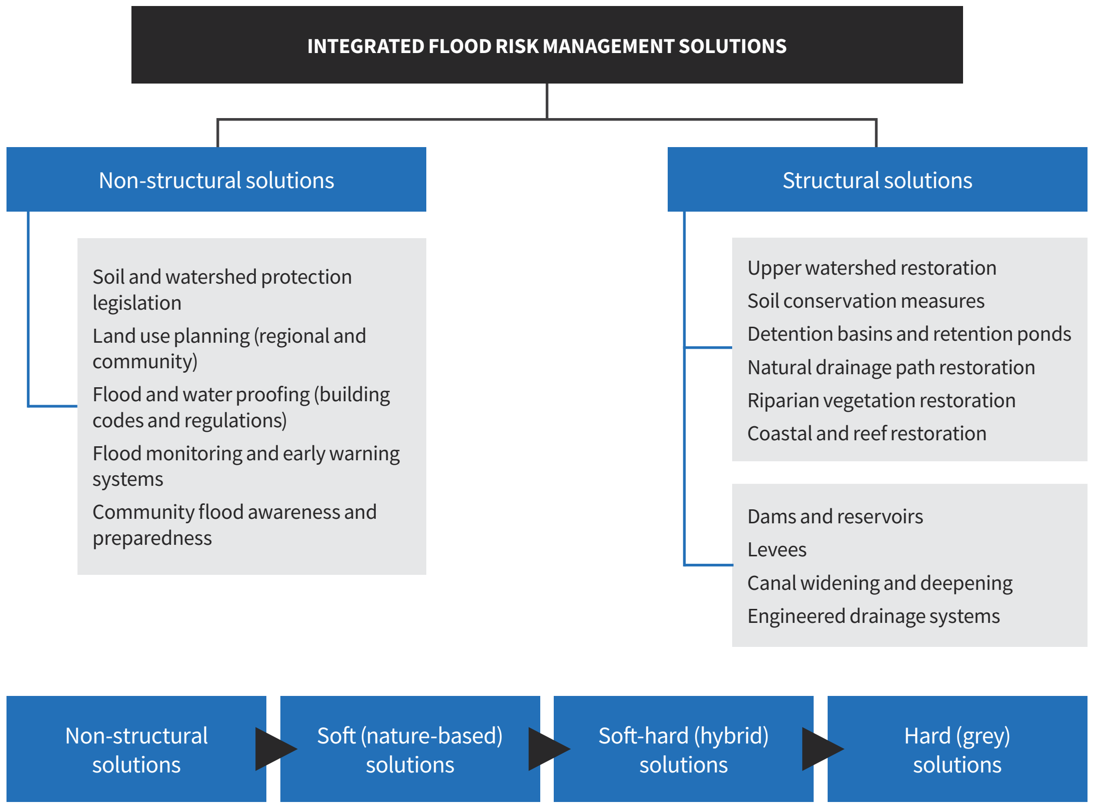
In Afghanistan, flash floods carry considerable amounts of debris and lead to loss of lives, crops, and animals, and jeopardise development efforts, with disproportionate impacts on women and marginalised communities. And flash floods can contribute to sediment load (Section 6.3.2). The Amu river carries about 250 million m3 of sediment from flash floods every year and erodes large tracts of fertile land (Bahadurzai & Shrestha, 2009).

INTEGRATED FLOOD MANAGEMENT

Although the primary cause of flooding is usually rainfall, which cannot be controlled, many factors contribute to the development of both riverine and flash floods and their impact, and these offer possibilities for management and mitigation. Upstream, infiltration may be reduced and runoff increased as a result of changes in vegetation cover and agricultural practices, infrastructure construction (roads and buildings), draining of wetlands, and failure to maintain drainage systems. Many of the factors leading to increased sediment (see Section 1.3.2) also lead to increased runoff. Similarly, in downstream areas prone to flooding, infrastructure such as roads, culverts, and check dams may obstruct the natural flow of surface runoff in flat areas. At the same time, flood risk is increased in many areas by increasing urbanization and location of settlements, roads, and other infrastructure close to narrow water courses and on floodplains.

IFM takes account of both causes and effects, and is therefore a planned adaptation strategy to climate change and DRR. IFM promotes an integrated – rather than fragmented – approach to flood management. It integrates land and water resource development in a river basin in a gender-sensitive and socially inclusive approach, within the context of IRBM (WMO 2009). It is not possible to eliminate all flood risks but they can be reduced with prevention measures (e.g. land use management and spatial planning); protective infrastructure (e.g. flood protection walls); natural resource management; better preparedness (e.g. early warning systems); and risk transfer (e.g. insurance, collective action).

FIGURE 21 NON-STRUCTURAL AND STRUCTURAL FLOOD RISK MANAGEMENT APPROACHES AND STEPS IN IMPLEMENTATION



Adapted from Ilieva (2018)

An IFM plan should address the following six key elements for managing floods (WMO 2009):

1. Manage the water cycle as a whole
2. Integrate land and water management
3. Manage risk and uncertainty
4. Adopt a best mix of strategies
5. Ensure a participatory approach
6. Adopt integrated hazard management approaches

IFM recommends a wide range of solutions which could include both non-structural and structural measures (Figure 21). Non-structural measures are measures not involving physical construction which use knowledge, practice, or agreement to reduce disaster risks and impacts, in particular through policies and laws, public awareness raising, training, and education (UNDRR, 2017). Non-structural measures work by using a different set of strategies, such as risk tolerance, risk prevention, and risk mitigation and encompass a wide diversity of measures such as land use planning, devising and enforcing construction and structure management codes, soil management, land acquisition policies, insurance, sensitizing the population through perception and awareness campaigns, disseminating information, as well as putting in place systems for emergency and post-disaster preparedness. Structural measures are any physical construction to reduce or avoid possible impacts of hazards, or the application of engineering techniques or technology to achieve hazard resistance and resilience in structures or systems. Ilieva et al. (2018) further classify structural measures as nature-based (soft) solutions (e.g. wetland restoration and natural drainage path recovery), grey (hard) solutions (e.g. dams and reservoirs), and hybrid solutions combining both soft and hard approaches (e.g. dikes with ecosystem restoration). Many of the nature-based solutions for flood control involve reducing runoff by retaining water on the slope and increasing infiltration, and are similar to the solutions used for sediment control described above in Section 6.3.2 and in Annex 1.

An integrated approach using a combination of structural and non-structural measures generally yields the best results (Shrestha, Chapagain, & Thapa, 2011).To reduce flood risk effectively, Ilieva et al. (2018) recommend applying non-structural solutions first and then considering structural solutions, first prioritizing nature-based solutions and then considering grey solutions in addition, or on their own (Figure 21). The HKH-HYCOS Regional Flood Information System for riverine flood forecasting and the community-based flood early warning system mentioned above are non-structural flood management solutions, whereas the flood control embankment mentioned above is a hard structural measure.

Annual floods also have beneficial effects that should be appreciated. Floods contribute to groundwater recharge and carry nutrients and sediments which are useful for agriculture and aquatic life as well as groundwater filtration, leading to natural water purification. Floods also support navigation by boats (ICIMOD, 2018). The impact on such benefits should also be taken into account when designing flood control measures.

6.3.4. GLOF risk reduction – Operationalizing water resource management at basin level

There are an estimated 54,000 glaciers in the HKH covering 60,000 km^2. Most appear to be melting more rapidly than before and shrinking (Bajracharya, Maharjan, & Shrestha, 2014). Among others, this is leading to rapid formation and expansion of glacial lakes (Yao et al., 2010), with an increased risk of destabilization and collapse of the moraine dams (Cruz et al., 2007) and subsequent glacial lake outburst floods (GLOFs). As of 2000, the HKH has witnessed more than 33 identifiable GLOFs, with at least 50 suspected, and the number is increasing (LIGG, WECS, & NEA, 1988; Wester et al., 2019). The risk posed by GLOFs can be transboundary (Ives, Shrestha, & Mool, 2010), with events taking place in high mountain areas in one country having devastating impacts downstream in another (Khanal et al., 2015). GLOFs can also impact the livelihoods of people living beyond the hazard zone due to disruptions in transportation, trade, and public services (see, for example, Section 8.2.1 in Module 8 and Annex 4 Information Sheet 3). It is difficult to predict GLOF events and human safety cannot be assured. However, updated information on glacial lakes, regular monitoring of potentially dangerous glacial lakes (PDGLs), and warning systems can help reduce the risk.

BOX 2

RECENT GLOF EVENTS IN THE HINDU KUSH HIMALAYA

On the 28 July 2015, the Lemthang Tsho gave rise to a GLOF in northwestern Bhutan following two days of incessant rainfall which opened up the englacial conduit resulting in emptying of interconnected supraglacial lakes (Gurung et al., 2017). On 5 July 2016, the moraine dammed Gongbatongshacuo lake in Tibet Autonomous Region, China burst following a debris flow into the lake; the floodwater caused severe damage in the Bhote Koshi valley in Nepal (Cook, Andermann, Gimbert, Adhikari, & Hovius, 2018). On 20 April 2017, a GLOF was triggered from the Langmale glacial lake in the Barun valley, Nepal, by a chain of events starting with a massive rockfall from Saldim Peak, which hit an unnamed glacier below causing an avalanche which plummeted down into the Langmale lake, causing a tsunami-like wave to form and topple over the moraines, resulting in immense damage downstream (GlacierHub, 2019). Finally, on 12 July 2018, a GLOF occurred in Peshghor village in Khenj district in Panjshir province, Afghanistan. The outburst happened as a result of erosion and melting of the debris/ice core in a moraine dam, leading to failure and sudden breaching of the dam and outflow of the lake (Maharjan, 2018).

PHYSICAL GLOF RISK MANAGEMENT

Remote sensing can help in monitoring and tracking the formation or expansion of glacial lakes, and identifying lakes potentially of concern, on a large scale (Shrestha et al., 2017). Field-based monitoring and detailed investigation of potentially dangerous glacial lakes will help identify the condition and volume of individual lakes, and the possible impacts of GLOF hazards and the risk to downstream areas. Countries like Nepal and Bhutan have made considerable progress in GLOF risk management by monitoring glacial lakes, installing early warning systems (EWS; see, for example, Information Sheet 2 of Module 8), and taking mitigation measures. Early warning systems have been installed in the Tsho Rolpa lake, Tama Koshi valley, and Imja Tsho, Khumbu valley (ICIMOD, 2011; Kargel et al., 2015; Skyship Films, 2017) in Nepal. Structural mitigation activities for GLOF risk reduction were carried out for Tsho Rolpa in 2000 and Imja Tsho in 2016. In Bhutan, hazard zonation (red, yellow, and green zones) was carried out in two vulnerable valleys – Punakha and Chamkhar – which helped in providing useful inputs to disaster risk management practitioners and the administration. An early warning system was installed based on a meteorological observatory near the neighbouring Pechung, Raphstreng, Thorthomi, and Lugge glacial lakes in the Lunana region of the Punakha valley, using instrumentation to record discharge measurements. High frequency (HF) sets were used to relay warnings during structural mitigation activities undertaken at the lakes. In 2017, an early warning system was installed at Passu in Pakistan and was used successfully to warn communities when the water level was raised due to a blockage from a debris flow.

COMMUNITY-BASED GLOF RISK REDUCTION APPROACHES

Many settlements in the Himalayan region are situated near river banks or on high flood plains. Communities living directly downstream of a glacial lake face the greatest risk from GLOF events. To reduce risk and increase resilience, communities should be encouraged to become involved in activities like GLOF hazard and vulnerability mapping, risk assessment, deployment of early warning systems, and mitigation measures. They should be well informed and aware of the flood prone areas and GLOF risks to enable them to make timely decisions pre and post GLOF events. In addition, involvement in such activities will also give them insights into future planning in terms of the structural planning of houses, safeguarding socioeconomic assets, managing their agricultural crops, and adapting and building resilience against hazards. In community-based approaches, the gender dimension is a priority as women are usually primarily responsible for household tasks such as collecting water and firewood and herding animals, and they are the ones who spend most of their time at home. If women are provided with hands on information about glacial lakes and GLOF risks and are trained in adaptation measures, they will be more likely and able to adopt appropriate measures for safeguarding their homes, lives, livelihoods, socioeconomic assets, and infrastructure.

Community-based GLOF risk reduction approaches have been quite successful and provided considerable benefit during the mitigation activities undertaken on the Tsho Rolpa and Imja Tsho lakes in Nepal. Communities were actively involved in the drainage of the lake and installation of early warning systems, and learned to evacuate to safety on hearing warning alarms. Similarly, the communities participated considerably in the lowering of Thorthomi lake in Bhutan to reduce the risk of a GLOF.

6.3.5. Nested and inclusive organizations

When considering the operationalisation of specific topics such as spring management or flood control, it is important to identify all the stakeholders in the river basin who should be involved. Institutions are understood to be ‘the humanly devised constraints that shape human interaction’ and consist of complexes of norms, values, and behaviours that persist over time and inform action (North, 1990; Uphoff, 1986, as cited in Svendsen, Wester, & Molle, 2005). Organizations are defined as ‘groups of individuals bound by some common purpose to achieve objectives’ (North, 1990). The combination of institutions and organizations together forms institutional arrangements (Svendsen et al. 2005). Svendsen et al. (2005) proposed a framework of enabling conditions and functions to operationalize institutional arrangements for water management in a river basin. The framework includes a matrix for identifying the multitude of stakeholders in a river basin combining various sectors and actors (see, for example, Module 5). It is important to ensure that an inclusive approach is used, as only by involving all those with a stake in the outcome will it be possible to develop and implement effective plans.

6.4. ICIMOD’s Knowledge Park at Godawari

The easiest way to learn about the practical possibilities for managing water resources at local and watershed level is to visit a demonstration site, model village, or simply an area where various methods are being demonstrated and applied. There are a few such opportunities in the HKH region and those who are interested should try to discover any that are not too far distant (ICIMOD, 2009). The ICIMOD Knowledge Park at Godavari is of particular interest for those interested in integrated watershed management in catchments in the mid-hill regions of the central and eastern Himalaya.

The ICIMOD Knowledge Park lies on the southern slopes of the Kathmandu Valley and was set up in March 1993, following the generous provision of 30 hectares of land by the Government of Nepal. Originally named the ‘Godavari Trial and Demonstration Site’, the Park was intended for testing and demonstration of various methodologies related to integrated mountain development and sustainable farming practices on the sloping land of the mid-hills of the Hindu Kush Himalaya. Over the years, it has been transformed from a degraded site to a lush green micro-catchment. Among others, the Park has a 3-D model demonstrating groundwater movement to help understanding of springshed management. It also demonstrates a range of sustainable land management practices, simple technologies for water management and renewable energy, wetland revival, a community-based flood early warning system, and an automatic weather station (ICIMOD, n.d.). Many of its features can be observed in a virtual tour viewable online.

6.5. Frequently asked questions

WHAT IS REQUIRED TO OPERATIONALIZE WATER RESOURCES MANAGEMENT FOR RIVER BASIN MANAGEMENT IN THE HKH?

Operationalization of water resource management for river basin management requires a holistic, systematic, context-specific, multi-stakeholder, and iterative process. Technical, gender and socially inclusive, and institutional solutions are required for sustainable development of both groundwater and surface water and management at multiple scales, taking into account social, economic, and environmental objectives and upstream-downstream linkages.

BOX 3

RECENT GLOF EVENTS IN THE HINDU KUSH HIMALAYA

On the 28 July 2015, the Lemthang Tsho gave rise to a GLOF in northwestern Bhutan following two days of incessant rainfall which opened up the englacial conduit resulting in emptying of interconnected supraglacial lakes (Gurung et al., 2017). On 5 July 2016, the moraine dammed Gongbatongshacuo lake in Tibet Autonomous Region, China burst following a debris flow into the lake; the floodwater caused severe damage in the Bhote Koshi valley in Nepal (Cook, Andermann, Gimbert, Adhikari, & Hovius, 2018). On 20 April 2017, a GLOF was triggered from the Langmale glacial lake in the Barun valley, Nepal, by a chain of events starting with a massive rockfall from Saldim Peak, which hit an unnamed glacier below causing an avalanche which plummeted down into the Langmale lake, causing a tsunami-like wave to form and topple over the moraines, resulting in immense damage downstream (GlacierHub, 2019). Finally, on 12 July 2018, a GLOF occurred in Peshghor village in Khenj district in Panjshir province, Afghanistan. The outburst happened as a result of erosion and melting of the debris/ice core in a moraine dam, leading to failure and sudden breaching of the dam and outflow of the lake (Maharjan, 2018).

WHAT ARE THE POSSIBLE MEASURES FOR WATER RESOURCES MANAGEMENT FOR RIVER BASIN MANAGEMENT IN THE HKH?

Technological and institutional measures for GLOF risk reduction, flash flood and flood risk management, sedimentation management, and drought risk reduction are an integral part of river basin management. The solutions should be designed and implemented in a collaborative manner within a common methodological and operational framework.

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MODULE 6 | KEY TAKEAWAYS

Operational aspects of water and land management

SECTION 6.1
INTRODUCTION

Due to administrative decentralization, opportunities for engaging local communities in resource management have increased over the years.

SECTION 6.2
LEARNING OBJECTIVES

The key objective is to share some solutions which can be applied at regional to local scales for operationalizing IRBM.

SECTION 6.3
EXAMPLES OF MANAGEMENT APPROACHES IN OPERATIONAL IRBM AT DIFFERENT SCALES

The module looks at four examples of management approaches that can be used in operational IRBM together with the role of institutions.

SECTION 6.4
ICIMOD'S GODAVARI KNOWLEDGE PARK

The ICIMOD Knowledge Park is of particular interest to those interested in integrated watershed management in catchments in the mid-hill regions.

SECTION 6.5
FREQUENTLY ASKED QUESTIONS

Operationalization of water resource management for river basin management requires a holistic, systematic, context-specific, multi-stakeholder, and iterative process.

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MODULE 7

Knowledge management and communication

The importance of IRBM, especially in an era of climate variability and change, has to be communicated clearly and effectively.

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KEY MESSAGES

Knowledge Management (KM) is a multidisciplinary field of research and practice, which includes the process of applying a systematic approach to the capture, structuring, management, access, and dissemination of knowledge for improved decision making.

The key components of KM include people, processes, technology, and culture.

Knowledge management plays an important role in IRBM specifically in terms of developing and sharing strategies, tools, techniques, and perspectives that can help overcome the fragmented nature of existing data, information, and knowledge and can help in planning research and other knowledge activities, products, and promotion more effectively.

Developing and implementing a knowledge management and communication strategy in IRBM can help facilitate greater stakeholder involvement and ownership so that knowledge products and platforms and key messages are pitched for the right audiences, in the right way, and at the right time.

7.1. Introduction and relevance

This module is aimed at introducing knowledge management and communications concepts, principles, tools, and techniques that will help people working in IRBM to plan; to document, generate, compile, store, and share; and to identify systems, platforms, and protocols for knowledge generation and sharing in order to maximize the effectiveness of their IRBM activities. This module also intends to provide a common reference space for a consistent understanding of the different key terms used in the domain of knowledge management and communication for all relevant stakeholders working in IRBM.

In IRBM, it is useful to identify both high quality science and the effective local knowledge systems that support best practices, thereby facilitating stronger partnerships and networks, more effective technological implementation, enhanced decision-making, and stronger feedback loops to address emerging issues and potential conflicts.

Knowledge sharing, learning processes and tools, data and information management, effective communication, supportive infrastructure, and capacity development are critical knowledge management pillars for achieving more knowledge-intensive IRBM. They ensure that

- a broad and relevant array of stakeholders are engaged and informed to take collective action;
- scaling up and out of successful practices and innovations accelerates and reaches across boundaries and contexts; and
- policy/decision makers are equipped with enhanced evidence to enable improved policies.

The importance of IRBM, especially in an era of climate variability and change, has to be communicated clearly and effectively. At the same time, national level data and information on flows, users, and competing claims, as well as future scenarios need to be shared with relevant stakeholders in the form of knowledge products and on platforms that are accessible and user friendly. One such platform is the National Reports Submission Portal, which the Annex-I and Non-Annex-I countries/parties to the UNFCCC use to submit their 'National Communication' periodically. A 'National Communication' is a type of report submitted by the countries that have ratified the Paris Agreement under the UNFCCC. The National Communication reports are comparatively longer and represent the most standardized and comparable documents on the climate policies of different countries. Another similar document is the Nationally Determined Contribution, these are shorter and less specific (UNFCCC: https://unfccc.int/).

Much existing information may be fragmented, located in multiple institutions and inaccessible. Knowledge management can facilitate compilation, value addition, and access through appropriate platforms and knowledge products. Some of these messages also need to be communicated through the popular media and other forms to general audiences, particularly local stakeholders. This is particularly relevant for building the resilience of communities to climate shocks, and for DRR through early warning. Throughout, it is important to communicate and emphasize the holistic nature of IRBM and the shift from narrow or sectoral approaches.

7.2. Learning objectives

The learning objective of this module in terms of demonstrable skills or knowledge includes:

- a basic understanding of the principles of knowledge management and communication; and
- a consideration of issues and challenges of implementing knowledge management and communication approaches in IRBM work in the HKH region.

The aim is to enable you to define key KM concepts and to understand approaches for identifying target audiences, tailoring content, and using appropriate tools for communication. This learning can be used to establish and implement a knowledge management and communication strategy, to develop case studies, and to develop key messages communicating the importance of IRBM to specific and general audiences and stakeholders. Finally, the module discusses approaches to creating content yourself, including by using multimedia tools.

7.3. Knowledge management for IRBM

The module covers the key principles of knowledge management; understanding differences in data, information, and knowledge; identifying knowledge sources, platforms, and existing knowledge sharing networks and practices; knowledge management challenges and opportunities in IRBM in the HKH; and key principles of science communication and new media.

7.3.1. Key principles of knowledge management

Knowledge management principles are used in IRBM for a range of activities including mapping the institutional landscape, sources of information, access to information and knowledge, how access to that knowledge is mediated, and the platforms and tools used for knowledge sharing. But before applying knowledge management in IRBM, it is first necessary to have a basic grasp of the key principles.

Knowledge management is based on the idea that knowledge is an asset that should be managed. The importance of knowledge management cannot be overemphasized; effective knowledge management is a prerequisite for cooperation and success in an integrated broad scale undertaking. The DIKW (data, information, knowledge, wisdom) hierarchy is shown in Figure 22. Some of the key terms used in knowledge management practice are summarised below.

Data: Facts and figures which relay something specific, but which are not organized in any way and which provide no further information regarding patterns or context. One definition presented by Thierauf (1999) is "unstructured facts and figures that have the least impact on the typical manager."

Information: For data to become information, it must be contextualized, categorized, calculated, and condensed (Davenport & Prusak, 2000). Information thus paints a bigger picture; it is data with relevance and purpose (Bali, Wickramasinghe, & Lehaney, 2009). It may convey a trend in the environment, or perhaps indicate a pattern of sales for a given period of time. Essentially information is found "in answers to questions that begin with such words as who, what, where, when, and how many" (Ackoff, 1999).

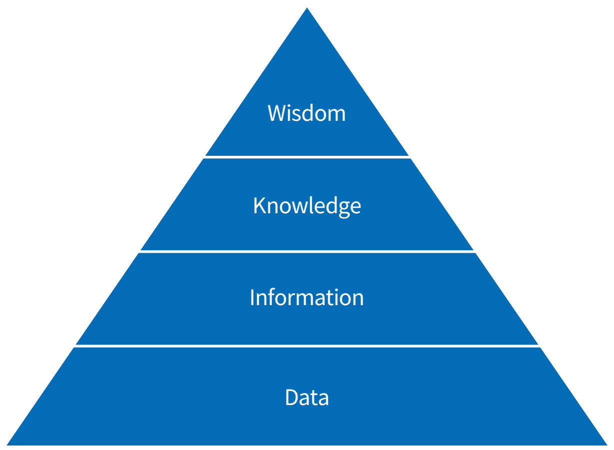
Knowledge: Knowledge is closely linked to doing and implies know-how and understanding. The knowledge possessed by each individual is a product of his/her experience, and encompasses the norms by which s/he evaluates new inputs from his/her surroundings:

Knowledge is a fluid mix of framed experience, values, contextual information, expert insight, and grounded intuition that provides an environment and framework for evaluating and incorporating new experiences and information. It originates and is applied in the mind of the knowers. In organizations, it often becomes embedded not only in documents or repositories, but also in organizational routines, practices, and norms (Davenport & Prusak, 2000).

In the age of today's knowledge economy, knowledge is considered a valuable asset that is embedded in products and in the tacit knowledge of individual employees. The following are some characteristics of knowledge which are different from other types of valuable assets (Dalkir, 2013):

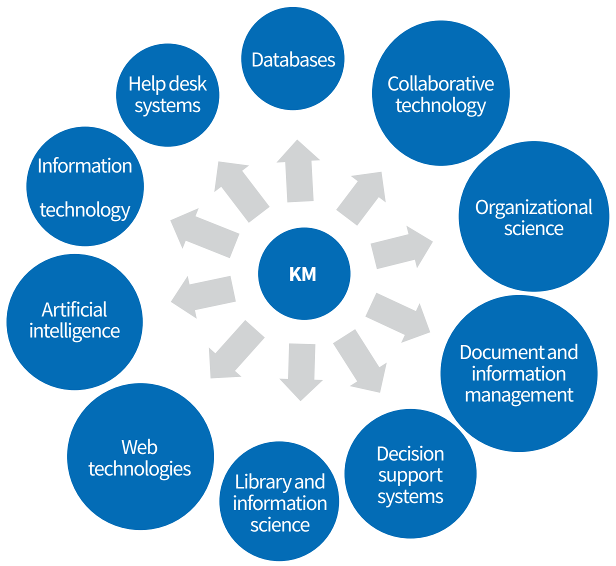
- Using knowledge doesn't consume it.
- Transferring knowledge does not result in losing it.
- Knowledge is abundant, but the ability to use it is scarce.
- Much of an organization's valuable knowledge walks out the door at the end of the day.

FIGURE 22 THE DIKW HIERARCHY (DATA, INFORMATION, KNOWLEDGE, WISDOM)



Source: Adapted from Ackoff, 1989

FIGURE 23 INTERDISCIPLINARY NATURE OF KM



Source: Dalkir, 2011

KNOWLEDGE MANAGEMENT

Knowledge management is the process of creating, sharing, using, and managing the knowledge and information of an organization. It refers to a multi-disciplinary approach to achieving organizational objectives by making the best use of knowledge.

Knowledge management is the deliberate and systematic coordination of an organization's people and its processes, technology, and culture/organizational structure in order to add value through reuse and innovation. This is achieved through the promotion of creating, sharing, and applying knowledge as well as through the feeding of valuable lessons learned and best practices into organizational memory in order to foster continued organizational learning.

KM has a multidisciplinary nature and draws upon a vast number of diverse fields as indicated in Figure 23.

WHY KNOWLEDGE MANAGEMENT?

The objectives of understanding and implementing knowledge management in an organizational setting are to

- facilitate a smooth transition from those retiring to their successors who are recruited to fill their positions,
- minimize loss of corporate memory due to attrition and retirement,
- identify critical resources and critical areas of knowledge so that the corporation knows what it knows and does well – and why, and
- build up a toolkit of methods that can be used with individuals, with groups, and with the organization to stem the potential loss of intellectual capital.

TACIT AND EXPLICIT KNOWLEDGE

There are numerous ways to categorize different types of knowledge, but for the purposes of knowledge management it is useful to take into consideration the concepts of tacit knowledge and explicit knowledge (Table 1).

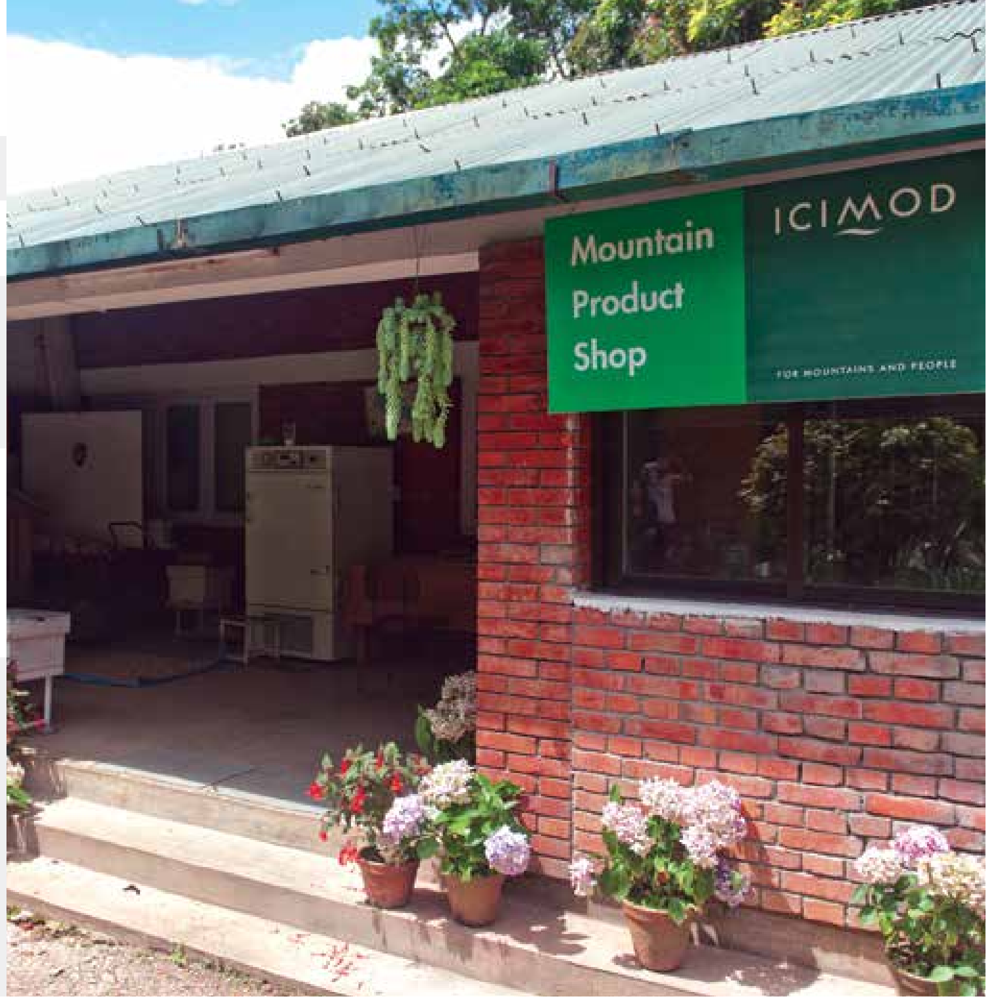
Tacit knowledge is the kind of knowledge that is often considered 'know-how' and some may see it as intuitive knowledge that a skilled practitioner may take for granted. It can be difficult to articulate and difficult to put into words, text, or drawings. Tacit knowledge tends to reside within the heads of 'knowers', whereas explicit knowledge is usually contained within tangible or concrete media. Explicit knowledge represents content that has been captured in some tangible form such as words, audio/video recordings, or images.

In the context of IRBM, it is important first to develop a comprehensive overview of the type of knowledge that will be required.

TABLE 1 EXPLICIT KNOWLEDGE AND TACIT KNOWLEDGE

	Explicit knowledge	Tacit knowledge
Nature	Easily identifiable Relatively easy to share Intrinsically incomplete, lacks context and requires interpretation	Within-person knowledge Difficult to articulate Hard to share Can be shared only directly
Typical examples	Information Know-that Theoretical knowledge	Intuition and insight Practical intelligence, skills and practice Know-how Rules of thumb Mental models and beliefs
Mechanisms for generating and sharing	Codification Documentation Databases and search engines Blogs, wikis, intranet	Practice Personal and team reflection Drawing mental maps Apprenticeship Social interaction and mentoring Storytelling and metaphors New codification systems can make some tacit knowledge easier to share, through converting some elements of it into explicit knowledge

Source: Goffin, Koners, Baxter, & van der Hoven, 2010



7.3.2. Importance of knowledge management

The major drivers behind increased interest in and application of KM lie in four key areas:

1. Globalization of business. Organizations today are more global – multisite, multilingual, and multicultural in nature.
2. Leaner organizations. We are doing more and we are doing it faster, but we also need to work smarter as knowledge workers, adopting an increased pace and workload.
3. Corporate amnesia. We are more mobile as a workforce, which creates problems of knowledge continuity for the organization and places continuous learning demands on the knowledge worker. We no longer expect to spend our entire work life with the same organization.
4. Technological advances. We are more connected. Advances in information technology not only have made connectivity ubiquitous but have radically changed expectations. We are expected to be 'on' at all times, and the turnaround time in responding is now measured in minutes, not weeks.
5. Each organization's KM practice provides benefits to individual employees, to communities of practice, and to the organization itself. This three-tiered view of KM helps emphasize why KM is important today.

KM FOR THE INDIVIDUAL

Helps people do their jobs and save time through better decision making and problem solving

- Builds a sense of community bonds within the organization
- Helps people to keep up to date
- Provides challenges and opportunities to contribute

KM FOR THE COMMUNITY OF PRACTICE

- Develops professional skills
- Promotes peer-to-peer mentoring
- Facilitates more effective networking and collaboration
- Develops a professional code of ethics that members can follow
- Develops a common language

KM FOR THE ORGANIZATION

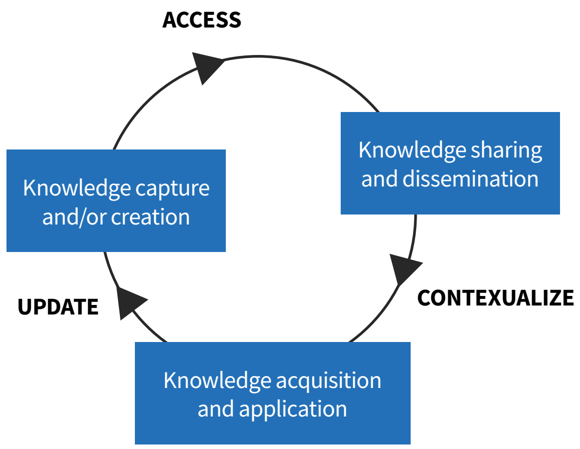
- Helps drive strategy
- Solves problems quickly
- Diffuses best practices
- Improves knowledge embedded in products and services
- Cross-fertilizes ideas and increases opportunities for innovation
- Enables organizations to stay ahead of the competition better
- Builds organizational memory

KM CYCLE

An integrated KM (Figure 24) cycle consists of three major stages

1. Knowledge capture and/or creation
2. Knowledge sharing and dissemination
3. Knowledge acquisition and application

FIGURE 24 AN INTEGRATED KM CYCLE



Adapted from Dalkir, 2011

7.3.3. Knowledge sources, platforms, and sharing

In the context of IRBM, it is important first to develop a comprehensive overview of the type of knowledge that will be required. This includes conceptual understanding of a river basin's drivers and impact including tools and approaches for understanding biophysical drivers of change; gendered vulnerabilities and the socioeconomic drivers of change; governance, policy, and institutional framework; water diplomacy and regional cooperation; and, operational aspects of water resource management. Once these have been clarified, it is possible to start identifying sources of data, information, and knowledge about the river basin; who is responsible for gathering the data/information, who holds them, and in what form; what knowledge management systems and platforms are used; and who is the audience, who can access the data/information.

Once the resources have been assessed, it is useful to consider potential knowledge management challenges and opportunities in the IRBM context. Specifically, it is useful to consider possibilities for improved communication flows and knowledge sharing practices.

The participants in the training for Afghan professionals looked at the range of institutions and stakeholders for IRBM in Afghanistan, the types of data and information they held, the platforms used for dissemination, and who had access. The results are summarised in Annex 3. The results showed that information is shared by different institutions and stakeholders and the public interest in it differs. Websites, news platforms, and institution offices are all used as information dissemination platforms.

7.3.4. Key principles of science communication and new/digital/social media

Successful IRBM means involving people at every level in interventions and activities. But first stakeholders need to be able to contribute to discussions, and commit to activities, from a basis of knowledge. People need to understand the situation, the issues to be addressed, the implications both locally and for others, and the need for and implications of specific interventions. All of this will require that you can effectively share and communicate information to a wide range of different audiences.

Furthermore, in climate change research, as in other subjects, it is good practice to recognise the different audience groups to which climate change information should be tailored. Communication analysis of climate change research has recently become of interest among researchers such as those studying trends in social engineering, to gain a better understanding of audience types and the impact of climate change communication. Long running projects like the U.S. based Yale Project on Climate Change Communication, have segmented their sample respondents into "…Six Americas… Alarmed, Concerned, Cautious, Disengaged, Doubtful, and Dismissive." (Hine et al., 2014). Similar studies have also been carried out in India where respondents in rural settings were found to be more disengaged than their urban counterparts (Hine et al., 2014). Such segmentations offer critical insights for both researchers and policymakers and help both in prioritizing the concerned areas, and suggesting the type of messaging required for different social groups.

In the following, we look at the basic principles of science communication; understanding the differences between communicating to scientific and non-scientific audiences; and evaluating the appropriateness of platforms for personal and professional communication.

SCIENCE COMMUNICATION

Science communication is generally understood to be the public communication of science-related topics to non-experts. This outreach or popularization often involves scientists but has also evolved into a professional field in its own right. Science communication also includes communication between scientists, as well as between scientists and non-scientists. Communicating science to the public is increasingly important in today's society. Perhaps the most widely recognized global expert body on the science of climate change, the Intergovernmental Panel on Climate Change (IPCC), has itself also considered the fundamental importance of communicating science effectively. In its recently released handbook for IPCC authors (Corner, Shaw, & Clarke, 2018), it identifies six basic principles for effective science communication:

- Be a confident communicator
- Talk about the real world, not abstract ideas
- Connect with what matters to your audience
- Tell a human story
- Lead with what you know
- Use the most effective visual communication

Perhaps the most important element contributing to effective communication – and thus effective science communication – is the ability to recognize the variety of different audiences who are the targets of the communication. Then, it is essential to calibrate the message such that the selected audience can understand it, and to determine the appropriate platform(s) for conveying the messages. Timing is also important; targeting the right audience at the right time can effectively bring visibility to your work and efforts.

STRATEGIES FOR COMMUNICATION

A comprehensive knowledge management strategy also includes a communication component. Within any organizational structure, it is useful to consider two types of communication strategy, those focused inward and those outward:

Internal communication strategy: This strategy should focus on engagement and sharing within an organizational structure where the activities are oriented towards achieving specific organizational objectives. Ensuring a free-flow of communication aids in proper organizational functioning and can help clarify expected information flows at different levels.

External communication strategy: This strategy should focus outward, encompassing the transmission of messaging and products produced by an organization that are shared through various channels such as newspapers, websites, and different mediums such as radio, television, and internet.

COMMUNICATION IN IRBM

The key to successful internal and external communication within IRBM is an understanding of the length and breadth of the landscape. For example, there are different needs for internal audiences such as those working within universities or government agencies and for external audiences such as a yak herding communities in the upstream of a river basin and paddy farmers downstream. Taking the time to assess the communication needs, capabilities, and platforms for internal and external audiences will allow for effective communication. In today's information age, communication requirements have shifted significantly from, "… attempting to create a need for the information one is disseminating… [to]… disseminating information for which there is a need" (Servaes, Jacobson, & White, 1996).

The role of communication at various levels, from policy and technical, and at various levels, from policy makers to the general public, cannot be overstated. Communication and raising awareness plays a crucial role in policy implementation, as the success of policy implementation depends on the involvement of a wide range of stakeholders, including the general public. A free flow of information, appropriately packaged, greatly reduces resistance to change and helps people to see the benefits of working towards multiple social, environmental, and economic objectives in a river basin (Ramsar Convention Secretariat, 2010).

At the local level, the communities in the basin have a right to information about IRBM and what is being planned in the river basin that may affect water access, use rights, water flows, and quality. The IRBM communication plan must address the issue of preparing and disseminating information in a form that is accessible and understood by local stakeholders, including how IRBM is different from a sectoral approach to river basin management, what are the implications of an integrated approach, and the favourable outcomes of such an approach. Communication at this scale in the basin could be more visual, and use a variety of media such as radio, television, local language press, and social media. Working upward, communication from the bottom up must clarify the community's concerns and incorporate their traditional knowledge so that they are able to inform and shape policy decisions related to the resources in the basin. Recent

Communicating science to the public is increasingly important in today's society. Science communication is generally understood to be the public communication of science-related topics to non-experts. This outreach or popularization often involves scientists but has also evolved into a professional field in its own right. Science communication also includes communication between scientists, as well as between scientists and non-scientists.

experience has shown that effective collaboration between agencies and local people increases the chance of success in achieving and implementing effective river basin plans (Ramsar Convention Secretariat, 2010).

At the national level, communication must be focused on conveying the idea of IRBM and generating support from national stakeholders, emphasizing the principles of the approach and the shift away from a sectoral view of the river basin. This is crucial to reinforce and enable integration. At its core, this will involve advancing the idea of integrating sectoral plans, upstream-downstream linkages, and communication of basin-level information to all stakeholders. It is important that stakeholders who have historically been excluded from the planning and decision-making processes are privileged in the consultation and communication processes. A range of communication products may be required targeted at various stakeholders, such as policy briefs for decision makers and good practice compilations for practitioners and nodal agencies. A national level communication strategy could guide communications on IRBM by clarifying the strategic and specific objectives and the key target groups, elaborating key messages, and identifying the appropriate communication tools.

When dealing with international water courses, openness and sharing of information are key to the achievement of IRBM since all involved riparian countries have "natural monopolies" in data collection and dissemination within their national territories (GWP, 2000). At the regional level, the communication plan must prepare common ground for riparian states to adopt an integrated approach to basin planning, including for consensus building and conflict resolution. A communication hub such as the Koshi Disaster Risk Reduction Knowledge Hub (http://www.icimod.org/kdkh), which brings together stakeholders from three riparian countries, could provide a platform for collating and sharing knowledge at the basin level to all stakeholders. Such a hub can also enable real time or near real time sharing of information for water resource management and to mitigate disaster risk.

BOX 1

EXAMPLE – INFORMATION AND COMMUNICATION TECHNOLOGY AND SOCIAL MEDIA IN AFGHANISTAN

Afghanistan provides a good example of the use of ICT and social media for IRBM in the HKH region.

The Ministry of Communication, Government of Afghanistan, notes the usefulness of information and communication technologies (ICT) as, "...a key, driving element for socio-economic development" and further focuses on, "access to and information regarding...weather data and other information... for farmers..." (UNPAN). Extending this beyond agriculture and across all areas related to IRBM, important questions arise about communication mandates and responsibilities with regard to data and information.

Post 2012, as 3G technology became more available to users in Afghanistan, the "...relationship between mobile, internet, and social media penetration strengthened as increasingly-common smartphones and faster data made data packages available to a wider population..." (InterNews, 2017). Indeed, the Heinrich Böll Foundation has found that social media is playing an increasingly important role in Afghanistan, noting that "Social media has become the first source of information for many people in Afghanistan" (Hossaini, 2018).

INFORMATION AND COMMUNICATION TECHNOLOGY, SOCIAL MEDIA AND IRBM

Information and communication technology (ICT) has become embedded across the HKH as a means of supporting development through provision of up-to-date information on topics as widespread as weather forecasts for crop management, market prices for value-chain interventions, and flood forecasting, as well as building partnerships and mutual support networks. ICIMOD has even instigated an 'ICT for Mountain Development Award' that recognizes innovations that can help promote mountain development and environmental conservation. ICT also provides a backbone for knowledge management and communication in IRBM.

In recent times, social media platforms have emerged as an effective and inclusive means for communication (see for example Box 1). Social media platforms thrive on user engagement and theoretically function as participatory technology that allows for public consumption of content. In the context of IRBM, which aspires towards greater cooperation in river basins, communication tools like social media can, "...put research activities in the hands of local individuals and groups" and can be "...aimed not at generating objective findings, but at social change" (Jacobson, 2003).

Although social media tools provide access to a plethora of information, the use of such technology has its own inherent limitations. Not all platforms of communication are appropriate, and certain protocols are needed to ensure that information is ultimately used for achieving development-oriented goals.

7.4. Frequently asked questions

WHAT IS KNOWLEDGE MANAGEMENT?

Knowledge management is the systematic management of knowledge assets for creating value, meeting strategic requirements, and creating the conditions and developing the tools and practices that enable people and organizations to more effectively share, create, access, and retain knowledge. A primary goal of knowledge management is to facilitate the sharing of knowledge.

WHAT IS EFFECTIVE COMMUNICATION?

Effective communication is communication between two or more persons wherein the intended message is successfully delivered, received, and understood. The effective communication includes not just the way you use the words but also covers several other skills such as non-verbal communication, ability to understand your own emotions as well as of the other person with whom you are communicating, engaged listening, and ability to speak assertively, among others.

MODULE 7 | KEY TAKEAWAYS

Knowledge Management and Communication

SECTION 7.1

INTRODUCTION AND RELEVANCE

Knowledge sharing, learning processes and tools, and supportive infrastructure are among critical knowledge management pillars for achieving more knowledge-intensive IRBM.

SECTION 7.2

LEARNING OBJECTIVES

The aim is to enable you to define key knowledge management concepts and to understand key communication approaches.

SECTION 7.3

KNOWLEDGE MANAGEMENT FOR IRBM

A national level communication strategy could guide communications on IRBM by clarifying objectives, target groups, and key messages.

SECTION 7.4

FREQUENTLY ASKED QUESTIONS

A primary goal of knowledge management is to facilitate the sharing of knowledge.

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MODULE 8

Learning from the field: Linking IRBM theory to practice

The best way to comprehend a river basin system is to undertake a physical journey along a river.

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KEY MESSAGES

IRBM needs to establish holistic and systematic management and development of water, land, and other resources.

Individual and issue-based interventions have implications for the river basin system as a whole, and these interventions need upstream and downstream linkages at various levels (catchment, sub-basin, and basin scale).

Interventions in upstream areas have important impacts on water resources and affect people downstream. Therefore, cooperation allows for a sharing of benefits and costs by all resource users at various levels (watersheds, sub-basin, and basin scale).

8.1. Introduction and relevance

Before embarking on IRBM, it is important to try and visualize a whole river basin system from upstream to downstream to understand the range of issues and opportunities presented by a river as it traverses through different elevations and zones and the interlinkages between upstream and downstream and different water uses and activities. The best way to comprehend the system is to take a physical journey along a river from upstream to downstream, visiting typical land use areas and observing interventions related to water along the way. As an example, this unit describes a field visit to the Koshi river basin in the central Himalaya offered to participants in the IRBM training for Afghani professionals organized in Kathmandu, Nepal.

The Koshi river basin has seven major sub-basins. The trip followed the flow of the main river within Nepal, starting in the Sun Koshi sub-basin (which to the north, includes the main source of the Sun Koshi river in the Tibet Autonomous Region in China). Ideally the observations should go from the source region itself to the outlet, but for practical reasons this trip remained within the national borders and information was provided about the other parts of the river. The learning visit was designed to showcase the range of issues and opportunities for IRBM, and the different scales at which actions are taken to address them. The aim was to enable participants to apply theory to practice through exposure to the field challenges, adaptation efforts, upstream-downstream linkages, and local water governance structures and initiatives in a well-inhabited and studied river basin.

The visit spanned three days with extensive road travel along the river starting in the upper reaches in Nepal at the border with China, and traversing to the downstream plains area bordering India. Figure 25 shows the route; the detailed agenda is shown in Annex 4. By observing the ground-based interventions and realities, participants were able to witness the changing nature of the river and different issues and opportunities as it makes its journey from the high mountains, through the mid-hills, to the flood plains. The trip entailed looking at land and water management in the upstream and downstream areas from the perspective of how increasing limitations in water availability can be balanced through the wise use and management of water to sustain and improve livelihoods. Governance structures at the local scale were studied to discover how communities plan their resource use. Since the opportunities and risks are associated with the river, the consequences of interventions are easily transferred to both upstream and downstream countries, irrespective of political boundaries. The main features highlighted in different parts of the basin from high elevation to low are summarised below, with further details provided in the information sheets in Annex 5.

8.2. Opportunities and challenges for IRBM along the Koshi river

8.2.1. The upper reaches

On the first day, participants visited the upper reaches of the river, where it enters Nepal from China in the Sun Koshi sub-basin. The main river is called the Bhote Koshi at this point; the name changes to Sun Koshi close to Barabise where it merges with the small tributary of that name whose source lies in Nepal. The Sun Koshi sub-basin is a transboundary basin shared between Tibet Autonomous Region in PR China (where the river is called Poiqu) and Nepal. The basin covers an area of 3,394 km^2, 60% within China, with an elevation range from 8,012 to 620 masl. The basin outlet lies near Dolalghat in Nepal where the river joins with its only right tributary, the Indrawati. The only highway linking Nepal and China (the Arniko highway) passes through this basin and is aligned along the river channel. Annex 5, Information Sheet 1 gives more details of the basin, including hydrometeorological stations, rainfall distribution, seasonal discharge, glaciation, and the socioeconomic scenario.

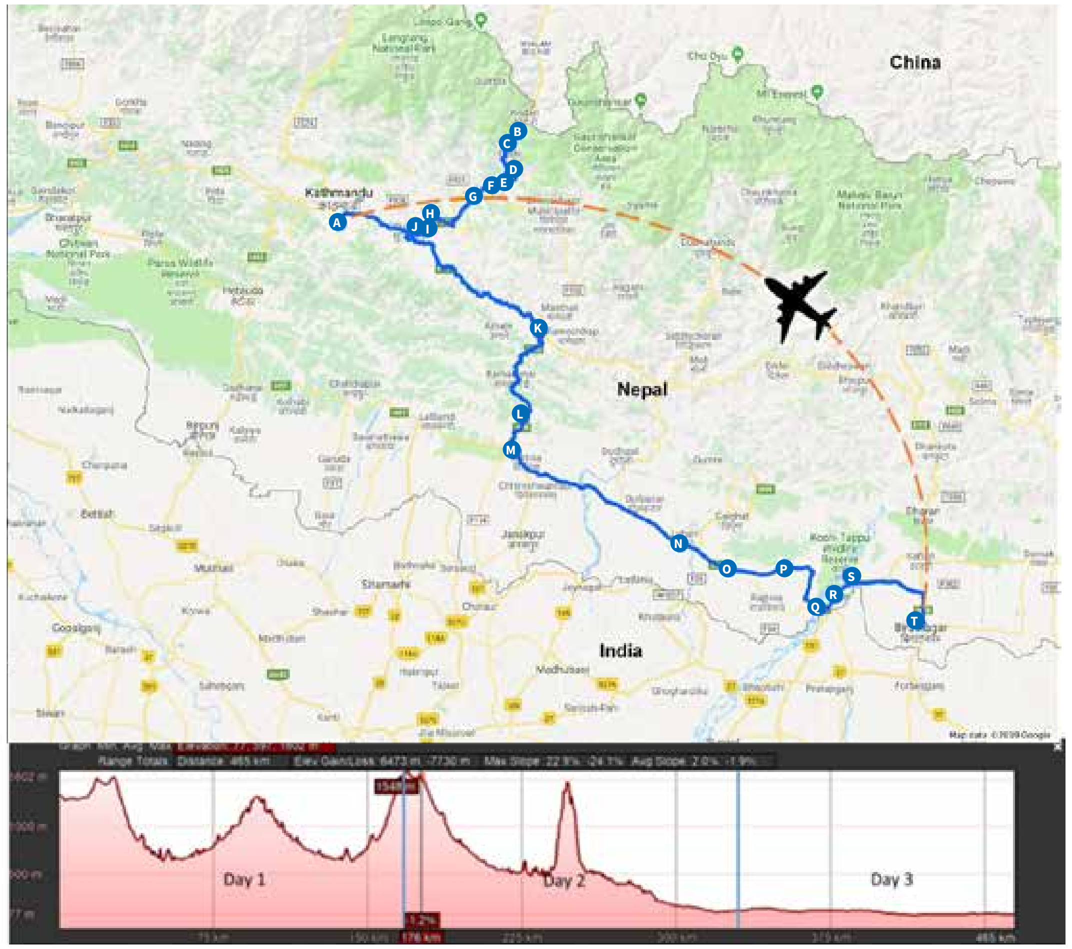
The Bhote (later Sun) Koshi river offers a perfect example of the importance of transboundary cooperation, and especially sharing of real time hydro-meteorological data. The river descends steeply, it drops 7500 m in elevation within a distance of around 220 km. The steep geology makes

FIGURE 25 ROUTE MAP – LOCATION AND ELEVATION

Day 1 Route
- A. ICIMOD, Patan
- B. Bhote Koshi Power Plant
- C. Last Resort
- D. Barabise Water Level Station
- E. Jure Landslide
- F. Sunkoshi Hydropower Plant
- G. Balefi Confluence
- H. 0 kilo
- I. Climate Smart village entry
- J. Dhulikhel Mountain Resort

Day 2 Route
- J. Dhulikhel Mountain Resort
- K. Khurkot
- L. Bahunmara village
- M. Lalgadh
- N. Hotel Durbar, Lahan

Day 3 Route
- N. Hotel Durbar, Lahan
- O. Kalyanpur Solar pump
- P. Mahuli
- Q. Koshi Barrage
- R. Koshi Embankment Breach
- S. Aqua Birds Wildlife Camp, Koshi Tappu
- T. Biratnagar Airport, Biratnagar



it highly prone to flash floods, both GLOFs and LDOFs and floods associated with intense rainfall, which can originate across the border in China. The associated risks are high as the only highway linking Nepal and China runs alongside the river and is heavily used and lined by settlements.

HARNESSING ECONOMIC POTENTIAL WHILE ADDRESSING FLOOD CHALLENGES: THE BHOTE KOSHI POWER PROJECT

There are two medium size hydropower stations along the upper reaches of the river – the Sun Koshi and Bhote Koshi – as well as several mini hydropower plants within the basin (Annex 5, Information Sheet 2). The Bhote Koshi Power Plant provides a good example of the common challenges for hydropower in the Himalayan region, especially run-of-the river systems, and the importance of flood early warning systems to save lives and property. Annex 5, Information Sheet 2 provides more details of the plant. The installation is potentially vulnerable to flash floods, especially GLOFs, from the upstream and the power plant has installed a flood warning system with sensors at the Nepal-China border. However, as a result of the short distance, this only gives a lead time of five minutes at the plant which is barely enough for evacuation of people from the plant site. The lead time could be increased considerably by installing the sensors further upstream across the border, closer to the source of any potential GLOF. This highlights the need for a platform for dialogue on transboundary flood management.

GLOF RISK AND OTHER FLASH FLOOD EVENTS: EXAMPLE OF THE SUN KOSHI BASIN

As in much of the Himalayan region, the Sun Koshi basin is highly prone to flash floods of different origins, including glacial lake outburst floods (GLOFs), landslide dam outburst floods (LDOFs), and intense rainfall floods. The headwaters area of the basin in TAR China is heavily glaciated, but the glaciers are retreating rapidly leading to the formation and growth of an increased number of glacial lakes. Outburst of such lakes can result in an outburst flood (GLOF) with potentially devastating consequences downstream. A GLOF in the area would affect the flow of vehicles, goods, and people along the Arniko and Lamosangu-Jiri highways, indirectly affecting many village development committees (VDCs) in Dolakha, Ramechhap, and Solukhumbu districts. GLOFs are a potential risk across much of the Himalaya and should also be considered in IRBM planning.

The route along the river shows evidence of the impact of previous GLOFs in the remnants of Phulping bridge, which was washed away by a GLOF in 1987. Further downstream at the Balephi confluence there is a huge boulder, the Bhinse rock, composed of augen gneiss, which does not match the surroundings geologically. The boulder is believed to have been transported by a historic GLOF and indicates the scale of flood that is possible.

Landslide dam outburst floods (LDOFs) can occur when a landslide forms a dam across a river as a result of slope failure, which can then break out catastrophically releasing the trapped water. LDOFs are also fairly common in the Himalayan mountains. The upper reaches of the Sun Koshi still show evidence of a LDOF at Larcha in 1996 which washed away 22 homes and killed 54 people.

Annex 5 Information Sheet 3 provides more information about GLOFs and other flash flood events in the Sun Koshi basin, and an example of risk assessment and preparation of a risk map for a GLOF event using modelling.

OTHER TOPICS

Tourism, especially mountain and adventure tourism, are also important in upper areas of the Himalayan basins, and should be considered in resource use planning. Tourism can place a disproportionate demand on water and also affect vegetation through fuelwood demand. At the same time, it can be a major source of income. IRBM planning also needs to take into account the positive potential of tourism for income generation, the potential negative impact on resource use, and the threat (and potential) for tourism if interventions result in changes in the landscape. The upper reaches of the Sun Koshi provide some good examples, with many tourist facilities near the border, especially resorts focussed on adventure tourism.

8.2.2 The middle reaches

MITIGATING FLOOD IMPACT: THE REGIONAL FLOOD INFORMATION SYSTEM IN THE HINDU KUSH HIMALAYAN REGION (HKH-HYCOS)

The Himalayan rivers originate in the high mountains and flow down to the sea through extensive plains areas that support hundreds of millions of people. These rivers are prone to flooding on a regular basis due to the heavy seasonal rainfall and melt processes. They are also all to a greater or lesser extent transboundary, as are the floods they bring. Meaningful regional cooperation is needed among the countries sharing the basins so that resources can be effectively directed towards reducing flood vulnerability and mitigating flood impact through improved flood management.

ICIMOD, the World Meteorological Organization (WMO), and partner countries have developed the HKH-HYCOS project to enhance regional cooperation in hydrometeorological data collection and sharing for flood forecasting to support disaster prevention and flood management at the regional level (Annex 5 Information Sheet 4). The project has developed national flood information systems for its partners and established a regional flood information system (RFIS) to facilitate transboundary exchange of real- and near-real-time data, best practices, and know-how in support of flood management.

The Koshi river has an automatic real time water level station at Barabise installed in 2013 under the HYCOS project. The station is equipped with two automatic sensors to measure two parameters, water level and rainfall. A data logger stores and transmits data at 15-minute intervals, simultaneously to the national flood information system (NFIS) and the RFIS.

Annex 5 Information Sheet 4 provides more information about the HYCOS project, which has upgraded hydromet stations in Bangladesh, Bhutan, Nepal, and Pakistan, as well as details of the Barabise station.

LANDSLIDE HAZARDS AND LANDSLIDE DAM OUTBURST FLOODS: THE JURE LANDSLIDE

In the early hours of 2 August 2014, a landslide occurred above Jure village, about 1.4 km upstream from the Sun Koshi Hydropower project intake site. A 1.9 km long slope of land perched 1,350 m above the river bed collapsed, burying two dozen houses, taking the lives of at least thirty-three people, and injuring many more. Over 150 people went missing.

The massive landslide created a high dam across the Sun Koshi river. A Department of Hydrology and Meteorology (DHM) river gauging station at Pachuwarghat downstream of the landslide dam showed a rapid decline in water flow three hours after the landslide, after which the flow of water stopped completely for approximately 12 hours. An inflow of about 160 m3/sec of water quickly created a large lake behind the dam. Within 13 hours the newly formed lake – which rapidly grew to an estimated volume of 7 million cubic metres – extended about 3 km upstream, completely submerging the 2.6 MW Sanima Hydropower station and leading to relocation of an entire village. Had Nepal's security forces not taken timely action to release some of the stored water through controlled explosions, the backwater would have extended further upstream and caused great damage in Barabise, the nearest upstream town.

The event provides a good example of landslide dam formation, which is a common hazard across the Himalayan region, and the importance of land use planning taking account of such hazards, and preparedness of stakeholders to provide rapid remediation action to avoid both further upstream flooding and the potentially catastrophic impacts of outburst leading to a LDOF. Annex 5 Information Sheet 5 provides more details of the event.

INTERBASIN WATER TRANSFER: THE MELAMCHI WATER SUPPLY PROJECT

Provision of sufficient good quality water for urban use is one of the major challenges faced in river basin management. There are many different approaches. The Koshi basin presents an example of a planned project for inter-basin water transfer (IBT).

The Melamchi Water Supply Project is designed to divert about 170 MLD of fresh water to Kathmandu Valley from the Melamchi river in Sindhupalchowk district through a 26 km long tunnel. It is considered to be the most viable long-term alternative to ease the chronic water shortage situation within the Kathmandu Valley. The Melamchi river is a tributary of the Indrawati, which joins the Koshi river at Dolalghat. Thus diversion will have an impact on the Koshi river.

IBTs are a major form of river basin manipulation. Despite their high cost and complex engineering, the ecological and social implications of such schemes continue to be inadequately addressed. Since conveyance of water between natural basins is described both as a subtraction at the source and as an addition at the destination, their scale, costs, and environmental and developmental impacts must be considered carefully. IBT projects directly affect the management of both origin and destination basins, the socioeconomic and environmental conditions are often weakened in one of the basins in the long term.

Annex 5 Information Sheet 6 provides more details of the project and potential issues related to IBTs.

LIVING WITH WATER STRESS: CASE STUDY IN THE HILLS OF THE KOSHI BASIN

In Nepal, as elsewhere in the central and eastern Himalaya, around 80% of the precipitation falls within four months of the year, and much of this during a few extremely intense rainfall events. The result is too much water falling over a very short time period, making it very difficult to obtain the full benefit for people and vegetation. Most of the rainfall runs off the land and flows rapidly through the watersheds and basins of the high mountains and middle hills without fully replenishing the groundwater and other natural reservoirs and causing floods and havoc. During the rest of the year, there is very little water for household needs, agriculture, and industry.

The challenges associated with 'too much water' in the monsoon season and 'too little water' in the dry season are common to large areas of the Himalaya, especially in the heavily monsoon influenced central and eastern parts. The Koshi basin provides good examples of both the challenges and some approaches to addressing them. ICIMOD conducted a study on "Local Response to Too Much and Too Little Water in the Koshi Basin of Nepal" (ICIMOD, 2009), which examined both wet and dry sites and the mosaic of vulnerability that leaves people coping with the effects of climate-induced stresses and hazards. Although the study examined the impacts of both flood and extended drought – too much or too little water – the popular perception is that water availability has declined overall in the last decade. The people of Kavre are already experiencing climate-related hazards, such as extended periods without rainfall. They recognize that with changes in the climate, they will need to diversify their crops, agricultural practices, and livelihoods to cushion the impacts. People who can afford machinery respond by digging trenches in the dry river beds. Now the trenches and tube wells have to be guarded to protect them against those who cannot afford to get water this way, leading to increased inequality and conflicts in the society.

Annex 5 Information Sheet 7 provides more information about the study.

In the central and eastern Himalaya, around 80% of the precipitation falls within four months of the year, and much of this during a few extremely intense rainfall events. The result is too much water falling over a very short time period, making it very difficult to optimize the benefits for people and vegetation. The Koshi basin provides good examples of the associated challenges and some approaches to addressing them.

SUSTAINABLE MOUNTAIN DEVELOPMENT: THE RESILIENT MOUNTAIN SOLUTIONS FRAMEWORK AND RMVs

Social and economic changes in mountain communities – high outmigration of men, labour shortages, and decreasing cultivation of arable land – all pose challenges for agricultural productivity and natural resource management, and create additional responsibilities for women. The challenges are now being compounded by the impacts of climate change, which are expected to intensify in the coming years.

The Resilient Mountain Solutions approach combines the social, economic, and environmental dimensions of sustainable development with climate change adaptation, resilience, and preparedness for future risks to form an integrated approach to resilient mountain development. It adopts the working definition of resilience as "the ability of an individual, community, or a socio-ecological system to not only overcome stress, shock, or setback (recover or bounce back) but develop capabilities to move forward to a condition or state that can help transcend to a better state". The Resilient Mountain Solutions framework works within three major dimensions of resilience – climate resilience, socioeconomic resilience, and future resilience – categorized into nine sub-dimensions. This type of framework is very pertinent to development and support of communities in the middle reaches of the Koshi basin.

ICIMOD, together with the Center for Environment and Agricultural Policy Research, Extension and Development as the local implementing partner, has successfully piloted the RMV approach in eight villages in Kavre district in Nepal. The RMV approach is an innovation evolved from elements of the climate smart agriculture and climate smart village concepts of the Food and Agriculture Organization (FAO) and the Consultative Group on International Agriculture Research based on the experience gained in a climate smart village pilot in Nepal. The pilot made it clear that the aspirations of people in the mountain areas of the HKH can only be realized by adopting a much broader approach that integrates climatic, socioeconomic, and future resilience and considers challenges and opportunities specific to the mountain context. RMV is a comprehensive approach customized for mountain areas that equips communities with tools to improve their resilience to change and fosters sustainable development.

Annex 5 Information Sheet 8 provides more information on the Resilient Mountain Solutions Framework and RMVs.

COPING WITH WATER SCARCITY: TECHNOLOGY FOR HARVESTING SUBSURFACE RIVER WATER

Water scarcity is common in the mid-hills of Nepal in the dry season and limits the potential for growing additional crops. Mountain communities have developed unique solutions to address the problem. Dry and sandy riverbeds are reservoirs of sub-surface water which have been harnessed for a long time by both animals and humans.

The communities in Bahunmara developed an innovative technology to harvest sub-surface water from the dried out upstream riverbed of the Ratu river, a tributary of the Koshi river, by constructing a subsurface dam and transporting the water downstream to their villages to use in irrigation. The farmers developed the idea on their own to address the problem of shortage of water for irrigating their farms after they found abundant water below the surface of the dry river bed. There is no perennial source of water in the river and the river dries early in the winter season, but the subsurface (seepage) water was found to be perennial and present throughout the winter and dry seasons.

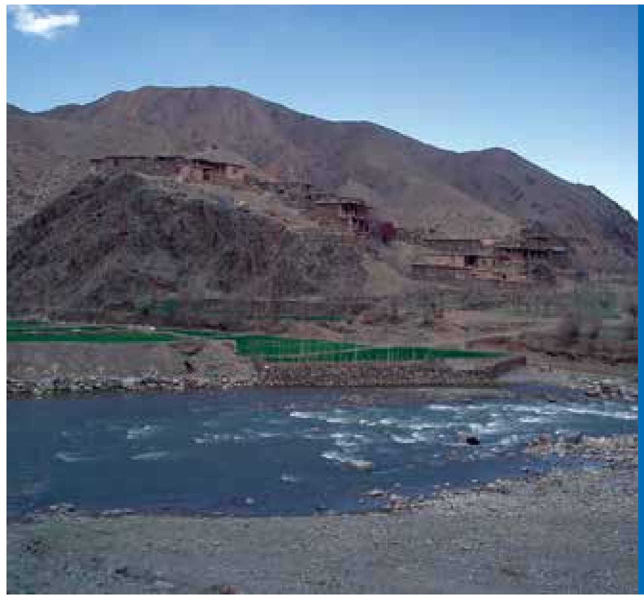
This technology was further developed by the Community Development and Advocacy Forum Nepal (CDAFN), an NGO, who constructed an improved irrigation channel to bring the water directly to the users. It has been adopted by many more communities, who now abstract large quantities of seepage water on a regular basis, raising the question of the potential impact on water balance and long-term sustainability.

Annex 5 Information Sheet 9 provides more information on the system, its benefits, and potential concerns.

8.2.3 The lower reaches

PREPARING FOR FLOODS: CBFEWS

The Ratu river is a tributary of the Koshi river which originates in the Siwalik Hills in Nepal and flows through the Terai, the northern extension of the Indo-Gangetic plains, to India. As in many of the plains areas along the HKH, the river regularly floods villages in the border area between Nepal and India.



People in the HKH face economic and institutional water scarcity in areas where water is plentiful but inaccessible.

Together with partners and the local communities, ICIMOD has implemented a CBFEWS to provide warning to communities along the Ratu river on both sides of the Nepal-India border. CBFEWS is a system of tools and plans to help communities detect and respond to flood risk. A low-cost telemetry-based system provides early flood information to 6,685 households with a population of 35,804 in four villages in Mahottari District, Nepal and 12,500 households with a population of 59,600 in six villages in Sitamarhi District, Bihar, India. On 12 Aug 2017, flood waters from the river reached Shrikhandi village in the Sitamarhi district of Bihar. But thanks to the CBFEWS, villagers had seven to eight hours of lead time to prepare themselves for the coming flood and had already moved their cattle and other possessions to safer places. The more vulnerable villagers, especially women and children, were also able to move to safer ground.

Annex 5 Information Sheet 10 provides more details of the CBFEWS system.

ACCESSING WATER FOR AGRICULTURE: SOLAR PUMPS AND GROUNDWATER IRRIGATION

People in the HKH face economic and institutional water scarcity in areas where water is plentiful but inaccessible. Some of the inaccessibility is caused by a lack of irrigation infrastructure and rural electrification in the plains. In order to support affordable and sustainable access to agricultural water in the Terai region of Nepal, ICIMOD tested the use of SPIPs as a clean, climate resilient, and pro-poor solution to tackle issues related to the nexus between water, food, and energy security in the plains. ICIMOD has now installed 60 SPIPs across four Terai districts in Nepal as a basis for impact evaluation studies.

Solar pumps are nearly as powerful as their diesel and electric counterparts. The use of SPIPs has both positive and negative implications for IRBM. The pumps allow farmers to switch from polluting diesel pumps to environmentally friendly energy; they eliminate drawing water at night, thereby controlling over-extraction; and they help farmers to increase their income through diversification, for example farming fish and high value crops.

Notwithstanding the benefits, there can be negative impacts. Extraction during the dry season can lead to a lowering of the water table, and irrigation to salination. The pumps can encourage farmers to over-extract groundwater or plan for more water-intensive crops since the marginal cost of pumping with SPIP is zero. The long-term implications for the water balance in a basin also remain unclear. All these issues need to be considered in planning for IRBM.

Annex 5 Information Sheet 11 provides more details of the solar pump groundwater irrigation system

LOCAL WATER GOVERNANCE: THE WUMP INITIATIVE

ICIMOD, in partnership with HELVETAS Swiss Intercooperation Nepal, has started an initiative in three different ecological zones in the Koshi Basin to help promote effective, efficient, and equitable water management at the local level. The goal is to encourage the development of WUMP, which are locally-prepared plans that lay out a five-year usage strategy for all water-related issues, including

irrigation, drinking water, sanitation, and disaster reduction. The aim is to improve access to and equitable distribution of water – especially to those who are routinely marginalized, such as women and the poor. These plans are unique in that they are developed by local communities themselves allowing them to address the specific needs of each community. A WUMP is essentially a local governance mechanism for planning and using water resources at the local level.

ICIMOD and HELVETAS work actively with communities in the initial stages in order to ensure a long-lasting impact. While HELVETAS has experience in local level planning, ICIMOD provides communities with up-to-date scientific knowledge on monsoon trends and water availability throughout the year, as well as creative solutions for sustainable water use. This information, which communities might not have access to otherwise, is worked into the plans. Once the plans are prepared, they are approved by the VDC council, which provides monetary and in kind support and ultimately takes over implementation. In the long term, the goal is for the plans to be taken up and endorsed by the district development committee and for the plans to facilitate talks between communities that live along the same tributary in order to create a larger, integrated master plan. If successful, the project will be replicated in other districts in the Koshi River basin.

Annex 5 Information Sheet 12 provides more details of WUMPS and their implementation.

STRUCTURAL INTERVENTIONS AND THEIR IMPLICATIONS: THE KOSHI BARRAGE AND EMBANKMENT

Many of the complexities of transboundary river management are highlighted at the lower end of the basin, embodied in the opportunities and challenges posed by the Koshi Barrage.

The Koshi Barrage was built between 1959 and 1962 after an agreement was made between the governments of India and Nepal on 25 April 1954. The treaty, which was revised in 1966, entrusts India with the responsibility for the maintenance and operation of the barrage, which is located at Bhim Nagar in Nepal close to the India-Nepal border. The barrage was constructed for flood control and to provide water for irrigation, and also serves as a river gradient control measure through which sediments are deposited in the upstream reaches. The 1,149 m long barrage has 56 gates that control river flow to the downstream; it is designed to discharge water at a rate of 950,000 cusec.

The Koshi river is subject to frequent flood events and dynamic shifts in the river channels of the plains. Because of this, embankments were built on both sides of the river to help control flood water and protect nearby settlements. The eastern embankment is about 157 km long (32 km in Nepal and 125 km in India) and the western embankment 129 km long (28 km in Nepal and 101 km in India). During construction, a rehabilitation programme was implemented in Nepal and India to resettle communities to safer areas outside the embankment.

The Koshi Barrage provides a useful example for discussion of the general issue of embankments, possible challenges associated with bilateral agreements, and the role of barrages in flood control and the potential risks.

Annex 5 Information Sheet 13 provides more details of the Koshi Barrage.

STRUCTURAL INTERVENTIONS FOR FLOOD CONTROL: FLOOD HAZARD IN THE KOSHI RIVER BASIN

Floods are a serious problem in the Koshi river basin, especially in the lower reaches where they are often referred to as the 'sorrow of Bihar'. Every year, when streamflow increases during the monsoon season, floods wreak havoc on downstream areas causing loss of lives and damage to property.

Regular floods are compounded when the embankments breach. The Koshi river has a history of breaches. In the most recent one in August 2008, the eastern embankment of the Koshi river breached 12 km upstream of the barrage at Kushaha. After the breach, most of the monsoon discharge and sediment load started flowing along a new path in Sunsari District in Nepal and Saharsa, Supaul, Araria, Madhepura, Khagaria and Purnia districts in India that was dominated by agricultural land, settlements, and infrastructure. The new river course is believed to be the same path the river followed 80 years prior. The breach and subsequent floods caused unexpected devastation and heavy damage in both India and Nepal, including the deaths of 235 people and 787 livestock. A population of 4.8 million was affected by the flood, 322,169 houses were destroyed, and more than 338,000 ha of agricultural land was damaged. It is still possible to observe the extent of the damage caused.

Annex 5 Information Sheet 14 provides more details of the breach and subsequent floods.

The Koshi Barrage was constructed between 1959 and 1962 for flood control and to provide water for irrigation, and also serves as a river gradient control measure through which sediments are deposited in the upstream reaches. The barrage provides a useful example for discussion of the general issue of embankments, possible challenges associated with bilateral agreements, and the role of barrages in flood control and the potential risks.

8.3. Frequently asked questions

HOW CAN NEPAL'S EXPERIENCE HELP AFGHANISTAN?

The exposure visit was organized to help participants relate to experiences in Nepal and contextualize them in relation to the situation in Afghanistan. The technologies and approaches showcased in the field provide useful learning in terms of both successes and failures and ways to implement and adapt different approaches at different scales in river basins in Afghanistan.

WHAT EFFORTS ARE BEING MADE TO MAKE THE PILOTS SUSTAINABLE AND FORWARD INTEGRATED?

We would like to ensure that the capacity of relevant stakeholders is enhanced, whether from government, likeminded organizations, or communities, in a way that they can continue, replicate, and lead the processes. It is important to involve the government line agencies from the very beginning of the conceptualization and planning process so that there is ownership even after phase out of a project.

8.4. Further reading

Das, P. J., Bhuyan, H. K., Pradhan, N. S., Khadgi, V. R., Schipper, L., Kaur, N., & Geoghegan, T. (2013). *Policy and institutions in adaptation to climate change: Case study on flood mitigation infrastructure in India and Nepal* (Working Paper 2013/4). Kathmandu: ICIMOD.

ICIMOD. (2009). Local responses to too much and too little water in the greater Himalayan region. Kathmandu: ICIMOD. Retrieved from http://lib.icimod.org/record/8021

ICIMOD. (2011). *Too much water too little water* [Film]. Kathmandu: ICIMOD. Retrieved from http://lib.icimod.org/record/9378

ICIMOD. (2017a). *Making local water planning gender and socially inclusive: Towards gender inclusive water sector development*. Retrieved from http://lib.icimod.org/record/32744

ICIMOD. (2017b). *Reaching the most vulnerable: Community-based flood early warning system* [Film]. Kathmandu: ICIMOD. Retrieved from http://lib.icimod.org/record/32709

MODULE 8 | KEY TAKEAWAYS

Learning from the field: Linking IRBM theory to practice

SECTION 8.1
INTRODUCTION AND RELEVANCE

Before embarking on IRBM, it is important to try and visualize a whole river basin system from upstream to downstream.

SECTION 8.2
OPPORTUNITIES AND CHALLENGES

'Too much water' in the monsoon and 'too little water' in the dry season are common to areas in the Himalaya.

SECTION 8.3
FREQUENTLY ASKED QUESTIONS

A field journey entails learning in terms of successes and failures, and ways to implement and adapt IRBM approaches.

ICIMOD. (2018a). *Community-based flood early warning system: The story from then to now.* Kathmandu: ICIMOD. Retrieved from http://lib.icimod.org/record/34317/files/CBFEWS.pdf

ICIMOD. (2018b). *Empowering vulnerable communities in Gilgit-Baltistan through community based flood early warning system.* Kathmandu: ICIMOD. Retrieved from http://lib.icimod.org/record/33864/files/icimodCBFEWS018.pdf

Mukherji, A., Chowdhury, D. R., Fishman, R., Lamichhane, N., Khadgi, V., & Bajracharya, S. (2017). *Sustainable financial solutions for the adoption of solar powered irrigation pumps in Nepal's Terai*. Retrieved from http://lib.icimod.org/record/32565/files/icimodWLE2.pdf

Nepal, S., Flügel, W. A., & Shrestha, A. B. (2014). Upstream-downstream linkages of hydrological processes in the Himalayan region. *Ecological Processes, 3*(1), 19.

Nepal, S., Neupane, N., Shrestha, H., & Tharu, R. B. (2017). *Upstream-downstream linkages for catchment level water use master plans (WUMP) in the mid-hills of Nepal* (Working Paper 2017/23). Kathmandu: ICIMOD.

Nepal, S., Pandey, A., Shrestha, A. B., & Mukherji, A. (2018). *Revisiting key questions regarding upstream–downstream linkages of land and water management in the Hindu Kush Himalaya (HKH) region*. Kathmandu: ICIMOD.

Pradhan, N. S., Bajracharya, N., Bajracharya, S. R., Rai, S. K., & Shakya, D. (2016). *Community based flood early warning system for the Hindu Kush Himalaya – Resource manual*. Kathmandu: ICIMOD. Retrieved from http://lib.icimod.org/record/32318/files/icimodCBFEWS016.pdf

Pradhan, N. S., Khadgi, V. R., Schipper, L., Kaur, N., & Geoghegan, T. (2012). *Role of policy and institutions in local adaptation to climate change – Case studies on responses to too much and too little water in the Hindu Kush Himalayas*. Kathmandu: ICIMOD. Retrieved from http://lib.icimod.org/record/16944/files/attachment_791.pdf

Pradhan, N. S., Khadgi, V., & Kaur, N. (2014). *The role of policies and institutions in adaptation planning: experiences from the Hindu Kush Himalaya*. Practical Action Publishing.

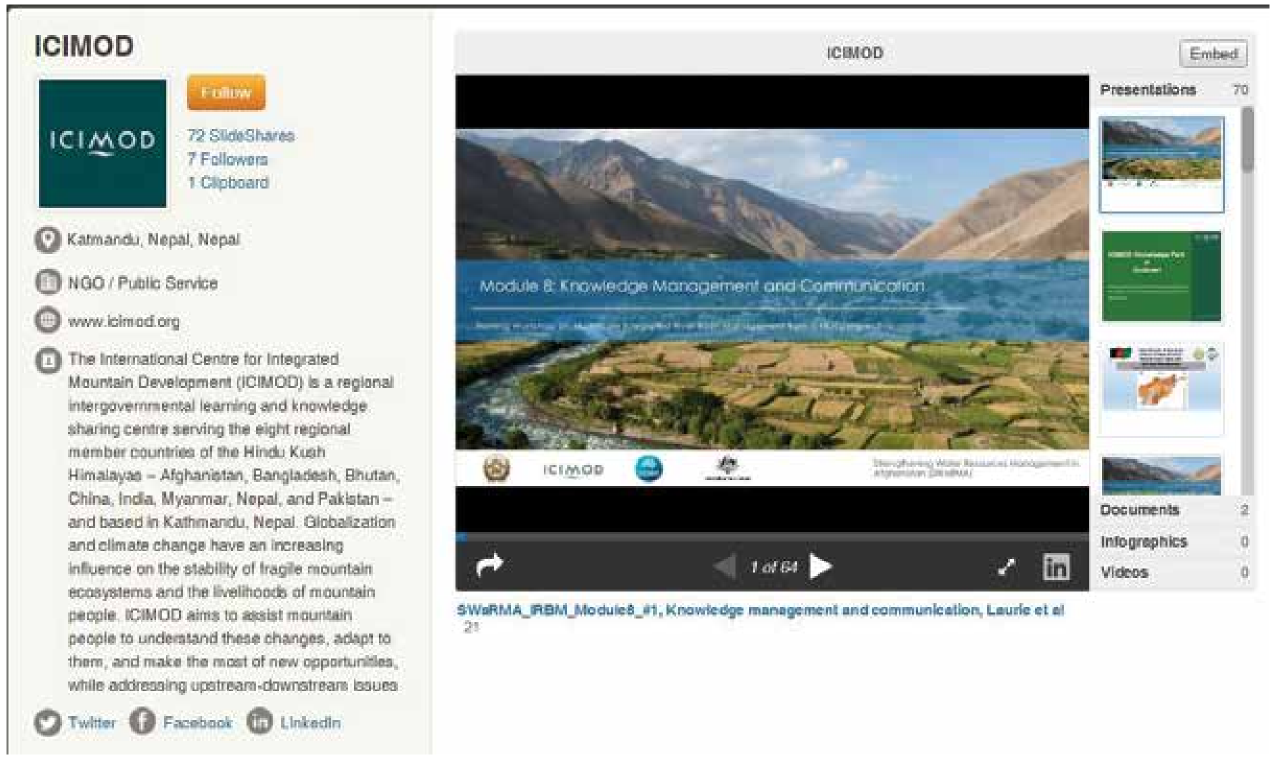
Shrestha, M. S., Grabs, W. E., & Khadgi, V. R. (2015). Establishment of a regional flood information system in the Hindu Kush Himalayas: Challenges and opportunities. *International Journal of Water Resources Development, 31*(2), 238–252.

Annexes

ANNEX 1

Workshop and presentation materials

1a. Training materials (https://www.slideshare.net/ICIMOD)



1b. Workshop agenda

Training workshop on Multiscale Integrated River Basin Management (IRBM) from a Hindu Kush Himalayan perspective

Initiative: Strengthening Water Resource Management in Afghanistan (SWaRMA)
Programme: River Basins and Cryosphere (RP3)
Training coordinator: Santosh Nepal

S.N.	Title	Resource person	Online link (Slideshare/ ICIMOD/
3:00 – 3: 30	Registration	Indu Chitrakar, Programme Associate, ICIMOD	
3:30 – 3:40	Opening remarks and contextualizing IRBM from an HKH perspective	David Molden Director General, ICIMOD	
3:40 – 3:50	IRBM approach of ICIMOD's Regional Programme on River Basins and Cryosphere	Arun Bhakta Shrestha Regional Programme Manager, River Basins and Cryosphere, ICIMOD	SWaRMA_IRBM_ opening_#1
3:50 – 4:00	Contribution of SWaRMA in co-creating learning opportunities Objective and agenda of the workshop	Neera Shrestha Pradhan Programme Coordinator SWaRMA	SWaRMA_IRBM_ opening_#2
4:00 – 4:10	CSIRO's contribution in basin management	Shahriar Wahid CSIRO	
4:10 – 4: 20	Introduction and expectations of the participants		

4:20 – 4: 50	Highlights of multiscale IRBM and module introduction Interaction session: Reflections on Afghanistan's water resources management Group discussion Question 1: What are the major water resources management challenges in Afghanistan Questions 2: What are the opportunity of IRBM in Kabul river basin Reflection from the group discussion Questions/answers	Santosh Nepal Group Lead, Climate and Hydrology, ICIMOD [The participants will be divided into two group and discuss these questions] [At the end, the group will present their group discussion outcome]	Slideshare/ SWaRMA_IRBM_ opening_#3
4: 50 – 5:00	Remarks by David Molden Vote of thanks by ICIMOD		

Module 1: Conceptual understanding of river basin's drivers and impact for IRBM

Contributors: Santosh Nepal (lead), Arun B Shrestha, Ramesh Ananda Vaidya, Philippus Wester, Kabi Raj Khatiwada, Neera Shrestha Pradhan Aditya Bastola, Madhav Belbase, (WECS, Nepal), Jalal Naser Faqiryar, Ministry of Energy and Water, Afghanistan

28-Jan 2019 (Day 1)				
Start time	**(mins)**	**Presentation topics**	**Resource persons**	**Online link (Slideshare/ ICIMOD/**
9:00	45	Principles of IWRM and IRBM : Challenges for the Himalayan river basins	Ramesh and Flip, ICIMOD	SWaRMA_IRBM_ module1_#1
9:45	30	River basin management: approach and challenges	Ramesh and Flip, ICIMOD	SWaRMA_ IRBMModule1_#2
10:15	45	Upstream-downstream linkages and Multiscale IRBM	Santosh Nepal, ICIMOD	SWaRMA_IRBM_ Module1_#3
11:00	30	Tea\coffee break		
11:30	30	Challenges of water resources management in Afghanistan	Jalal Naser Faqiryar, MEW	
12:00	30	IRBM implementation in Nepal: challenges and way forward	Madhav. Belbase, WECS	SWaRMA_IRBM_ Module1_#4
12:30	15	Experiences of IWRM implementation from Australia	Andrew Johnson, ICEWaRM	SWaRMA_irbm_ Module1_#5
12:45	60	Lunch break		
13:45	30	Climate change impact on hydrological regime using DPSIR framework	Arun B Shrestha, ICIMOD	SWaRMA_IRBM_ module1_#6
14:15	120	Interactive group work: Conceptualizing the impact of climate change on a river basin Participants perception on climate change impact on biophysical components Participants discuss climate change impacts in a group, organize the ideas in flip card and discuss the impacts)	Santosh Nepal, ICIMOD	SWaRMA_IRBM_ module1_#7
15:00	30	Tea\coffee break		
15:30		Group work continued By imagining specific examples of their river basins, participants will come up with conceptual framework for CC impacts on different components		

Module 2: Tools and approaches for understanding biophysical changes

Contributors: Arun B Shrestha (lead), Santosh Nepal, Nisha Wagle, Sudip Pradhan, Faisal Mueen Qamar, Rishi Ram Sharma (WECS), Dilip Gautam (External resource person), Shahriar Wahid and Susan Cuddy (CSIRO), Andrew Johnson (ICE WaRM)

29 January 2019 (Day 2)				
Start Time	**(mins)**	**Presentation topics**	**Resource persons**	**Online link (Slideshare/ ICIMOD/**
9:00	30	Introduction of the module How analytical tools help in IRBM What are the ranges of available tools Relevance of those tools and limiting factors	Arun B. Shrestha, ICIMOD	SWaRMA_IRBM_ module2_#1
9:30	30	Opportunities and challenges in implementing analytical tools for IRBM in Afghanistan	Afghan resource person	
10:00	30	Information management in IRBM (presentation and demonstration of HI-CHAP and RDS)	Sudip Pradhan, Saurav Pradhananga, ICIMOD	SWaRMA_IRBM_ module2_#2
10:30	30	Tea\coffee break		
11:00	60	Water availability assessment using hydrological models	Santosh, Saurav, ICIMOD	
12:00	30	Drought monitoring (presentation and demo)	Faisal Mueen Qamar, ICIMOD	SWaRMA_IRBM_ module2_#3
13:30	60	Lunch break		
1:30	30	Water ecosystem interaction	Susan Cuddy, CSIRO	SWaRMA_IRBM_ module2_#4
14:00	45	Role of hydrometeorological monitoring for IRBM in Nepal	Rishi Ram Sharma, WECS	SWaRMA_IRBM _module2_#5
14:45	45	Flood management in Nepal	Dilip Gautam	SWaRMA_IRBM_ module2_#6
15:30	30	Tea\coffee break		
16:00	45	Basin planning experience from Australia (interactive seminar)	Andrew Johnson, ICEWaRM	SWaRMA_IRBM_ module2_#7
16:45	15	Wrap-up discussion	Arun B. Shrestha, ICIMOD	
30 Jan 2019 (Day 3)				
Start Time	(mins)	Presentation topics	Resource persons	
9:00	120	J2000 model as a tool to analyse water availability scenarios Basic structure of the model and input requirements Outputs of the model Hands-on on what-if scenarios How can the results be used	Santosh Nepal, Saurav Pradhananga, Kabi Raj Khatiwada, ICIMOD	
11:00	15	Tea\Coffee break		

11:15	75	Scenario planning in IRBM (interactive seminar)	Shahriar Wahid, CSIRO	SWaRMA_IRBM_module2_#8
12:30	15	Wrap-up and concluding remarks	Arun B. Shrestha, ICIMOD	
12:45		Lunch (12:45 – 1:30)		

Module 3: Understanding gendered vulnerabilities and the socioeconomic drivers of change

Contributors: Chanda Gurung Goodrich (lead), Pranita Bhushan Udas, Aditya Bastola

30 Jan 2019 (Day 3)				
Start Time	**(mins)**	**Presentation topics**	**Resource persons**	**Online link (Slideshare/ ICIMOD/**
12:30	60	Lunch break		
13:30	10	Expectation of the participants (Interaction)	Chanda Gurung Goodrich & Aditya Bastola. ICIMOD	SWaRMA_IRBM_module3_#1
13:40	5	Objectives of the module	Chanda Gurung Goodrich & Aditya Bastola, ICIMOD	SWaRMA_IRBM_module3_#1
13:45		Session 1: Gender and identity		
	30	Society, gender and river basin system Interactive presentation/game (self-reflection)	Chanda Gurung Goodrich, ICIMOD	
14:15	60	a. Understanding gender and identity (gender/sex, social exclusion/inclusion, equality and equity, identity, diversity) b. Gender concepts	Game(s)/presentation/quiz Chanda Gurung Goodrich & Aditya Bastola, ICIMOD	
15:15	30	Tea\coffee break		
15:45	60	Continue…Understanding gender and..….		
16:45	15	Gender and social dynamics in Afghanistan	Afghanitan Resource person/Interactive presentation	
31-Jan 2019 (Day 4)				
9:00		Session 2: Gendered vulnerabilities		
	15	Understanding vulnerabilities and paradigm shifts	Chanda Gurung Goodrich, ICIMOD	
9:15	45	Conditions and drivers of gendered vulnerability	Chanda Gurung Goodrich, ICIMOD	
10:00	30	Tea\Coffee break		
10:30		Session 3: Gender mainstreaming and analysis		
	15	Gender, social inclusion and governance at scales in river basin	Aditya Bastola, ICIMOD	
10:45	20	Interactive session on brief gender analysis:	Chanda Gurung Goodrich, ICIMOD	
11:05	50	Identifying gender vulnerabilities and socioeconomic drivers of change in Afghanistan - at scales in Afghanistan – 3 groups working at individual/households, community, basin scales	Video/ Group work/ Presentation Chanda Gurung Goodrich & Aditya Bastola, ICIMOD	
12:00	15	Gender mainstreaming and analysis tools	Aditya Bastola, ICIMOD	
12:10	15	Session 4: Closing session Feedback & Evaluation (Feedback tools)	Chanda Gurung Goodrich & Aditya Bastola, ICIMOD	
12:30		Lunch break		

Module 4: Governance, Policy and institutional framework

Contributors: Arabinda Mishra (lead), Avash Pandey, Omaid Nazmuddhin

31-Jan 2019 (Day 4)				
Start time	**(mins)**	**Presentation topics**	**Resource persons**	**Online link (Slideshare/ ICIMOD/**
12:30	60	Lunch break		
13:30	60	Introduction to river basin governance need and challenges; different approaches to river basin governance; the concept of adaptive governance, its relevance	Arabinda Mishra, ICIMOD	SWaRMA_IRBM_module4_#1
14:30	30	Tea\Coffee break		
15:00	60	Principles of adaptive governance and their match with IRBM objectives	Arabinda Mishra	SWaRMA_IRBM_module4_#1
16:00	60	Putting theory to practice – examples of adaptive governance from select case studies and participantgs experiences	Arabinda Mishra, Avash Pandey, ICIMOD	
1 February 2019 (Day 5)				
9:00	60	Relevance and role of traditional community level institutional arrangements (case discussion; case from Afghanistan)	Arabinda Mishra, Avash Pandey and Omaid Nazmuddhin	
10:00	30	Tea\Coffee break		
10:30	120	Group work on tools and techniques of putting adaptive governance principles to practice	Arabinda Mishra, Avash Pandey	
12:30		Lunch break		

Module 5: Water diplomacy and regional cooperation

Contributors: Anjal Prakash (lead), Avash Pandey

2-Feb 2019 (Day 6)				
Start time	**(mins)**	**Presentation topics**	**Resource persons**	**Online link (Slideshare/ ICIMOD/**
9:00	60	Water diplomacy and regional cooperation: key principles and challenges	Anjal Prakash	SWaRMA_IRBM_module5_#1
10:00	60	Key principles of international water laws and International negotiations in transboundary river basins	Ram Babu Dhakal, MoFA	SWaRMA_IRBM_module5_#2
	15	Water diplomacy and cooperation in Afghanistan	Sadia Bariz	SWaRMA_IRBM_module5_#5
11:00	15	Tea\coffee break		
11:30	30	Transboundary cooperation in HKH basins: Overview of issues and opportunities	Arun B Shrestha, ICIMOD	SWaRMA_IRBM_module5_#3
12:00	30	Why Eastern Himalayan countries should cooperate in transboundary water resource management	Golam Rasul	SWaRMA_IRBM_module5_#4
12:30	60	Lunch break		
13:30	90	Roleplay: Musing River Hydro-Electric Project on a Large River Basin in South Asia	Anjal Prakash and Avash Pandey, ICIMOD	
15:00	15	Tea\Coffee break		
15:15	90	Nile River Basin Management: Identifying challenges for river basin (40 min documentary plus discussions)	Anjal Prakash	
16:45	15	What did I learn today?	Anjal Prakash	

Module 6: Operational aspects of water and land management

Contributors: Sanjeev Bhuchar (lead), Finu Shrestha, Sarad Joshi, Anna Sinisalo, Vijay Khadgi, Neera Shrestha Pradhan, Mandira Shrestha, Dipankar Shakya, Madhav Dhakal, Gunanidhi Pokhrel, Karishma Khadka, Keshar Man Sthapit (External Resource Person), Philippus Wester, Samden Sherpa

03-Feb 2019 (Day 7)				
Start Time	**(mins)**	**Presentation topics**	**Resource persons**	**Online link (Slideshare/ ICIMOD/**
9:00	60	GLOF risk reduction	Finu Shrestha, Sarad Joshi, Anna Sinisalo, ICIMOD	SWaRMA_IRBM _module6_#1
10:00	30	Tea\coffee break		
10:30	60	Integrated flood risk management	Vijay Khadgi, Neera Pradhan Shrestha, Mandira Shrestha, ICIMOD	SWaRMA_IRBM _module6_#2
11:30	60	Groundwater and springshed management	Madhav Dhakal, Gunanidhi Pokhrel, Karishma Khadka, ICIMOD	SWaRMA_IRBM _module6_#3
12:30	60	Lunch break		
13:30	60	Sediment management including landslide treatment river bank stabilisation	Keshar M. Sthapit, (external), Sanjeev Bhuchar, ICIMOD	SWaRMA_IRBM _module6_#4
14:30	30	Sharing of solutions by participants	Participants	SWaRMA_IRBM _module6_#5
15:00	30	Tea\coffee break		
15:30	45	World Café on operationalising water and land management	Sanjeev Bhuchar, Karishma Khadka, Keshar M. Sthapit, Madhav Dhakal, Finu Shrestha	
16:15	45	Institutional perspective	Sanjeev Bhuchar, Phillipus Webster, Karishma Khadka ICIMOD	
04-Feb 2019 (Day 8)				
9:00	180	Godavari visit to observe IWRM technologies	Sanjeev Bhuchar, Madhav Dhakal, Samden Sherpa, Karishma Khadka, Gunanidhi Pokhrel, Dipankar Shakya, ICIMOD	SWaRMA_IRBM _module6_#6
12: 30	60	Lunch break		
13:30	90	Brief on the exposure visit by the Module 7 team		

Module 7: Exposure Visit

Contributors: Vijay Khadgi (lead), Neera Shrestha Pradhan, Arun Shrestha, Santosh Nepal, Kabi Raj Khatiwada, Dipankar Shakya, Sanjeev Bhuchar, Aditya Bastola, Debabrat Sukla

05-Feb 2019 (Day 9)			
Start time	**(mins)**	**Presentation topics**	**Resource persons**
7:00	Whole day	Visit to: Bhotekoshi Power Plant The Last Resort Barahbise Hydro-met Station Jure Landslide site Balefi Conflence Water diversion and IRBM at 0 kilo Panchkhel	ICIMOD
19:00-20:00		Group interactions at Hotel in Dhulikhel	
06-Feb 2019 (Day 10)			
7:00	Whole day	Visit to: Upstream downstream Water management at Khurkot Community water management site of Bahun Mara village CBFEWS station in Bardibas	ICIMOD
19:00-20:00		Group Interactions at Hotel in Lahan	
07-Feb2019 (Day 11)			
7:00		Visit to: Solar Power Irrigation Pumps at Kalyanpur Water Users Master Plan At Mahuli Community Development Center Koshi Barrage Koshi embankment breach site Lunch at Koshi Tappu	ICIMOD
14:00		To Biratnagar	
16:00		Flight back to Kathmandu	

Module 8: Knowledge Management and Communication

Contributors: Laurie Ann Vasily (lead), Udayan Mishra, Debabrat Sukla, Nargis Mansoor, Samuel Thomas

08-Feb 2019 (Day 12)				
Start time	**(mins)**	**Presentation topics**	**Resource persons**	**Online link (Slideshare/ ICIMOD/**
9:00	60	Session I: Overview of knowledge management principles	Laurie Vasily/ Udayan Mishra, ICIMOD	SWaRMA_IRBM_ module8_#1
10:00	60	Session II: Knowledge sources, platforms and sharing	Laurie Vasily/ Udayan Mishra, ICIMOD	SWaRMA_IRBM_ module8_#1
11:00	30	Tea\Coffee break		

11:30	60	Session III: Knowledge management challenges and opportunities in IRBM	Laurie Vasily/ Udayan Mishra, ICIMOD
12:30	60	Lunch break	
13:30	120	Session IV: Key principles of science communication and new/digital/social media	Laurie Vasily, Debabrat Sukla, Bindu Bhandari, ICIMOD
15:30	30	Tea\Coffee break	
16:00	60	Reflection of the overall training workshop on Multiscale Integrated River Basin Management (IRBM) from a Hindu Kush Himalayan perspective	ICIMOD

1c. The participants of the training workshop

Name	Designation
Abdul Ahmad Zazay	Head of Hydrology, Water Resource Directorate, Ministry of Energy and Water
Ezatullah Bader	Irrigation Design Engineer, Irrigation Directorate Ministry of Agriculture Irrigation and Livestock (MAIL)
Farangis Rassouly	Hydrologist- Integrated River Basin Management, ICIMOD/WRD Ministry of Energy and Water
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ANNEX 2

Sediment management including landslide treatment and river bank stabilization

Origins of sediment

Sediment is produced when soil and mineral particles are washed away from their original location and carried by water in a basin's river system (suspended sediment) before being deposited at a location downstream of the original source (sediment deposits). These processes can be divided broadly into those that occur 'naturally', such as landslides, and those related to human activity, such as agriculture and construction. The approach to management differs somewhat in the two cases (although some similar methods are used in both) thus they are treated separately in the following.

Guiding principles of sediment management related to 'natural' production

CONTRIBUTING FACTORS

Water induced disaster events are a major contributor of sediment in the Himalayan river basins. For example, Sthapit (1996) estimated that a sediment load of 415 cu.m per hectare of watershed was produced following a rainfall episode with 500 mm rain within 24 hours in the Kulekhani watershed in Nepal. The sediment mostly came from the numerous landslides and stream bank erosion triggered by the heavy rain (Figure A1). Landslides refer to the downslope movement of a mass of material under the influence of gravity, generally as a result of slope failure. They happen relatively frequently in mountainous terrain, especially when the soil is saturated with water as happens in the HKH during the monsoon (SCSA, 1982). Stream bank erosion is erosion or cutting of the bank and land adjoining the stream or river; it can destroy habitation, agriculture, forest land, and any other structure close to the river channel.

STABILISING SLOPES AND PREVENTING SLOPE FAILURE

To anticipate and prevent slope failure, it is first necessary to understand why a slope fails. Essentially, a slope fails if the slope angle of the land is greater than the angle of repose, where the angle of repose is the steepest angle relative to the horizontal plane at which a sloping surface formed of loose material is stable (SCSA, 1982). However, the angle of repose is not fixed, it is different for different slopes depending on such factors as the

FIGURE A1: LANDSLIDES (TOP) AND STREAM BANK EROSION (BOTTOM) FOLLOWING HEAVY RAINFALL (>500 MM IN 24 HOURS) IN THE KULEKHANI WATERSHED, 19–20 JULY 1993 (PHOTOS: KESHAR MAN STHAPIT)

bedrock, and type of soil, moisture condition, and conservation status (e.g. vegetation cover, structural measures for soil and water conservation), and can change over time. The underlying material can change with weathering, the moisture status will change with precipitation, and the conservation status will be affected by human activity. As these parameters change, the angle of repose also changes, and if the value becomes lower than that of the slope, the slope will fail. Therefore, it is very important to understand the angle of repose and apply conservation measures that effectively increase it.

The base of the slope, or toe, is also important for slope stability. Toe stability is essential to avoid slope failure. Slopes are cut to prepare the base for construction. Cutting the base of a slope, for example, to construct a road or irrigation canal can disturb the toe sufficiently to trigger slope failure. Most landslides along river banks are triggered by toe cutting as a result of river bank erosion.

The conservation techniques used to avoid slope failure can focus on soil type, moisture condition, or conservation status, in part depending on the main cause of instability. It is difficult to control the soil type unless a massive effort is made to replace the material. In some special cases this may be done but it is very unusual.

Similarly, it isn't possible to actually control rainfall. But the amount of moisture retained in the slope can be reduced in a number of ways. One approach is to improve the drainage, if necessary through piping. Another is to construct diversion drainage to prevent runoff flowing onto the slope; while taking care not to simply move the problem elsewhere.

The most widely used technique is to strengthen the angle of repose through conservation techniques, generally an integrated combination of vegetative and engineering measures. These include improving vegetative cover on the slope, improving the infiltration capacity of the slope, reducing the moisture content in the soil, and improving the soil holding capacity through root development. Some of the techniques are similar to those used to reduce sediment production (see next section).

GUIDING PRINCIPLES OF SEDIMENT MANAGEMENT RELATED TO HUMAN ACTIVITY

There are three main approaches to managing sediment: 1) reducing the amount of sediment produced by stabilising slopes, adjusting land use practices, and increasing vegetation cover; 2) retaining the sediment that is produced close to the site of production; and 3) managing the sediment that does enter the river system downstream to minimise negative impacts and maximise its beneficial effects.

REDUCING SEDIMENT PRODUCTION

The foremost principle of sediment management is to reduce sediment production from the watershed through proper soil and water conservation practices. Soil erosion is a process in which soil particles are detached from one place and transported and deposited in another. Therefore introducing land use practices that reduce soil detachment at the origin are the first step in preventing and reducing erosion. The greater the disturbance of the soil, the greater the erosion, thus reducing soil disturbance is the first aim. In agriculture, this means following methods of conservation tillage or minimum tillage in which soil disturbance is minimized. Vegetation cover also plays a very important role in reducing sediment from a watershed. A runoff study in Nepal indicated that although rainfall during the pre-monsoon period (March to June) is less than 30% of the annual total, the period contributed 60% of the annual soil loss as a result of lack of vegetation cover during this time (Sthapit and Balla, 1998). Similarly, vegetation cover in most of the watersheds in Afghanistan is very poor and soil erosion, flooding, and sedimentation downstream are common during intense rainfall events. Vegetation cover can be increased through actions such as mixed cropping with fast and slower germinating crops, growing green manure in fallow periods, designing the agricultural calendar to retain vegetation on agricultural land at times with a higher risk of intense rainfall events, and planting bare land with hardy plants like seabuckthorn (Rongsen, 1992). Agricultural practices like contour ploughing and planting, and strip cropping can also be used to reduce sediment production. Where land must be kept bare for some purpose, it can be covered structurally, for example stone pitching, plastering, covering with tarmac, and similar.

RETAIN SEDIMENT CLOSE TO ITS SOURCE

There are many situations and activities in which sediment production is unavoidable. Here, the aim is to retain the sediment close to the site of production and reduce the amount entering the river system. Growing crops, planting trees, constructing contour trenches and reservoirs to hold water, and carrying out development activities all involve digging and disturbing the soil, which generally results in some level of soil erosion even when disturbance is reduced to a minimum. The aim in such cases is first to reduce the carrying (transportation) capacity of the eroding agent (water) across the site, and second to trap the sediment that does flow from the site before it enters the river system.

There are a number of ways to reduce the carrying capacity of water. In the Himalayan region one of the most common methods is to reduce the slope, and thus water velocity, by terracing. The amount of runoff, i.e. the amount of water flowing across the slope, can be reduced by increasing the infiltration capacity of the soil, or holding excess runoff in eyebrow or contour trenches or in conservation ponds, which can also be used to support irrigation and spring recharge. Water flow can also be diverted away from a slope or areas of vulnerable soil along grass-lined channels promoting infiltration (swales), or stone-lined ditches.

There are various methods available for trapping sediment near its source. Sloping agricultural land technology (SALT) or contour hedgerow planting, are designed to trap sediment in such a way that it naturally forms terraces (Pratap and Watson, 1994), but any type of hedgerow planting across the slope or along the ridge of terraces or risers can help to hold washed off soil in place. Digging of contour trenches and eyebrow pits to hold water (NEPCAT, 2004) leads both to soil disturbance and production of sediment, and to trapping of sediment as it is washed into trenches and pits dug lower on the slope. Grasses and bushes planted along the lower edges of pits and trenches will also help to trap sediment. Slightly further from the site of production, check dams constructed in gullies reduce water flow velocity and thus gully erosion and thus sediment production, and trap sediment flowing off the neighbouring slopes ICIMOD (2007).

MANAGEMENT OF SEDIMENT DOWNSTREAM

No matter how little soil is disturbed and how much sediment is held in a watershed, some sediment will come down into the valleys and plains. The key issue is how this sediment can be managed to minimize downstream environmental degradation and maximize use of these sediments for environmental benefit.

One approach is to construct dams to trap the sediment and then to harvest it for use elsewhere. For example, if the sediment is mainly sand, it can be used in construction, and if it is good soil, it can be spread on agriculture fields. Some sediment may just provide good filling material. This type of harvesting can provide an economic incentive as well managing the environmental damage.

Sediment can also be managed through appropriate irrigation systems that are designed to distribute it uniformly across the irrigated area. Similarly, flood water can be spread evenly across valleys and plains through construction of appropriate structures, thus distributing the nutrients coming from the watershed in the sediment together with the water. Flooding and distribution of nutrients contributes to the fertility of the plains. In Bengal, for example, the layers of silt deposited by rivers every year are essential for jute cultivation. Floods in the Nile too are welcomed by man (Ahmad, 1981).

SOME KEY TECHNIQUES FOR SEDIMENT MANAGEMENT.

The table in the next page summarizes some of the key techniques used in sediment management taken from a series of publications by Nepal's Department of Soil Conservation and Watershed Management. Many of the techniques used both for slope stabilization and reduction of sediment production from exposed land are similar to those proposed for flood risk management (see Section 6.3.3) and especially prevention of flash floods (Shrestha et al., 2012). Thus selection of the techniques to be used should be based on an integrated approach that takes into account the level of hazard and risk across the basin and mitigation of all factors.

KEY TECHNIQUES FOR SEDIMENT MANAGEMENT

Title	Description	Issue(s) addressed
Palisade	Woody cuttings planted in a line across the slope, usually following the contour	Erosion control, reduction of runoff velocity
Fascine	Bundles of live branches laid across shallow trenches	
Wattling	Rows of fences made of vegetative material (preferably live cuttings) placed across the slope	
Brush layering	A layer of woody cuttings planted in a line across the slope, usually following the contour	
Check dam	A small, low dam constructed across a gully or any other water- course	Runoff velocity reduction, sediment trap
Retaining wall	A wall built to resist the pressure of earth filling or backing, deposited behind it after it is built	Slope stabilisation, erosion control, sediment trap
Rip-rap	Stone pitching for surface protection with mainly grass inter-planted between the stones.	Runoff velocity reduction, erosion control
Conservation plantation	Planting of vegetation, especially grass, shrubs, and trees, along with moisture conservation and protection measures, mainly on degraded land including forest, barren land, and gravel and sandy river beds	Erosion control, runoff velocity reduction
Contour buffer strip development	Planting of a permanent belt of erosion resistant vegetation (trees, shrubs, and grass) generally across a slope	Erosion control, sediment trap
Water harvesting conservation dam	Construction of a dam for harvesting and storing runoff water; generally, dams are constructed across rivulets, gullies, or a valley to store the water.	
Ground water recharge pit/ trench	Construction of pits/trenches to recharge groundwater, mainly through increasing infiltration by holding the water in place	Groundwater recharge, runoff velocity control
Irrigation channel improvement	Vegetative and structural measures applied to reduce erosion damage to an existing irrigation channel resulting from erosion upslope or downslope	Erosion control
Landslide treatment	Vegetative and structural measures applied in a landslide area and its influential catchment to stabilize the landslide.	Erosion control, reduce sediment production
Terracing	Slope modification (levelling) of sloping agricultural lands, management of drainage, and grass plantation on the risers, to conserve soil and water	Soil erosion control, increase moisture retention
River/stream bank protection	Vegetative and structural measures to protect a river/ stream bank and adjoining property (habitation and farmland) from erosion	Erosion control, sediment management
Road slope stabilization	Vegetative and structural measures applied to a road slope to maintain stability of the road and prevent erosion	Erosion control
Water and sediment management in flood plain	Vegetative and structural activities applied to manage the water and sediment brought to a flood plain so as to minimize adverse impacts, and maximize benefits, on the flood plain.	Sediment management

Source: DSCWM 1992, 2004, 2016

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ANNEX 3

Data, information and knowledge for IRBM in Afghanistan: Stakeholders, resources, platforms for dissemination, and access

High power, highly interested			
	Data, information, knowledge	**Platform**	**Access**
Ministry of Energy and Water (MEW)	It manages hydro-meteorological data, (manages 183 stations), it also manages the water yearbook	Media releases and website news	MEW access to all hydrometeorological data
Ministry of Agriculture Irrigation and Livestock (MAIL)	Agricultural production and yield; it also manages hydro-meteorological data,	MAIL office	It has access to the hydro-met data
Afghanistan Meteorological Department (AMD)	It has hydrometeorological data		It has access to the hydro-met data
Ministry of Education (MoE),			
Afghanistan National Disaster Management Agency (ANDMA), Media, Independent Directorate of Local Governance (IDLG), MRRD, Administrative Office of the President (AoP), Afghanistan Urban Water Supply and Sewerage Corporation (AWSSC), Independent Directorate of Local Governance (IDLG)			
High power, less interested			
Ministry of Foreign Affairs (MoFA)	Foreign policy	Official website	
Politicians, Senators, Local government, leaders, National Directorate of Security (NSD), Academia			
Low power, highly interested			
Municipalities	Scheme map	Master plan	
Farmers	Irrigation area, hydrology and water availability	Farmers association	All related ministries, MAIL
Researchers and Research Centers	Research results on soil, water	Research	Academic
Students	Research assistant	Government office	Academic
Afghanistan's Central Statistics Organization (CSO), MULD	Statistical	Houses, development	People
Private companies	Culture		
Ministry of Public Health, Ministry of Public Work, Mineral water production communities/ CDC, NGOs, International Agencies			
Low power, low interest			
Smaller business	Geographical information		
Ministry of Women Affairs (MWA)	Gender information	Website and Media	Afghanistan's Central Statistics Organization (CSO)
Ministry of Counter Narcotics (MCN)	Narcotics statistics	Media	Donors
Ministry of Labor, Social affairs and Martyrs and Disabled (MoLSAMD)	Statistical Data		
Afghanistan Urban Water Supply and Sewerage Corporation (AWSSC)	Water quality, groundwater L discharge	Test-research lab	Hydrological department MRRD/MEW
Ministry of Urban Development and Housing (MUDL)	Survey mapping implementation	Survey analysis	All departments (ministries/NGO)
Private company	Water quality	Contractors	Donor
Mineral production companies	Water quality	Lab/test	
NGOs	Water quality capacity building	Lab test	International organizations, MoPH
Ministry of Justice (MOJ), Ministry of communication and Inter technology (MCIT), Ministry of Information and Culture (MOIC), Ministry of Borders and Tribal Affairs (MOBTA)			

ANNEX 4

Agenda of the Koshi River basin field visit

Time	Location	Agenda
DAY 1		
7.00	ICIMOD	Departure
9:30 – 9:45	Sukute Beach	
12:00 – 12:30	Bhotekoshi Power House	Discussion: Bhotekoshi power plant (Information Sheets 1, 2)
13: 00 – 14: 00	The Last Resort	Briefing: The suspension bridge is about 160 m above the river bed and was built for Bungy Jumping Friendship Bridge Larcha LDOF site (Information Sheet 3)
14:45 – 15:15	Barabise hydro-met station	ICIMOD has upgraded the hydrological station at this site in collaboration with DHM. (Information Sheet 4)
15:45 – 16:00	Jure	Landslide vulnerability and its effect on the community (Information Sheet 5)
	Sunkoshi Hydropower	View in passing
16:30 – 16:45	Balephi confluence	Bhinse rock
17:15 – 17:30	Zero kilo	Talk on Melamchi Water Diversion (Information Sheet 6)
	Panchkhal	While passing, discuss 'too much too little water' (Information Sheet 7) and "climate smart villages" (Information Sheet 8)
18:00	Dhulikhel	
19:00 – 20:00	Dhulikhel	Group interaction and reflection
DAY 2		
7:00		Depart
9:45 – 10:15	Khurkot (Khurkot Thakali Bhancha Ghar)	Briefing on upstream downstream water management at Khurkot
12:15 – 13:00		Subsurface water harvesting at Bahun Mara village (Information Sheet 9)
13:40 – 14:40	Gautam Hotel	Bardibas
14:40 – 15:10	Ratu bridge, Bardibas	Lalgadh, visit CBFEWS station in Bardibas – interact with caretakers (Information Sheet 10)
17:00	Lahan	Arrival
19:00-20:00	Hotel Durbar	Group interaction and reflection
DAY 3		
7:30		Depart
8:00 – 8:30	Kalyanpur	Discussion on solar power irrigation pumps (Information Sheet 11)
9:30 – 10:15	Mahuli	Discussion on Water Users Master Plan at Mahuli Community Development Center (MCDC) (Information Sheet 12)
11:15 – 11:45	Koshi Barrage	Observation and discussion
12:05 – 12:20	Koshi embankment	Briefing on embankment breach (Information Sheets 13 and 14)
12:50 – 13:50	Water birds wildlife camp	Observation
14:00 – 15:15		To airport

ANNEX 5

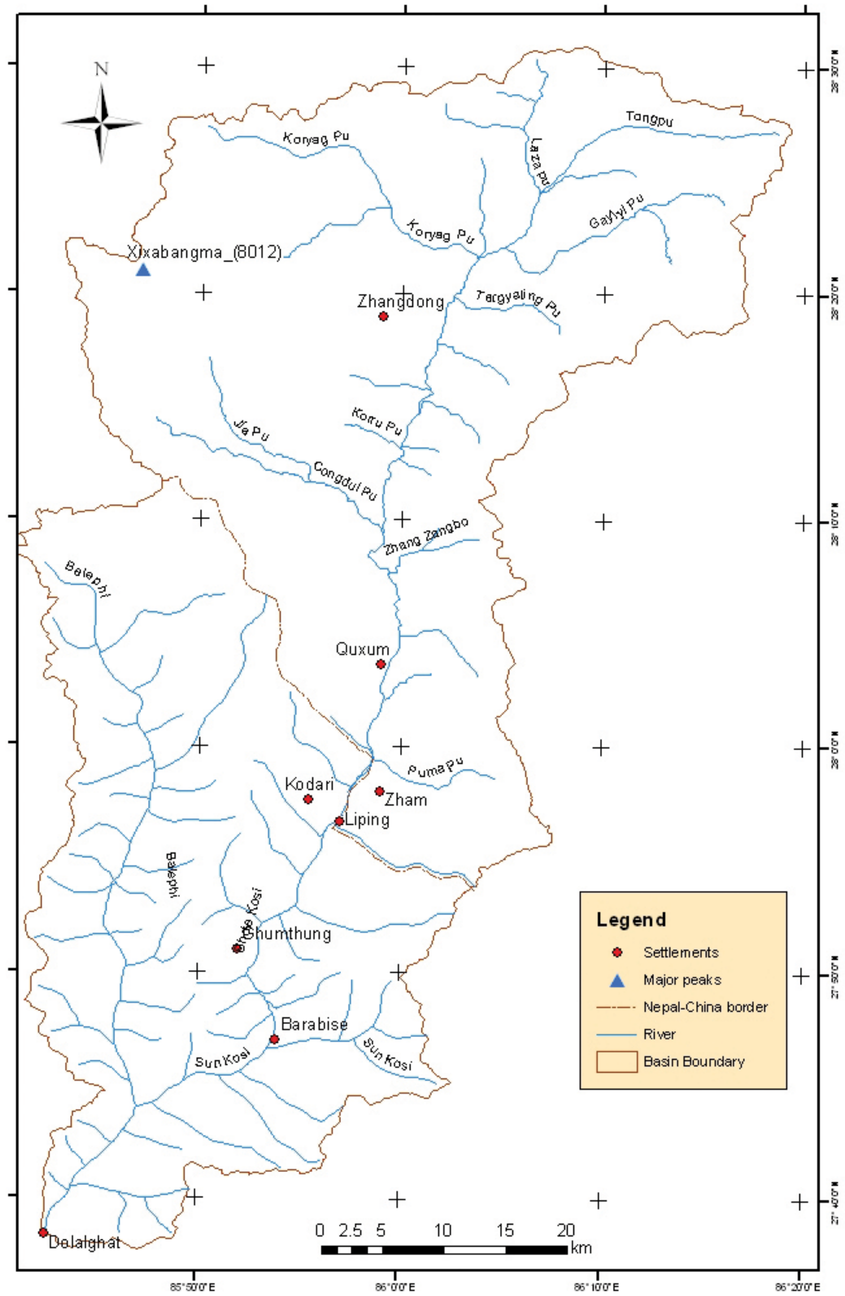
Information sheets

Information sheet 1: The Sun Koshi River Basin

Introduction

The Sun Koshi is a transboundary river basin shared between Tibet Autonomous Region in PR China and Nepal (Figure A2). The river has its source on the northwestern slopes of Laptshegang mountain and is called Poiqu until it crosses into Nepal near Liping. It takes the name Bhote Koshi in the upper reaches in Nepal, changing to Sun Koshi close to Barabise where it merges with the small tributary of that name, whose source lies in Nepal. The basin is located between latitudes 26°37' to 28°32'N and longitudes 85°43' to 86°18'E. It covers an area of 3,394 km², 60% (2,007 km²) within China, and has an elevation range from 8,012 masl at Xixiabangma to 620 masl at the river outlet near Dolalghat in Nepal. The only highway linking Nepal and China (the Arniko highway) passes through this basin and is aligned along the river channel.

FIGURE A2: THE SUN KOSHI RIVER BASIN – LOCATION AND RIVER NETWORK



Meteorology and Hydrology

The Chinese part of the Sun Koshi basin lies on the leeward side of the Himalayan range. There is only one meteorological station in this part of the basin at Nialamu (3,310 masl). The next closest station is at Dingri (4,300 masl) about 76 km away to the northeast. The mean annual precipitation at Nialamu is around 700 mm and at Dingri about 300 mm. The Nepalese part of the basin lies on the southern slope of the Himalaya. There are six rainfall stations within this part of the basin and several more in the vicinity. The precipitation is considerably higher, annual rainfall ranges from about 1,300 to 4,100 mm. The precipitation pattern follows the general trend in the Himalaya with an increase in annual rainfall from south to north on the southern slope followed by a drastic decrease on the leeward side, and marked seasonal variation on the southern slope with most of the precipitation in the monsoon season (Figure A3). Seasonal variation in precipitation and river discharge at Barabise is shown in the Figure A4.

FIGURE A3: SEASONAL AND ANNUAL VARIATION IN PRECIPITATION, AND CHANGE WITH LATITUDE, AT STATIONS IN THE POIQU/ SUN KOSHI BASIN

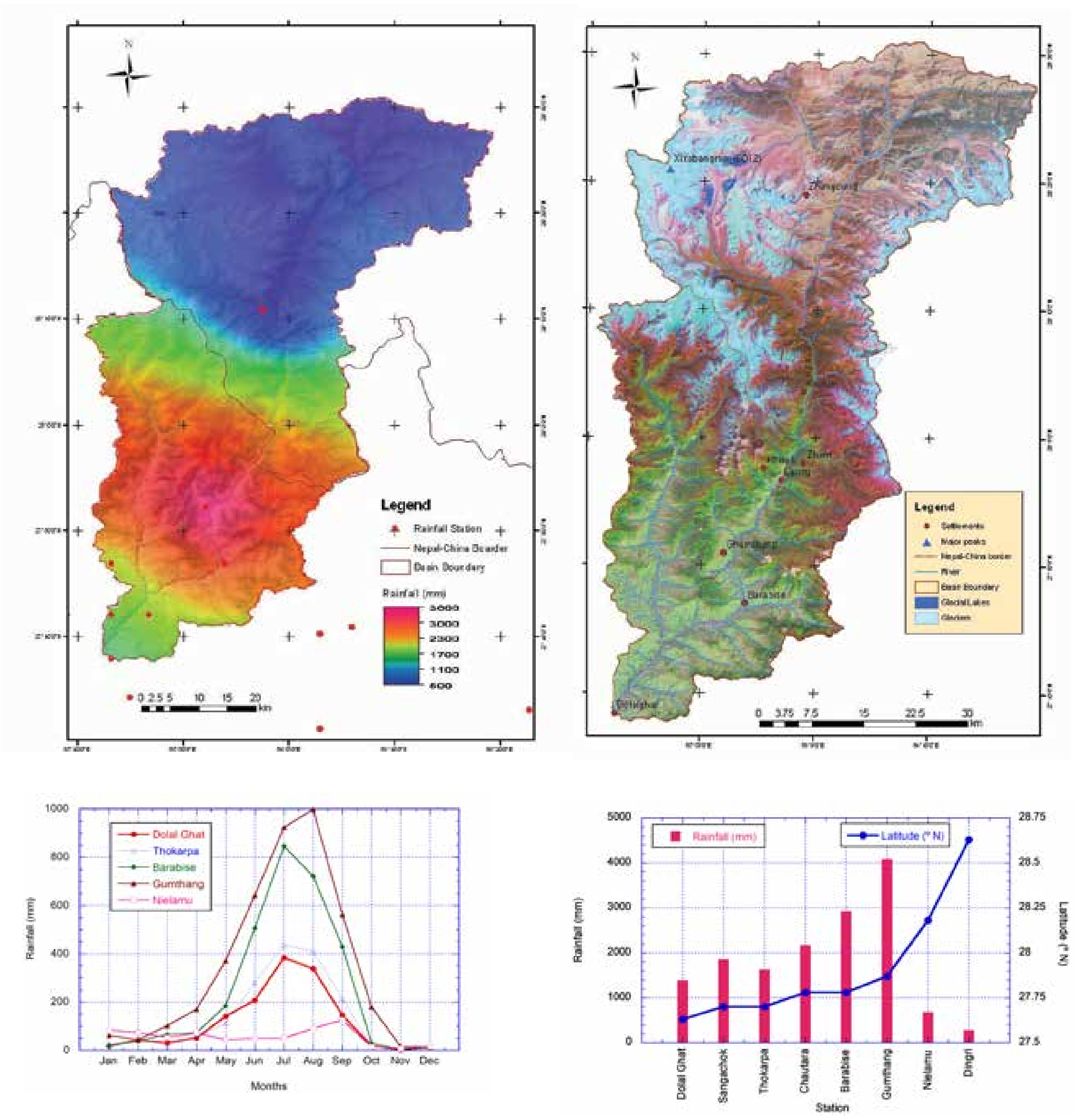
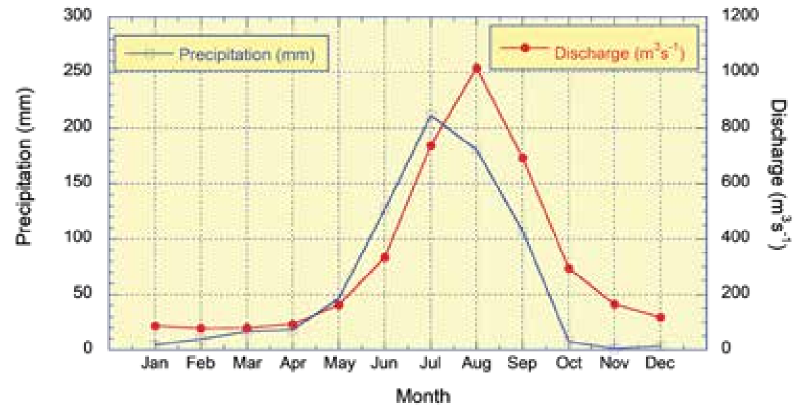
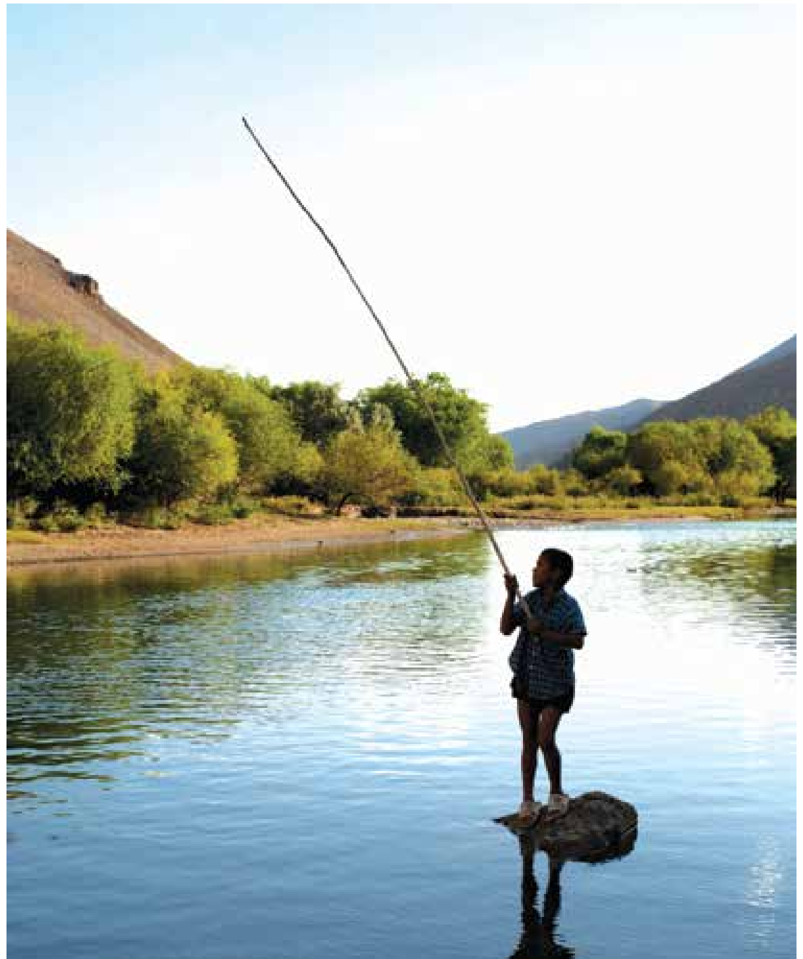


FIGURE A4: SEASONAL VARIATION IN PRECIPITATION AND RIVER DISCHARGE AT BARABISE



The part of the basin in the Tibetan Plateau is heavily glaciated, while the Nepalese side has very little glacier cover. In 2000, the glaciated area was 232 km^2, or 7% of the total basin area, with 11.5% of the area in TAR, China glaciated. The glaciers are retreating rapidly, however, with some on the east slope of Mt. Xixabangma retreating at rates of 50–70 m per year. The rapid deglaciation has resulted in the formation and growth of several glacial lakes. In 1988, there were 119 glacial lakes in the basin, covering an area of 13.4 km^2 areas, by 2000 this had grown to 139 lakes with an area of 16.4 km^2, an increase of 18% in 12 years. Nine glacial lakes in the basin have been identified as potentially dangerous (Ives et al., 2010; Yamada & Sharma, 1993).



Socio-economic scenario

The basin is highly important socio-economically. The only all weather highway linking Nepal with China passes through this basin and has great economic significance with a high volume of goods transporters. There are two medium size hydropower stations on this part of the river – the Sun Koshi and Bhote Koshi – and several mini hydropower plants within the basin. These power plants are connected to the central power grid by a high tension transmission system.

In 2009, ICIMOD conducted a detailed socio-economic study of the Sun Koshi river corridor in relation to GLOF risk assessment. The total number of people living in these areas according to the 2001 population census was 639,000. The major source of family income for a large proportion of families was wage labour followed by trade and business and agriculture. Agriculture is still the dominant sector in the lower reaches – the Sukute, Lamosangu, and Barabise area. The main sectors providing employment opportunities are mining of sand gravel, stone and slate; small-scale industries such as carpet, paper, and bread; transport and construction work, especially loading and unloading of goods, and maintenance of roads and drainage systems; and trade and business, mainly in hotels and restaurants. In addition, many people go to Kathmandu in search of jobs and work as wage labourers. Many families are also involved in wholesale and retail trade. Food scarcity is more widespread in the upper reaches than in the lower reaches. Close to 50% of families are below the poverty line. The proportion of poor households is relatively higher in Tatopani and Liping in the upper reaches, Shakhuwa and Chaku in the middle reaches, and Sukute and Balephi in the lower reaches .

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Information sheet 2: Bhote Koshi Power Project

The hydroelectric project Bhote Koshi Power Project, also known as the Upper Bhote Koshi Hydroelectric Project is a run-of-the-river power plant in Sindhupalchowk District in central Nepal, approximately 110 km northeast of Kathmandu. It was constructed between 1997 and 2000 with power generation starting in January 2001 (Figure A5). The dam, located at 27°56′20″N 85°56′42″E, diverts water downstream into a 3,300 m (10,827 ft) long head race tunnel which terminates in two penstocks that supply the two 22 MW Francis turbine-generators with water (Figure A6). The drop in elevation between the dam and power plant affords a normal hydraulic head of 135.5 m (445 ft). The BKPP is a 45 MW power plant with 2 turbine/generator units.

The first hydropower company in Nepal

The Bhote Koshi Power Company (BKPC) entered into a Project Agreement with the Government of Nepal in July 1996 for the development of the UBKHEP. BKPC has a 40-year license to build, own, operate, and transfer the UBKHEP as per the Electricity Act, 2049 (1992). BKPC entered into a Power Purchase Agreement (PPA) with the Nepal Electricity Authority (NEA) in July 1996 for the sale and purchase of energy. The PPA is valid for 25 years from the Commercial Operation Date (COD) of 24 January 2001. The power produced by BKPC is connected to the NEA substation in Lamosanghu, 25 km away, via a 132 KVA transmission line.

BKPP was the first privately funded hydropower project in Nepal. The project cost was about USD 98 million. The major part of the finance was provided by Panda Energy International, who have since divested their holding to the local shareholders.

Bhote Koshi power project: Salient features

Type: Peak-run-of-the-river

Rated net head: 134 m

Rated turbine discharge: 36.8 m3/s

Head race tunnel: 3301 m, 4 m dia., shotcrete and concrete

Pressure shaft: 430 m long, 3 m dia., steel lined

Surge tank: 8 m dia., 45 m high restricted orifice

Installed capacity: 45 MW

Turbine generator set: 2 sets

Type of turbine: Francis

Rated output: 22.5 MW x 2

Rated speed: 428.57 rpm

Type of generator: Vertical shaft synchronous

Capacity: 25 MVA

Voltage ratio: 11/132 KV

Power transformer: 11/132 KV single phase

Designed average annual generation: 246 GWh

Catchment area: 2,132 sq. km

Average annual discharge: 66.4 m3/s

Civil construction started: 1997

Commercial operation started: 24 January 2001

Construction cost: USD 98 million

T/G supplier: Harbin

EPC: Harza, Hydrochina Zhongnan

FIGURE A5: AN EARLY WARNING STATION AT THE BHOTE KOSHI POWER HOUSE

FIGURE A6: DIVERSION STRUCTURE FOR THE BKPP

GLOF early warning system

The BKHP is vulnerable to potential GLOFs. Recognizing this risk, BKHP has installed an early warning system to provide warnings if a surge is detected from upstream. The early warning system uses Meteor Burst communication, in which the ionized trails of meteors extend the range of transmitted radio signals, to receive signals at the warning station .The sensors of the early warning system are located at the border between Nepal and China, and the power plant relays the flood information to downstream communities residing along the path of potential destruction. But as a result of the short distance to the sensors, the lead time at the power plant is only five minutes, which is barely enough for evacuation of people from the plant site. The lead time could be increased considerably by installing the sensors further upstream across the border, closer to the source of any potential GLOF. This highlights the need for a platform for dialogue on transboundary flood management.

Information sheet 3: GLOF risk and other flash flood events in the Sun Koshi Basin

Introduction

As mentioned in Information Sheet 1, the glaciers in the headwater area of the Sun Khoshi basin in TAR China are retreating rapidly leading to the formation and growth of an increased number of glacial lakes. Nine glacial lakes in the basin were identified as potentially dangerous in 2005 (Ives et al., 2010), and this number may have increased. Thus GLOFs are a potential risk in the Sun Koshi basin.

Past GLOF events in the basin

Three major GLOF events have been recorded in the basin. The first occurred in 1935 when the Tara Cho lake burst out. The flood event damaged a wide area of cultivation and livestock, mainly in the headwaters close to the lake in TAR, and no cultivation has been possible since then in the valley just downstream of the lake because of the debris deposits. In 1964, the Zhangzangbo lake burst out but did not cause much damage. This was perhaps because it was only a partial outburst due to piping in the moraine dam. The same lake burst out on 11 July 1981. This GLOF lasted for about one hour and caused significant damage downstream in the Nepalese part of the basin. The amount of water released was estimated at 6.3 million m3. The flood washed away a large portion of the highway linking China and Nepal, damaged three bridges along the highway, including the Friendship Bridge at the China-Nepal border, and severely damaged the diversion weir of the Sun Koshi hydropower plant. The total damage in Nepal amounted to about USD 3 million.

Other flash flood events

The basin is also frequently affected by intense rainfall floods. In 1987, one such flood caused severe damage to the Arniko Highway. Landslide dam outburst floods (LDOFs) are also common, LDOFs were recorded in the Bhairab Kunda in 1996, 1998, and 1999, and the Devisthan Khola in 1999, 2002, and 2005. These LDOFs caused some damage to the Upper Bhote Khosi hydropower plant facilities. The most extreme LDOF event in this area in recent

times was the Larcha LDOF on 22 July 1996. Larcha is a small settlement near the confluence of the Bhairab Kunda stream and the Bhote Koshi. Rainfall of 80 mm was recorded in a 24 period at Gumthang which led to several landslides along the Bhairab Kunda, one of which dammed the stream. The subsequent outburst of the dam caused a flood and debris flow which wiped out Larcha village. The event occurred around midnight, and 22 houses were washed away or damaged and 54 people killed in a matter of minutes. Around 150 m of the Arniko Highway was also damaged by the flood.

GLOF risk in the basin

In 2009, ICIMOD conducted a comprehensive GLOF risk assessment of the Sun Koshi basin. This included a dam break scenario and socio-economic impact assessment taking an outburst of the Lumu Chimi lake in the headwaters of the basin as the basis for calculations (Shrestha et al., 2010). The peak flood at the China-Nepal border was estimated to be more than 9,600 m3/s. The flood was routed along the river valley to derive the inundation scenario and to estimate potential impacts.

It was calculated that close to 5,800 people in 900 households would be directly affected by a GLOF of the same magnitude as that which occurred in 1981 as they either live within or have property within the GLOF hazard zone. This figure increased to 2,519 households with 16,313 people if the GLOF were to be 10 m higher than the 1981 GLOF. A GLOF would affect the flow of vehicles, goods, and people along the Arniko and Lamosangu-Jiri highways, spreading the indirect impact to many VDCs in Dolakha, Ramechhap, and Solukhumbu districts. Based on the 2001 population census (Central Bureau of Statistics 2001), a total of 639,000 people could be indirectly affected by damage to the two highways. Many more people involved in international trade with China and tourism activities to Tatopani and the Khumbu region would probably also be affected. The livelihood support system of more than 3,800 families living inside and outside the GLOF hazard areas would probably be severely affected, including wholesale and retail traders, hotels, industry, transport services, government services, and tourism. The Sun Koshi river is one of the world's top ten rafting rivers, with about six rafting spots along a 28 km reach of the river. A GLOF would affect seven hotels and numerous rafting operators, river guides, and tourism operators that serve the rafting tourism industry along the river. The transport sector would also probably be affected. More than 60 jeeps, 50 buses and minibuses, and 60 trucks shuttle daily along the Arnico Highway. Tatopani, which is located near the Nepal-China Friendship Bridge, is an international trade hub with China. The volume of international trade, including the amount of revenue collected by the government, would be affected by GLOF damage to bridges and roads and the consequent disruption in the flow of goods and services. The estimated total value of property at risk from a GLOF was USD 153 million under Scenario 1 (a GLOF level the same as in 1981) and USD 189 million under Scenario 2 (a GLOF level based on the model.). There would be a drastic increase in the share of private property (buildings, land, crops) and roads affected.

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Information sheet 4: HKH-HYCOS – Making flood information travel faster than flood water

http://www.icimod.org/hycosrfis

Introduction

The Indus, Ganges, Brahmaputra, and Meghna rivers originate in the Hindu Kush-Himalayas (HKH) and support the lives and livelihoods of over 700 million people living in their basins. These transboundary rivers flow through two or more countries and are prone to floods especially in the monsoon season. These floods result in enormous costs in terms of people killed or displaced, infrastructure damaged, and economic output lost.

It is widely recognised that these floods cannot be totally controlled; therefore, the limited resources should be directed towards reducing flood vulnerability and mitigating flood impact through improved flood management. This calls for meaningful regional cooperation among the countries sharing the basins, namely Bangladesh, Bhutan, China, Nepal, India, and Pakistan.

The HYCOS project

ICIMOD, the WMO, and partner countries developed the HKH-HYCOS project to enhance regional cooperation in hydrometeorological data collection and sharing for flood forecasting to support disaster prevention and flood management at the regional level. The project has developed national flood information systems for its partners and established a RFIS to facilitate transboundary exchange of real- and near-real-time data, best practices, and know-how in support of flood management. The RFIS is accessible at http://www.icimod.org/hycosrfis

The project has upgraded 38 hydromet stations in Bangladesh, Bhutan, Nepal, and Pakistan and built the capacities of partners in installing and operating hydromet stations. Data from the upgraded stations are transmitted in real time to their respective national flood information systems and to the RFIS. In addition, data for the region are available from other sources

- Over 300 meteorological stations under WMO's Global Telecommunications System
- Real time data from close to 80 hydromet stations from the national network in Nepal

A regional flood outlook has also been developed which uses satellite precipitation estimates to prepare flood outlooks, and real time data provided by the participating countries to validate it, adding value to the RFIS and improving the efficiency of the outlooks.

The Barabise station

The Barabise water level station is situated on the Bhote Koshi river (Figure A7). The station was installed on 26 April 2013 under the HYCOS project. The station is equipped with two automatic sensors to measure two parameters: water level and rainfall. A data logger stores and transmits data at 15-minute intervals simultaneously to the NFIS national flood information system and the RFIS regional flood information system using one of the following methods:

a. Mobile phone using CDMA/ GSM (code division multiple access/ global system for mobile communications) technology

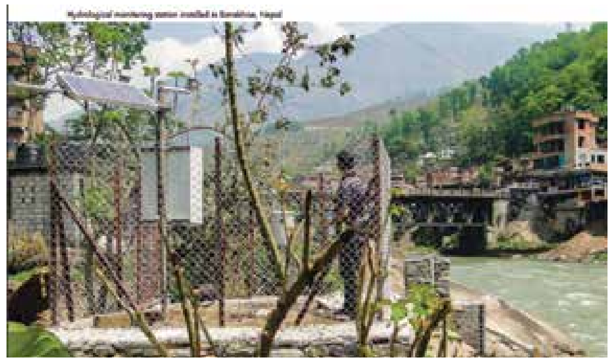
b. Backup mobile phone using GSM technology

c. Satellite communication system

The transmission system is configured hierarchically such that data transmission uses the first channel of communication by default. If transmission fails repeatedly, the system triggers an SMS alert to notify the authorities about the failure and automatically switches and transmits data using the second channel of communication. If the second channel also fails to transmit data, the system triggers an SMS alert to notify authorities about the failure and automatically switches to transmit data via the third channel.

The first two channels of communication use http protocol (the Internet) to transmit data, which is the most economical approach. The third channel, satellite communication, is expensive and is provided as the technical backup of last resort. It has been generally observed that the first two channels of communication are prone to failure or overload during natural hazards such as floods and earthquakes. Thus the last resort backup is needed to ensure that vital data about impending flood events are received at the most crucial times and is triggered during such events.

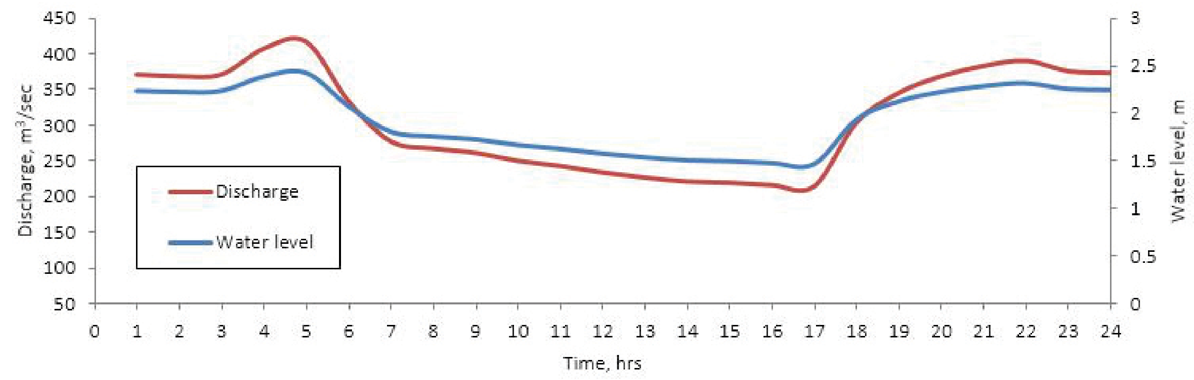
FIGURE A7: BARABISE STATION



a) Staff gauge, tipping bucket, rain gauge, data collection platform (DCP), and solar panel

b) Location of the bubbler pot

FIGURE A8: DISCHARGE AND WATER LEVEL AT A RIVER GAUGING STATION IN PACHUWARGHAT ON 2 AUGUST 2014



Source: www.hydrology.gov.np

Information sheet 5:
Eye on the Sun Koshi landslide: Monitoring and infrastructure planning key to minimizing scale of disasters

https://www.icimod.org/?q=14356

By Arun B Shrestha, Narendra R Khanal, Mandira Shrestha, Hari Krishna Nibanupudi, and David Molden on 04 Aug 2014

In the early hours of 2 August 2014, a landslide occurred above Jure village, about 1.4 km upstream from the Sun Koshi Hydropower project's intake site. In an instant, a 1.9 km long slope of land perched 1,350 m above the river bed collapsed, burying two dozen houses, taking the lives of at least thirty-three people, and injuring many more. Over 150 people are still missing.

The massive landslide created a high dam across the Sun Koshi River. A river gauging station of the DHM at Pachuwarghat downstream of the landslide dam showed a rapid decline in water flow three hours after the landslide, after which the flow of water completely stopped for approximately 12 hours (Figure A8). An inflow of about 160 m3/sec of water quickly created a large lake behind the dam. Within 13 hours the newly formed lake – which rapidly grew to a volume of an estimated 7 million cubic metres – extended about 3 km upstream, completely submerging the 2.6 MW Sanima Hydropower station. Had Nepal's security forces not taken timely action to release some of the stored water through controlled explosions, the backwater would have extended further upstream and caused great damage in Barabise, the nearest upstream town. However, the risk that the dam will breach still remains, bringing with it the threat of a catastrophic flood. The Ministry of Home Affairs has declared the area a 'flood crisis zone', and has issued a warning to communities downstream, with many vulnerable villages being evacuated.

It cannot be predicted when and how the landslide dam will erode and how the stored water will be released. However, it is probable that the Arniko Highway, a major trade link between China and Nepal with exchange that stands at nearly at NPR 38 million per day (nearly USD 400,000), will remain blocked for a long time. This could mean serious medium- term impacts for Nepal. Damage from the landslide has already interrupted power supply from several hydropower plants in the valley, including the Sun Koshi and Bhote Koshi power plants, contributing to the country's scheduled power cuts.

Monitoring hazards to prevent disasters

This is not the first time the Sun Koshi valley has experienced a lethal flood, and this is certainly not the last time. Like many places around the HKH region, the Sun Koshi's weak geological formation and steep topography combined with frequent intense rainfall events and the increasing impact of climate change makes it prone to different types of water-induced hazards, including landslides.

MOSAIC OF GOOGLE EARTH IMAGES SHOWING THE LANDSLIDE, INUNDATION AREA, AND MAJOR HYDROPOWER INSTALLATIONS ALONG THE RIVER CORRIDOR

The valley is also vulnerable to the outburst of growing glacial lakes located in the northern part of the catchment in the Tibet Autonomous Region of China. In 1981, the Zhangzangbo glacial lake located 20 km upstream from the Nepal-China border breached; the resulting flood caused extensive damage in Nepal from the border down to the village of Dolalghat.

Although we cannot control natural hazards like landslides and floods, there are many things that can be done to minimize their adverse impact on lives, livelihoods, and valuable infrastructure. More efforts to map landslide risks are needed, and much more frequent monitoring of potential landslide sites is necessary. Both will help in designing mitigation measures and reducing risks.

In hindsight, photo documentation from 2013 shows a number of scars along the mountain slope in Jure. If there had been an appropriate monitoring mechanism in place, measures could have been taken to raise awareness about the potential of a larger land slip. While the exact timing and size of landslides are difficult to predict, potential landslide areas can be mapped relatively accurately and the approximate size of the potential landslide can be calculated.

A LANDSLIDE ABOVE JURE IN 2013; THE SAME LANDSLIDE AFTER THE LANDSLIDE EVENT ON 2 AUGUST 2014
PHOTO LEFT: NARENDRA R KHANAL; PHOTO RIGHT: ROCKY TALCHABHADEL/DHM

Over the last 30 years, the Sun Koshi valley has experienced three major floods. In 1982, a landslide dam outburst flood (LDOF) in the Balephi river, a tributary of the Sun Koshi, killed 97 people. Another flash flood event in 1987 killed 98 people, and a 1996 flood swept away Larcha village, killing 54 people.

Landslides and other natural disasters are also common outside of the Sun Koshi valley. Nepal alone experienced 13 large landslide events between 1967 and 2010, the most recent being the 2010 Madi landslide in Central Nepal. Recent natural disasters across the rest of the HKH region include the Swat valley flash flood and Attabad landslide disaster in Pakistan in 2010, the disastrous 2012 Seti flash flood in Nepal, the Uttarakhand disaster in July 2013, and the landslide in Badakhshan, Afghanistan in May this year.

Knowledge and information from past disasters can also support disaster risk management. Regular monitoring of hydrological and meteorological variables generates valuable information that can be fed into hydrological models. These models can be used to provide information about areas at risk of inundation during a flood event, including for potential glacial lake outburst floods. This type of analysis can be used in zoning river corridors and preparing land use plans.

Putting planning into practice

While zoning and land use planning are essential elements of risk management, if they are not properly implemented, these efforts are futile. Despite an entire village being washed away by the 1996 Larcha flood, a village has been resettled in the exact same location. With these settlements constructed along the flood plain, many households remain at risk of being destroyed in future floods. Even commercial enterprises are taking calculated risks, with a mini-hydropower project now constructed in Larcha. In areas with significant commercial activity like Khadichaur, the construction of settlements along the flood plain has increased in the past decade.

Across the HKH region, improper or insufficient planning of infrastructure and settlements has put unnecessary lives and investments in harm's way. It is believed that unregulated and haphazard development is partially to blame for the severity of the 2013 Uttarakhand disaster. During such events infrastructure may also create additional risks, for example when stored water is released from hydropower reservoirs into already full river channels.

Experience from the 1981 GLOF event in the Sun Koshi valley has shown the value of proper planning. Following the 1981 flood, more than USD 3 million was spent to rehabilitate the Arniko Highway. During this process, the 27 km stretch of road damaged by the flood was raised 20-30 m above its previous position, and the three destroyed bridges were replaced with arc structures, both of which reduced the potential losses of infrastructure during future floods.

Enhancing cooperation to reduce risk

Because of the transboundary nature of rivers in the HKH region, events of a large magnitude often impact more than one country. The Government of Nepal has informed the Government of India about the potential threat of flooding should there be a sudden outburst of the temporary lake formed behind the landslide dam.

Recognizing the risk for communities downstream, all of the gates of the Sapta Koshi barrage, which is under the control of the Government of Bihar, were opened. The Bihar government has sounded a flood alert in eight districts and have begun the evacuation of nearly 200,000 people living along the Koshi embankment in India.

The Governments of China and India have already offered technical support to the Government of Nepal in its response to the Sun Koshi event. China has good experience in managing mountain hazards, including a landslide following the 2008 Wenchuan earthquake that blocked a valley. Their technical expertise would prove invaluable in managing the massive landslide in the Sun Koshi valley. However, this cooperation should be extended beyond this particular event to long-term transboundary collaboration in managing risks, including in regular monitoring and assessment of potential risks and the implementation of early warning systems.

The scale of the Sun Koshi landslide is beyond the capacity of local communities to manage alone. However, national governments must promote the central role of communities in landslide risk management, including preparedness, adaptation, and mitigation. This is especially true in remote areas where limited access can delay the national disaster response efforts.

GOOGLE EARTH IMAGE OF KHADICHAUR VILLAGE IN THE SUN KOSHI VALLEY IN 2000 (TOP) AND 2012 (BOTTOM). IN THIS STRETCH OF JUST 1 KM, AT LEAST FOUR SETTLEMENTS WERE CONSTRUCTED IN HIGH HAZARD ZONE AREAS IN 12 YEARS.

Consultation with local communities and the use of indigenous knowledge is crucial, particularly in the case of landslides. Use of indigenous knowledge in scientific and technical risk assessments can strengthen the resilience of communities, help communities take decisions informed by their own knowledge, and, when combined with scientific data, correct their own misperceptions about potential risks. This will help communities translate risk perceptions into enhanced preparedness for landslides and other hazards.

Before and after the Sun Koshi landslide

Retrieved from: https://earthobservatory.nasa.gov/images/84406/before-and-after-the-sunKoshi-landslide

In the early hours of August 2, 2014, nearly 2 kilometres of hillside collapsed in rugged northern Nepal. Some 5.5 million cubic metres (194 million cubic feet) of rock and debris tumbled down into the Sun Koshi (Sunkoshi) river valley. The initial slide buried dozens of homes in the village of Jure and killed 156 people.

The destruction on August 2 was just the beginning of the disaster. The landslide blocked the Sun Koshi river and buried the Arniko Highway. For nine hours after the slide, a gauging station downstream showed the Sun Koshi's flow had stopped. Instead, water backed up behind a 55-metre tall (180-foot tall) earthen dam, creating an ever-growing lake that submerged dozens of houses and a hydropower substation. According to media reports, the loss of the power station led to a 10 percent decrease in Nepal's electricity generating capacity, causing outages in the capital and elsewhere in the country.

The Nepalese army quickly set to digging and blasting two outlet channels into the dam in an attempt to drain the lake. With tens of thousands of people living in cities and villages downstream, geologists were concerned a sudden breach could cause devastating floods. However, 17 days later, the Nepalese Army was still digging, and the level of the lake had yet to change, most likely because efforts were focused on widening rather than deepening the outlet channels.

Finally, Nepalese authorities caught a break. Early on September 6, without warning, the dam breached, probably because of extra pressure after heavy rainfall increased the river's flow. Fortunately, even though the surge of water damaged homes as far as 6 kilometers (4 miles) downstream of the dam, the floods were less severe than initially feared. Due in part to widespread evacuations of downstream villages, no casualties were reported.

While it was cloudy on most days the Landsat 8 satellite passed over the area, the Operational Land Imager (OLI) did capture a few images of the landslide and the aftermath. The top image shows the area on September 15, 2013, long before the landslide occurred. Notice what appear to be scars left by an earlier landslide. OLI took the middle image on September 2, 2014, a month after the landslide. The barrier lake covered a large portion of the river valley, stretching nearly as far as Barabise, a town a few kilometres upstream. On the earthen dam, the two manmade outlet channels are visible. OLI acquired the bottom image on September 18, 2014, after the dam had breached and the lake had receded significantly.

SEPTEMBER 2, 2014 SEPTEMBER 18, 2014

SEPTEMBER 15, 2013

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NASA Earth Observatory images by Jesse Allen, using Landsat data from the U.S. Geological Survey. Caption by Adam Voiland.

Information sheet 6: Melamchi Water Supply Project

Adapted from the Government of Nepal, Ministry of Water Supply and Melamchi Water Supply Project

The Melamchi Water Supply Project

The Melamchi Water Supply Project is designed to divert about 170 MLD of fresh water to Kathmandu Valley from the Melamchi river in Sindhupalchowk district through a 26 km long tunnel. It is considered to be the most viable long-term alternative to ease the chronic water shortage situation in the Kathmandu Valley. The Yangri and Larke rivers, which lie in the upstream proximity of Melamchi, are also being investigated as future supply sources.

The Melamchi Water Supply Development Board was established by the Government of Nepal on 9 November 1998 as the implementing agency for the Melamchi water supply project, with the Ministry of Physical Planning and Works as the executing agency. The Chair of the Board is the Secretary of the Ministry of Water Supply and Sanitation. The Board, as an independent project implementing body, has come a long way since 1998 to collecting the necessary funds to implement the project. The major donor of the project, the Asian Development Bank (ADB), approved a loan of USD 120 million (out of an estimated total project cost of USD 464 million equivalent at 2000 prices) on 21 December 2000, effective from 28th November 2001.

Project objective

The primary objective is to alleviate the chronic shortage of potable water in the Kathmandu Valley on a sustainable long-term basis, and thereby to improve the health and wellbeing of its inhabitants, particularly the poor. The project is designed to provide good quality potable drinking water as per the World Health Organization's Guideline to feed an improved distribution network as set out by the Melamchi Water Supply Project – Subproject II.

Environmental management

The major work of construction is the excavation of the planned 26.3 km long diversion tunnel using the drill and blast method. The program reviews all the Environmental Impact Assessments for the project areas and evaluates project activities for future adverse effects that may arise during the design, pre-construction, construction, and operation phases to ensure implementation of the project activities in a socially and environmentally acceptable manner. The program also alerts the management on any environmental challenges during project implementation including short and long-term effects.

It has been nearly 20 years since the Melamchi project was initiated as a potential source of additional water for Kathmandu Valley. The project has since been scaled back and delayed, and although the tunnel is close to complete, is now working at a slow pace surrounded by uncertainty.

Discussion

IBTs are a major form of river basin manipulation. Despite their high cost and complex engineering, the ecological and social implications of such schemes continue to be inadequately addressed. Since conveyance of water between natural basins is described both as a subtraction at the source and as an addition at the destination, their scale, costs, and environmental and developmental impacts must be considered carefully.

A number of countries have benefited enormously from IBTs. However, IBTs may cause changes (both positive and negative) in the ecological environment of both basins. Because IBTs have enormous ecological risk, it is necessary to comprehensively analyse the inter-basin water balance relationship, coordinate the possible conflicts and environmental quality problems between regions, and strengthen the argumentation of the ecological risk of water transfer and eco-compensation measures.

IBT projects directly affect the management of origin and destination basins and the socioeconomic and environmental conditions are often weakened in one of the basins in the long term. Plans should also satisfy the integrated recognition of the conditions and potentials in the study region, have a comprehensive and systematic management approach, and ultimately take into consideration all the environmental, economic, social, and political dimensions.

Information sheet 7: Living with water stress in the hills of the Koshi Basin, Nepal

Key messages

- Decentralised systems, such as rainwater harvesting, offer incremental solutions to addressing emerging water stress but require larger policy shifts to scale up and acheive a significant impact.
- Access to and flow of information, goods, and services into and out of an area is a necessary condition for being able to respond to stresses.
- Social capital and the presence of multiple institutions help to support adaptation.
- Diversification and access to alternative sources of livelihood emerged as a central strategy for helping people adapt • to stress, whether induced by climate change or other ongoing change processes.
- The variety of income sources, not the level of income, seems to be important for adaptation.

The study in the Koshi Basin of Nepal examined both wet and dry sites and the mosaic of vulnerability that leaves people coping with the effects of climate-induced stresses and hazards. Although the study examined the impacts of both flood and extended drought – too much or too little water – people generally consider that water availability has declined overall in the last decade

The people of the hills and the Terai of Nepal's Koshi basin are already experiencing the stress of climate related hazards, such as erratic monsoon behaviour, floods, and extended periods without rainfall. They are coping with the effects, but need to develop effective adaptive strategies. The information collected clarifies people's perceptions about adaptation. Clearly, they recognise that the diversification of crops, agricultural practices, and livelihoods can cushion the impacts of changes in frequency, intensity, and duration of rainfall (flood or extended drought)

This document is available at: http://lib.icimod.org/record/26784/files/c_attachment_665_5857.pdf

This document is a part of "Local Responses to Too Much and Too Little Water in the Greater Himalayan Region (2009)" where five case studies were carried out between June 2008 and September 2009 (in Chitral District, Pakistan; the Koshi basin, Nepal; Bihar, India; Assam, India; and Yunnan province, China) to document adaptation strategies at local or community level to constraints and hazards related to water and induced by climate change in the Himalayan region. Find the full document at: http://lib.icimod.org/record/8021

Information sheet 8: Climate Smart Villages: Building affordable and replicable adaptation pilots in mountain areas

Background

Based on FAO's approach of climate smart agriculture – which combines the three dimensions of sustainable development (economic, social, and environmental) for an integrated approach to climate adaptation, resilience, and food security – ICIMOD has developed the Climate Smart Village approach, which is customized for mountain areas. The approach equips communities with tools to improve their resilience to climate change and other changes and fosters sustainable development, particularly of agriculture.

ICIMOD, together with its partner, the Centre for Environment and Agriculture Policy Research, Extension and Development, has developed four CSV pilots in villages of Kavre District, Nepal, through its Himalayan Climate Change Adaptation Programme. The pilots are working with 508 households in 18 farmers' groups, and 75% of the participants are women. Based on the success of the model, two other ICIMOD initiatives are exploring the potential for implementation and uptake in other areas.

The project is supported by institutions at various levels: district development committees, agrovets, VDCs, district agricultural development offices, the Alternative Energy Promotion Centre, and insurance companies. This rich collaboration broadens ownership of the Climate Smart Village model, and helps to ensure the sustainability of the project's impacts.

As the next step, the project will also engage with local governments and policy makers for scaling up the Climate Smart Villages model to a wider context. The model has already been taken up by two other initiatives of ICIMOD for implementation in other areas.

The full document on climate smart villages is available at:
http://lib.icimod.org/record/30770/files/CSV15.pdf

Information sheet 9:
Technology for harvesting subsurface river water in Bardibas Municipality

Bardibas Municipality-6, Rajabas, Mahottari District, Nepal

Introduction

Water scarcity is common in the mid-hills of Nepal in the dry season and limits the potential for growing additional crops, and mountain communities have developed unique solutions to address the problem. Dry and sandy riverbeds are reservoirs of sub-surface water which have been harnessed for a long time by both animals and humans. For example, in Panchkhal, communities generally dig trenches to access sub-surface water from the riverbed during the dry season to address short term scarcity.

The communities in Bahunmara developed an innovative technology to harness sub-surface water from the upstream riverbed of the Ratu river by constructing a subsurface dam and transporting the trapped water downstream through subsurface pipes to their villages to use in irrigation. The farmers developed the idea on their own to address the problem of shortage of water for irrigating their farms after they found abundant water below the surface of the dry river bed. There is no perennial source of water in the river and the river dries early in the winter season, but the subsurface (seepage) water was found to be perennial and present throughout the winter and dry seasons.

The technology was further developed by the CDAFN, an NGO, who constructed an improved irrigation channel (mulkulo) to bring the water to the users in Rajabas.

Water discharge past and present

Rajabas is a fertile river terrace with a high potential for crop production, but due to lack of irrigation facilities, winter cultivation in the alluvial areas was not possible even in the lowlands. The Ratu river presented a typical case of too much and too little water. The river flooded in the monsoon season causing problems, but was dry in the winter and pre monsoon seasons so the villagers faced water shortages. Until recently, there were many water sources around Rajabas village in the dry season, but now seepage water is the only source of perennial water. The remaining water sources are recharged in the monsoon but run dry soon after the onset of winter.

Design and results

The mulkulo (canal) was constructed in 2013 to channel the subsurface seepage water with financial and technical assistance from Caritas Nepal and Germany, together with a local contribution. The main structure used to transport the seepage water was a reinforced concrete cut wall along the river together with a gabion wall to filter the water at the intake point upstream, constructed using cement, rods, sand, pebbles, boulders, gabion cages, and earth. The canal is 196 m long from the point of water entry, 0.8 m wide, and 1.8 m deep. The mulkulo serves an alluvial area of more than 70 hectares in the monsoon season and 53 hectares in the winter season based on the availability of water. Figure A9 shows the improved irrigation channel.

FIGURE A9: GLIMPSES OF THE IMPROVED IRRIGATION CHANNEL IN RAJABAS

Direct benefits to farmers

The direct benefits of irrigation channel improvement included provision of irrigation water for cultivation, especially vegetables and cash crops; provision of drinking water for domestic and wild animals; and environmental improvement for tourism. A comparative before and after study of the direct benefit found that the cropped area increased by 233%, crop production by 334%, and farmers' income by 248% as a result of increasing the number of crops annually from one to two or three and improvements in both quality and quantity of production.

Conclusions

The irrigation channel improvement to access subsurface seepage water offers a means for supplying water for crop production, irrigation, and drinking water for livestock and wild animals especially in the Siwalik region of Nepal. It has also helped in reducing soil erosion and promoting greenery.

An investment of NRs 1,105,000 (approximately USD 11,275 in 2014) was contributed by different stakeholders in cash or kind. The local people's participation with a cash contribution in the form of 'bighauti' (the traditional custom of collection of capital for social welfare based upon landholdings) was particularly high (52%), and accompanied by contributions from Caritas Nepal/Germany through CDAFN, the local community forest user group, and the VDC of 25%, 18%, and 5%, respectively. This is a very good example of people's participation and the model is replicable in other regions of Nepal.

Discussion

Although harvesting the subsurface water has benefited the local communities, the impact on overall water balance, watershed management, water availability in the downstream communities, and ensuring environmental flows remains unknown and needs to be considered. Close to 50 communities are already harvesting the subsurface water for drinking and irrigation purposes, sometimes harvesting more than 500 thousand litres per day. Is this technology/model sustainable and should it be promoted along the entire stretch of the river? What must be taken into consideration before replicating the model in other rivers and other places?

Information sheet 10: Community Based Flood Early Warning System

A community based flood early warning system (CBFEWS) is an integrated system of tools and plans to detect and respond to flood emergencies that is managed by communities. The people-centric CBFEWS developed by ICIMOD emphasizes the four essential elements of early warning systems (EWS). Although the detection of a flood risk and its communication to vulnerable communities is driven by technology, the success of CBFEWS depends on a community's preparedness to respond to floods.

KEY ELEMENTS OF CBFEWS IMPLEMENTATION

Why CBFEWS?

1. Low cost technology and tools
2. People centered
3. Upstream/downstream linkage
4. Close to real time information
5. Provide guidance on how to respond to warnings

How does CBFEWS work?

CBFEWS is based on a set of simple instruments installed upstream to detect floods. It generates flood signals that are communicated to downstream communities. The system consists of two units: a transmitter unit at the riverbank and a receiver unit at a caretaker's house, at a safe distance from the river.

A sensor in the transmitter senses water level rise and transmits this data to the receiver. The receiver unit generates audible and visible signals. Telemetry based versions of CBFEWS instruments also upload data to the cloud server. The trained caretaker interprets the alerts and relays the early warning information to downstream communities through pre-established channels to enable flood vulnerable individuals, communities, and organizations to prepare and take action to reduce harm or loss of lives and property.Telemetry allows for water levels to be viewed in a time series chart directly through the internet.

A CBFEWS flyer with this and more detailed information is available at: http://lib.icimod.org/record/34317

KEY ELEMENTS OF CBFEWS IMPLEMENTATION

1.RISK KNOWLEDGE AND SCOPING	2. COMMUNITY BASED MONITORING AND EARLY WARNING	DISSEMINATION AND COMMUNICATION	RESPONSE CAPABILITY AND RESILIENCE
Systematically collect data and undertake scoping and risk assessments	Install early warning instrument; flood monitoring by upstream communities	Communicate flood information and provide early warning - upstream to downstream communities	Enhance community response capabilities and build resilience

Source: Based on UNISDR, 2006, http://www.unisdr.org/2006/ppew/whats-ew/basics-ew.html

Information sheet 11: Solar pumps and groundwater irrigation

SPIPs are a proven technology, and can potentially be a game changer in Nepal's irrigation sector by providing clean irrigation to millions of farmers. However, the relatively high capital cost of SPIPs is the main impediment that prevents large scale adoption of SPIPs. Given this, can we design appropriate financial solutions that will help in the large scale adoption of this clean and efficient technology? We ran a randomized experiment in order to estimate demand for SPIPs under three financial models – 'grant'; 'grant-loan' and 'grant-pay as you go' in Saptari district of Nepal. We provided an additional 10% discount to women applicants, provided they owned the land on which SPIPs were to be installed. These models were based on policies of the Alternative Energy Promotion Centre, and similar schemes available in India and Bangladesh. VDCs were randomly divided into three groups and one financial option was provided to each group of VDCs. This randomized control trial helped estimate absolute demand for each of the models. We ran 45-days promotional campaigns to solicit demand from farmers. The main findings from our experiment were:

Promotion campaigns need to be carefully crafted to reach out to a maximum number of potential customers.There is a high demand for SPIPs in the Terai region of Nepal. We received 65 applications from Saptari district. This is a significant number given that there are no more than 15-20 SPIPs in Nepal right now, and all of these are pilot demonstrations by NGOs.

- Giving additional discounts to women farmers can lead to a lessening of structural inequities in land ownership. 77% of our applicants were women. For them to avail of the special women's discount, land on which the SPIPs were to be installed had to be transferred to women – either solely, or jointly with any other male family member. We found, in 82% of the cases, land has already been transferred to the woman applicant.
- Giving a one-time grant is not enough for a high cost farm equipment like SPIP. Loans and pay as you go options are also needed. We found that 20% of demand was for the grant model, 46% for the grant-loan model, and 34% for the grant-pay as you go model.
- There is a viable business opportunity for solar entrepreneurs in rural Nepal to rent out SPIPs to farmers against rental fees as a part of the grant-pay as you go model. But this can happen only if private companies can directly avail of SPIP grants from the government of Nepal.
- Group ownership of irrigation assets is not a preferred market model, and only one out of 65 applications was from a group. This makes it important to re-think usual government grant policies that target groups instead of individuals, often under misplaced equity concerns. Group models, intermediated by reputable NGOs, however, may be tried out for reaching out to smallholder and marginal farmers who do not yet practice intensive irrigated agriculture.
- Farmers who have applied for SPIPs have more land, better access to irrigation and own more pumps on average. This shows farmers who are already practising irrigated agriculture are more likely to demand SPIPs under the market models that we offered. For reaching out to smallholder and marginal farmers, non-market models like NGO ownership should be explored – something we did not do in our study.

The full text of this document is available at: http://lib.icimod.org/record/32565

Information sheet 12: Making local water planning gender and socially inclusive: Towards gender inclusive water sector development

Why gender and social inclusion matters in local water planning

A crucial natural resource, water plays a multi-faceted role in the lives of rural residents in Nepal. However, climate change threatens to disturb that relationship as variations in temperature, rainfall, and rainfall patterns are affecting water availability. Thus, water scarcity has become an increasingly challenging issue, oftentimes leading to conflict, which leads to excess workloads for everyone. In situations like these, power differentials between men and women as well as different social groups can unduly influence decision-making processes around water. Gender inequality is a key obstacle in the quest for sustainable development in Nepal and beyond as it disempowers and increases livelihood insecurity – for both women and men. Water-related decisions are important not only to access water, but also to obtain and multiply the gains that come with accessing water, which are often in the hands of local elite, particularly elite men. In the changing demography of Nepal, most water responsibilities are in women's hands due to male migration for off-farm employment. For these reasons, water planning calls for gender and social inclusiveness.Water-related programs or policies have implications for gender and social equality and empowerment of women, the poor, and disadvantaged groups as these groups are frequently excluded from meaningful participation in decision-making processes. Their needs and concerns are seldom taken into account in the development of water resource management programs. The need for gender and social inclusive water planning is crucial to ensure the basic human right of individuals to access drinking water, and the equitable benefits of productive water use for farming.

About the study

Since 2014, ICIMOD and HELVETAS Swiss Inter-cooperation have initiated collaborative action research on WUMPs. Together they undertook pilot research project aiming to improve understanding of water issues and the need for participatory and inclusive water use planning at the local level. In 2015, ICIMOD commissioned a study entitled, "Review the Processes of Water Use Master Plan from Gender Equality and Social Inclusion Perspective" to make WUMP more gender equality and social inclusion responsive. The study was carried out in the VDCs where WUMP preparation was supported by HELVETAS Swiss Inter-cooperation and Rural Village Water Resources Management Project. The study focused on how gender equality and social inclusion is mainstreamed in WUMP formulation and implementation processes. It is hoped the findings of the study will constitute an important source of information for evidence-based policy advocacy to promote gender equality and social inclusion in IWRM.

Highlights

- WUMP practices have promoted gender and social inclusion in resource identification, planning, and prioritization of water programs.
- Achieving gender and social inclusion in water planning is about crossing existing gender and social barriers to achieve equitable participation in all activities.
- Conceptualizing gender and social inclusion as context and vision in WUMP practices can help to integrate Gender Equity and Social Inclusion concerns effectively.

Positive steps

WUMP guidelines 2073 BS (2016 AD) recently formulated by the Ministry of Water Supply and Sanitation and the Ministry of Federal Affairs and Local Development include gestures toward improved gender and social inclusion:

- The vision and objective of WUMP preparation is linked to discourses on social justice and equitable access to water for women and disadvantaged groups.
- There is emphasis on participatory and transparent planning with meaningful participation of key stakeholders at local and district levels.
- Ownership of WUMP processes by local bodies is endorsed.
- The guidelines stipulate for gender sensitive indicators in designing water plans, including the need for a gender-balanced decision-making team.

The full text of this document is available at: http://lib.icimod.org/record/32744

Information sheet 13: Koshi barrage and embankment

The Koshi Barrage was built between 1959 and 1962 after an agreement was made between the Governments of India and Nepal on 25 April 1954. The treaty, which was revised in 1966, entrusts India with the responsibility for the maintenance and operation of the Koshi Barrage (Dixit 2009). The barrage is located at Bhim Nagar, Nepal close to the India-Nepal border. The barrage was constructed for flood control and to provide water for irrigation. It also serves as a river gradient control measure through which sediments are deposited in the upstream reaches. The 1,149 m-long barrage also features 56 gates that control river flow to downstream areas (Figure A10). The barrage is designed to discharge water at a rate of 950,000 cusec. FigureA11 shows the Koshi River alluvial fan and the barrage.

The barrage provides major irrigation benefits to both India and Nepal. As a part of the extended treaty, the Sunsari Morang Irrigation Project (SMIP) – one of the largest irrigation projects of Nepal – was built to provide irrigation facilities for about 68,000 ha of land in Sunsari and Morang districts in Nepal (Dhungel, 2009). The original project was constructed by the Government of India, and later handed over to the Government of Nepal in 1975. The system diverts water from the left bank of the Koshi River at Chatara, about 40 km upstream of the barrage. The intake and main canal were designed with a discharge capacity of 45 m3/sec (PREA, 2012). Similarly, two irrigation canals have been extended from the eastern and western side of the Koshi Barrage. The eastern canal irrigates about 612,500 ha of land in the districts of Purnia and Saharsa of Bihar, India. The western canal passes through 35 km in Saptari District, Nepal serving 24,480 ha of land before crossing the Indian border. The western canal irrigates 356,600 ha of land in Bihar, making the total area in Bihar irrigated by the Koshi Barrage 969,100 ha. In addition to the immediate benefits of irrigation, the barrage also holds water during the rainy season and makes this water available for irrigation during the dry season.

The Chatara Hydropower Centre was conceptualized to provide power for dredgers to

FIGURE A10: KOSHI BARRAGE

FIGURE A11: KOSHI RIVER PASSING THROUGH THE KOSHI BARRAGE (INDICATED BY RED SQUARE)

remove silt from the irrigation canal. Later, the Nepal Electricity Authority wanted to expand the purpose of the project to generate power for supply to the grid. However, it was later realized that the availability of water is subject to the operation of the irrigation canal.

The river is subject to frequent flood events and dynamic shifts in the river channels of the plains. Because of this, embankments were built on both sides of the river to help control flood water and protect nearby settlements. The eastern embankment is about 157 km long (32 km in Nepal and 125 km in India) and the western about 129 km long (28 km in Nepal and 101 km in India). Figure 3 shows part of the embankment in an upstream area in Nepal. During its construction, a rehabilitation programme was carried out in Nepal and India to resettle families and communities to safer areas outside of the embankment. The Koshi River has a history of breaches, the most recent one occurring upstream of the barrage in 2008 (see Information Sheet 3 for more details). The other seven breaches took place downstream of the barrage in 1963, 1968, 1971, 1980, 1984, 1987, and 1991 (Mishra, 2008).

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Information sheet 14: Flood hazards in the Koshi River Basin

Floods are a serious problem in the Koshi River basin and are often described as the "Sorrow of Bihar". Water flowing from the seven tributaries in the upstream reaches of the Koshi river join together at a major confluence at Tribeni (above Chatara) before entering the Indo Gangetic plain and crossing into Bihar. Every year when stream flow increases during the monsoon season, floods wreak havoc in the downstream areas causing loss of life and damage to property.

The Koshi river basin is also known for its exceptionally high sediment carrying capacity. The young and fragile geological conditions of the Himalayan region together with the high intensity rainfall during the monsoon lead to a high erosion rate in the mountains and subsequent high sediment load in streamflow. The high flow and sediment load also lead to extensive river cutting and bank erosion causing the river to shift and meander. Sediment eroded from the mountains upstream is transported downstream and deposited in the plains and valleys, much of it across the river profile near Chatara. Over time the river's main channel has aggraded as sediment is deposited causing the river to shift its course. The alluvial fan of the Koshi River illustrates the dynamic nature of the river's channel over the past 220 years, during which the river has shifted westward by about 115 km across northern

Bihar in India. (Gole and Chitale, 1966; Thakur and Tamrakar, 2001).

Nearly 135 million tonnes of sediment are transported from the Koshi river basin each year (Sharma, 1997). The specific sediment yield is reported to be around 2,500 tonnes/km^2/year (equivalent to 25 t/ha), which is very high compared to other river systems: the Ganges transports 491 tonnes/km^2/year, the Brahmaputra 578 tonnes/km^2/year, the Amazon 207 tonnes/km^2/year, and the Nile 40 tonnes/km^2/year (Alford, 1992; Mool, Bajracharya, and Joshi 2001; Sharma, 1997). Figure 2 shows the sediment yield and drainage basin area of major sediment discharge rivers (greater than 10 million t/year). The natural process of sediment transport can create problems in conjunction with anthropogenic activities when rivers erode lands and wash away crops, with serious implications for local livelihoods (Nepal, 2012).

Koshi embankment breach in 2008

On 18 August 2008, the eastern embankment of the Koshi river breached at Kushaha, 12 km upstream of the barrage. After the breach, most of the monsoon discharge and sediment load started flowing along a new path believed to be the same path the river had followed 80 years earlier. This area in Sunsari district in Nepal and Sahrsa, Supaul, Araria, Madhepura, Khagaria, and Purnia districts in India, was dominated by agricultural land, settlements, and infrastructure. The river flowed through the older abandoned channel for nearly five months, inundating the East-West Highway in Nepal and many settlements and areas of agricultural land in Nepal and India. The breach and subsequent floods caused unexpected devastation and heavy damage, including the deaths of 235 people and 787 livestock. A population of 4.8 million was affected, 322,169 houses were destroyed and more than 338,000 ha of agricultural land was damaged (Mishra, 2008; Sinha, 2009).

The river was diverted back to its normal course on 26 January 2009 after the embankment was restored (Shinha, 2009). A huge amount of sand and sediment was deposited on fields and in irrigation channels and drainage ditches. In Nepal, the area immediately below the breach is still filled with sand and sediment and agricultural production has not yet resumed (Figure A12).

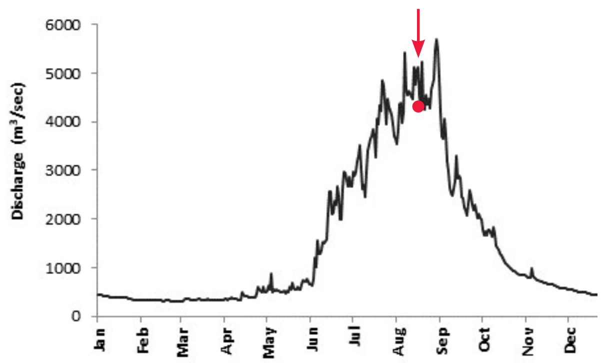

FIGURE A13: HYDROGRAPH OF THE KOSHI RIVER BASIN IN 2008 INDICATING FLOW (RED DOT) AT THE TIME OF THE EMBANKMENT BREACH (4270 M3/SEC). DATA SOURCE: DHM, NEPAL

According to data from the DHM in Nepal, the river discharge at Chatara at the time of the embankment breach was 4270 m3/sec (Figure A13), which is slightly higher than the long-term average for August (1985–2010). The maximum discharge recorded at the Chatara gauging station between 1985 and 2010 was 9610 m3/sec on 11 August 1987. Had the embankment breach occurred during such a high peak, one can only imagine the scale of the disaster. According to Dixit (2009), the breach and related flood were not the result of the larger context within which the embankment was conceptualized, built, and maintained. Dixit (2009) has discussed the possible causes of the breach extensively, they can be summarized as inappropriate technology for a high-sediment river, poor management of the embankment infrastructure, lack of a warning mechanism, institutional dysfunction, and government deficit and poor capacity to respond to the humanitarian crisis.

FIGURE4: FIVE YEARS AFTER THE 2008 BREACH OF THE KOSHI EMBANKMENT, DEPOSITED SAND AND SEDIMENT STILL DOMINATE THE LANDSCAPE, WHICH REMAINS VIRTUALLY INFERTILE WITH NO AGRICULTURAL PRODUCTION (PHOTO: SANTOSH NEPAL)

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