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IWRM Implementation in Nepal :

Harmonizing Water Demand and Supply Dynamics

Climate Adaptation and Resilience (CARE) for South Asia Project

IWRM Implementation in Nepal:

Harmonizing Water Demand and Supply Dynamics

A STATUS ASSESSMENT REPORT

adpc

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Message

As we navigate the complex challenges of the 21st century, it is evident that our ability to manage and safeguard our most precious resource—water—will be a defining factor in the sustainable development of Nepal. In a region characterized by its rich diversity, both in terms of culture and geography, the integrated water resource management takes on a significance that extends far beyond mere sustenance. It is, in essence, the cornerstone of our National Water Resources Policy and guiding our efforts in harnessing water resources for a prosperous future.

In this regard, this publication from the Asia Disaster Preparedness Center (ADPC) with support from the World Bank is timely in carrying out an analysis of the national approach on Integrated Water Resource Management (IWRM) in Nepal. We welcome the study and believe that it provides valuable inputs to our continuous efforts in reviewing our approach to water resources development and delivering on expectations of the public. The Department of Water Resources and Irrigation has also recently been successful in launching its new National Irrigation Policy 2080 (2024) with a greater emphasis on increasing both agriculture productivity and irrigation coverage with a concerted effort in developing new infrastructures, modernizing irrigation systems, proper maintenance of older systems while stressing on service delivery, recovery of irrigation service fees, public private participation; and greater attention to be more inclusive and gender responsive. The department is adopting a multi-pronged approach to achieve this through multipurpose, storage and inter-basin transfer projects; conjunctive uses of groundwater; and new-technologies in the irrigation sector.

I welcome the authors and ADPC in reinforcing our efforts in analyzing our approaches in integrated water resources development and suggesting the best ways forward. I believe this publication will be useful to all in the government and non-governmental sector, including academia in understanding the issues in IWRM management in Nepal and moving forwards.

Thank you.

Churna Bahadur Wali
Director General
Department of Water Resources and Irrigation, Government of Nepal

February 2024

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ACRONYMS

ADB	Asian Development Ban
ADPC	Asian Disaster Preparedness Center
CBS	Central Bureau of Statistics
DHM	Department of Hydrology and Meteorology
DoED	Department of Electricity Development
DWTFC	Drinking Water Tariff Fixation Commission
EPC	Environment Protection Council
ETFC	Electricity Tariff Fixation Commission
FAO	Food and Agriculture Organization of the United Nations
FY	Fiscal Year
GCA	Gross Command Area
GDP	Gross Domestic Product
GLOFs	Glacial Lake Outburst Floods
GoN	Government of Nepal
GWh	Gigawatt Hour
GWP	Global Water Partnership
ha	Hectares
IBN	Investment Board Nepal
ILOSTAT	International Labour Organization Statistics
IMP	Irrigation Master Plan
IPPAN	Independent Power Producers Association of Nepal
IWRM	Integrated Water Resources Management
KWh	Kilowatt hour
masl	meters above seas level
MCM	Million Cubic Meters
MDG	Millennium Development Goals
MOEAP	Ministry of Economic Affairs and Planning
MoF	Ministry of Finance
MoFE	Ministry of Forest and Environment
MoIAL	Ministry of Internal Affairs and Law
MoITFE	Ministry of Industry, Tourism, Forestry and Environment Committee
MoLMAC	Ministry of Land Management, Agriculture and Cooperatives
MOPE	Ministry of Population and Environment
MOPID	Ministry of Physical Infrastructure Development
MoSD	Ministry of Social Development
MW	Megawatt
NAP	National Adaptation Plan

NAPA	National Adaptation Programme of Action
NEA	Nepal Electricity Authority
NPC	National Planning Commission
NWRDC	National Water Resources Development Council
RIMES	Regional Integrated Multi-Hazard Early Warning System
TAC4	Technical Advisory Committee Background Paper no. 4,
UNCED	United Nations Conference on Environment and Development
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
WB	The World Bank
WEC	Water and Energy Commission
WECS	Water Energy Commission Secretariat
WRRDC	Water Resource Research and Development Centre

EXECUTIVE SUMMARY

Climate change impacts society in a multitude of ways. Rising temperatures and ensuing changes in the precipitation regimes are the two direct and major effects of climate change for Nepal. These further result in extreme events like floods and droughts, along with other subsequent effects like depletion of aquifers, deterioration of water quality, alteration in biodiversity, increased landslides and sediment mobilization which impact people's livelihoods and the environment. The effect can be gradual such as increasing water demands and decreasing productivity in irrigation, hydropower, navigation, industrial and other sectors or sudden shocks as glacial lake outbursts, landslides, floods or even pandemics causing cascading impacts and disrupting the society. Good water management requires that we need to consider all these facts and make decisions addressing the inherent system uncertainties, making assumptions about future supplies, demands, weather and operational constraints; which unfortunately vary according to location as well as time scales.

The adoption of IWRM has been the subject of much discussion, with its inclusion in the national policy and strategy documents for almost over two decades. The present review of the status and the understanding of the need for and implementation of Integrated Water Resource Management (IWRM) in Nepal is part of a series of documents being developed under the CARE for South Asia project. The status review discusses the current implementation mechanism of IWRM and resource allocation between competing uses and users and tradeoffs. The report also introduces the basic concepts of IWRM to ease an understanding of the subject. The discussion recognizes the need for a well-designed IWRM, which including options for managing future scenarios. Climate change will accentuate the extremes - in various instances witnessing either too much or too little water – and IWRM is well designed to handle shocks and variabilities in water availability or demands.

The report is expected to be of use to the water sector of the government and provincial offices dealing with policy, planning, implementation and monitoring of the water sector in general. These reports are meant, primarily for the Water Energy Commission Secretariat and the Ministry of Energy, Water Resources and Irrigation, as well as their relevant counterpart offices in the provincial offices. It will also be useful for the local level government officials involved in water resource management.

This study identifies the National Water Resources Act 1992 and the Water Resources Policy 2020 as its targets for support. The Act precedes the current Constitution, is not cognizant of the IWRM principles and is slated for a complete revision with the new National Water Resources Bill. This study also provides the supporting material for implementing Water Resources Policy 2020 by espousing the need of IWRM. It also supports in enabling the provincial and local level municipal and governments to formulate their own policies with a better understanding of IWRM and practicing the constitutionally mandated roles and responsibilities related to water governance.

In climate related and resilience building terms, this report also targets the National Adaptation Plan, Climate Change Policy 2019; as such, the report will be useful to the government officials working in climate change adaptation and mainstreaming climate change adaptation at the federal, provincial and local levels.

The report also will be useful to ADPC, donors and other international agencies working on climate and water as it informs and updates them to understand the ground issues on water resources in Nepal and help design further interventions in the water sector.

A detailed analysis of the water supply from fresh and groundwater resources shows that the surface water availability is about 225 billion cubic meters equivalent to about 7,700 m^3/person/year at an average flow of 7,125 m^3/s. Still, the sum of flows in the major rivers dwindles to about a thousand m^3/s in the months of February and March which is not able to meet the irrigation demands alone, while the sustainable groundwater availability is estimated to be 13 billion cubic meters, with a total of 238 billion cubic meters of water available on an average in a year while the demand analysis shows that the existing irrigation use is the dominant use with of 17,452 MCM is 93.3 % of the total consumption. Drinking water requirement is estimated to be 5.7% while industrial usage is a mere 1% of the total current demand.

Opportunities, issues and constraints of the river basins were also reviewed. The common issues identified are floods, inundation, inter-basin transfers and rehabilitation and resettlement, while the opportunities are irrigation development, hydropower generation, tourism, recreation and well-preserved watersheds. A review of policies and legal instruments indicates that Water Resources Policy 2020 specifically adopts IWRM while others policies are generally in tune with the IWRM requirements. This document targets government officials, policymakers and even the non-governmental sector to apprise them of the current status of the IWRM adoption in Nepal and suggests ways forward. This is expected to encourage the government and stakeholders to implement IWRM as a priority and increase cooperation between water agencies.

The review concludes that inclusiveness, equity, efficiency and sustainability require adoption of a systems approach. The traditional fragmented and sectoral approach of management has to be replaced by a more holistic one. The government of Nepal's water plan and policies incorporate and are conducive to practicing IWRM as a process of assuring sustainability, but the existing Water Act does not recognize IWRM. The draft National Water Resources Bill is based on IWRM principles. The Constitution of 2015 and the adherence to the federal system of governance allocates and more power devolved to provincial and local governments. Though there appears to be a dichotomy between policy and actual governance, the groundwork required for empowering and enabling local institutions has been set.

The monitoring and evaluation of SDG 6.5 show that the current status of IWRM implementation in Nepal is rather low, the overall score being 37%. The way forward for successful implementation of IWRM in Nepal will require work in the domains of enabling environment, institutional strengthening, management instruments, financing and capacity building.

1. INTRODUCTION

The Asian Disaster Preparedness Center (ADPC) and the Regional Integrated Multi-Hazard Early Warning System (RIMES) are jointly implementing a five-year (2020-2025) regional project called Climate Adaptation and Resilience (CARE) for South Asia with support from the World Bank. The overall objective is to contribute to an enabling environment for climate resilience policies and investments in South Asia's agriculture, transport, water, policy & planning, and finance sectors. The national-level activities are being implemented in Bangladesh, Nepal and Pakistan.

The project has two parallel but distinct components: RIMES is implementing the first component which focuses on promoting evidence-based climate smart decision making; ADPC is implementing the second component which focuses on enhancing policies, standards, and capacities for climate-resilient development in South Asia. ADPC is looking specifically into 1) Advisory services for policy and investment interventions; 2) Promoting climate resilient design and standards; and 3) Implementation support to climate-risk management solutions: capacity building and technical support.

As a part of the second component activities in the water sector in Nepal, a review of the IWRM approach in Nepal including water demand and supply analyses was carried out and presented in this report. It provides a status assessment of the current implementation of IWRM, and the balance of water supply and demand as an indicator of the need for continued implementation of an IWRM approach. IWRM is a process that can assist countries in dealing with water issues in an acceptable, cost-effective and sustainable manner (GWP-TAC4, 2000).

1.1 Policy and Need Relevance

Good governance of the water sector, such as that by implementing and practicing Integrated Water Resource Management (IWRM) approach improves service delivery. IWRM is a widely recognized as a better approach to manage water resources compared to traditional fragmented approach. It is based on a coordinated development and management of water resources, considering the social, economic, and environmental dimensions of water use (GWP-TAC4, 2000). IWRM aims to optimize the allocation and utilization of water resources to meet the needs of various sectors and stakeholders while ensuring their long-term sustainability. Climate variability is a known accelerator of extreme events (IPCC 2021) leading to water insecurity (IPCC, 2022) and possible spiraling down of resiliency.

IWRM has been the standard recommendation for efficient, equitable, and sustainable management of water resources since the 1990s, and has been increasingly accepted by developing nations as at their policy and strategic levels. The World Bank, Global Water Partnership and other multilateral, bilateral and non-governmental international agencies have embraced it as a standard framework for interventions (World Bank 2004) and have been advocating strongly for it.

Nepal possesses abundant water resources, rivers of Nepal discharging approximately 225 billion m^3 of water annually (WECS, 2011) corresponding to about 7,700 m^3/person/year. These water resources are considered a primary asset for Nepal's growth, as emphasized in the national Water Resources Strategy 2002 (WECS, 2002), the National Water Plan 2005 (WECS, 2005). The current 15th Five Year Plan envisions a prosperous and happy Nepal, aiming to transform the country into a high-income nation by 2043 (NPC, 2019).

The National Water Plan (WECS, 2005), which outlines water sector objectives and policy principles, adopts Integrated Water Resources Management (IWRM) as its central theme. It recognizes that the sustainable development of water resources can significantly contribute to poverty reduction and economic growth. Moreover, the recently adopted National Water Resources Policy (2020) also embraces the principles of IWRM and emphasizes the establishment of river basin organizations to enhance water resource management. However, the Water Resources Act 1992, which is in force till date, does not include IWRM in its statement. The National Water Plan recognizing IWRM had laid out an action plan to enact a suitable Water Resources Act with legal authority. The Bill, under preparation for almost two decades, has now gathered traction and is in the final stages of being presented in the parliament.

IWRM recognizes the dynamic nature of water resources and encourages adaptive management practices. It promotes continuous monitoring, assessment, and learning to adapt water management strategies based on changing conditions and new information. This enables proactive responses to emerging challenges, and makes the approach suitable for addressing potential impacts due to climate change, population growth, and changing water demands. Climate change is expected to subject the water resources management to slow onset of impacts as well as sudden impacts triggered by extreme droughts or precipitation events.

Nepal is ranked 9th on the long-term Climate Risk Index (CRI) on averaging the annual values from 1999 to 2018 (Eckstein et al., 2020). Rising temperatures and changes in the precipitation regimes are the two direct and major effects of climate change for Nepal. Analysis of trends in the period 1971 to 2014 (DHM, 2017) reveal increasing temperatures and decreasing annual rainfall in all seasons.). It was reported that the average temperature increased at the rate of 0.056°C per year from 1971 to 2014 (DHM, 2017), while the rate was higher at higher altitudes melting snow and glaciers faster. Climate change has intensified the hydrological phenomena causing intense extreme events such as high rainfalls which can even trigger cascading hazards, such as the Melamchi floods in June 2021, causing immense losses of life, property and infrastructure.

Future climate projection estimates carried out, during the National Adaptation preparation phase in 2019, show that the average Temperature is projected to increase by 0.92–1.07^{0}C in the medium term (2016–45) and 1.3–1.8^{0}C in the long term (2036–65) for different scenarios with the period of 1981–2010 taken as the reference (MOFE, 2019). Likewise, annual precipitation is expected to increase in both the medium and long term by 2–6 percent to 8–12 percent with more precipitation expected in the higher regions (MOFE, 2019)[1].

The anticipated effects of increasing temperature in Nepal apart from loss of snow cover, melting of snow and ice, glacial retreats, higher risks of glacial lake outburst floods (GLOFs), increased evaporation and more forest fires. Changes in precipitation regimes will increase numbers of and severity of floods, droughts, increased drawdown of aquifers, disruption of cropping patterns, deterioration of water quality, alteration in biodiversity, landslides and sedimentation all of which impact people’s livelihoods and the environment (MOFE, 2019; Davis and Hirji, 2019). For example, the number of people affected by flooding in Nepal is expected to go up to 350,000 in 2030, from 157,000 in 2010, as floods become more severe and frequent, (WB and ADB, 2021). Water is the primary medium through which we feel the impacts of climate change, and IWRM can play a crucial role in how we can deal with these extremities and reduce their impacts.

Water resources is also construed not merely as a physical and biological need, but also a catalyst for socio-economic development, that has multiple uses, potential conflicts and high public sentiments. The water resources sector’s performance has been rather dismal, with very low usage of the water resources - inadequate irrigation systems with about only a third of irrigation developed area receiving round-year irrigation facility and installed hydroelectric capacity is 1,278 MW (NEA, 2020), a mere 3% of the total economic potential capacity of 42,133 MW. The electricity consumption is also very low 225 kWhr per person and the nation still imports electricity from India. Despite stating IWRM approach in macro-level policies the water resource management sector is still under-performing, still short on delivering public expectations. The challenge is to turn “water riches” into sustainable prosperity. This proves the necessity of the review study of IWRM approach to identify areas of improvement.

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[1] These estimates are based on CMIP AR5 models and government owned reports, while newer 6th Assessment under CMIP6 are also available at the Climate Change Knowledge Portal of the World Bank for Nepal at Nepal - Mean Projections Expert | Climate Change Knowledge Portal (worldbank.org) in an interactive dashboard selecting climatic variables for different time frames, scenario pathways and models.

Targeted policy documents

The directly targeted policy documents are the National Water Resources Act 1992 and the Water Resources Policy 2020. The Act precedes the current constitution, is not cognizant of the IWRM principles and is slated for a complete revision with the new National Water Resources Bill. This study provides the supporting material for implementing Water Resources Policy 2020 by espousing the need of IWRM. It also supports in enabling the provincial and local level municipal and governments to formulate their own policies with a better understanding of IWRM and practicing the constitutionally mandated roles and responsibilities related to water governance.

These reports are meant, primarily for Water Energy Commission Secretariat (WECS) and the Ministry of Energy, Water Resources and Irrigation, as well as their relevant counterpart offices in the provincial offices. It will also be useful for the local level government officials involved in water resource management.

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1.2 Study Objective

The Integrated Water Resource Management (IWRM) approach has been considered as a sustainable means of developing and managing water resources (Ludwig et al., 2014). It is also adopted as one of the components of the UN's Sustainable Development Goals, SDG 6. Nepal is a signatory to the SDGs. Integrated Water Resources Management (IWRM) and Climate Change Adaptation (CCA) complement each other and are reported to be more effective and efficient (UNEP, 2022) when combined together.

The objectives of the report are to:

- The primary objective is to provide a status assessment report of the current implementation of IWRM in Nepal
- Introduce the concepts and process of IWRM to appraise the stakeholders on the suitability of IWRM for managing water resources sustainably
- Describe the role of IWRM in addressing climate change impacts in water resources
- Estimate water supply and demand of water in Nepal to identify management requirements, if any required.
- Identify and assess the policies, legal instruments and institutional structures present for water management in Nepal
- Study water projects implementing IWRM in Nepal to understand status of IWRM implementation in Nepal

It is also expected that this report documents the findings as a knowledge product and supports the project office in designing capacity building material on IWRM implementation to help build capacity of government officials on IWRM. It is expected that this will be an important source of information and informing tool to stakeholders.

1.3 Study Approach

The review is based on a desk study, reviewing material online and other collections of reports and documents using secondary data, analyzing them presenting them in this report. The analytical framework used is described below.

Analytical framework

The status assessment uses the step-wise analytical framework stated below:

i. defining the concept of IWRM;

ii. understanding the physical resource base, the water resources of Nepal including supply and demand for the whole nation;

iii. evaluating the opportunities, issues and constraints in Nepal;

iv. describing the regulatory scenario in Nepal including the legal instruments, institutions and their roles; and

v. consolidating the findings and recommending a way forward.

This analytical conceptual framework is congruent with the intersectoral coordination "comb" (GWP-TAC4, 2000) commonly used in defining IWRM (Figure 2-1). This report follows the analytical structure described above in the status assessment.

Numerous discussions were held with government officials and experts in the field to update and enhance the general understanding essential for preparing this report. Efforts are made to deconstruct the key motivation of IWRM as a priority policy area and its adoption for addressing water resources issues- especially in terms of sustainable water resource management and governance. The report is based on a water demand and supply analysis. Estimates of demand have been made calculating the consumptive use of irrigated agriculture, as well as the water supply demands of current and future population in thirty years horizon.

The report is organized with a brief introduction in Chapter 1 and the Chapter 2 which introduces the concept of IWRM. Chapter 3 describes the interrelationship of IWRM and climate change management and shows how IWRM can be a good practice for addressing climate change impacts on water resource management. Chapter 4 introduces the physical setting, resources and leads into the water supply and demand analysis. Chapter 5 lists the opportunities, issues and constraints which demand proper water resource management approaches to maximize opportunities, minimize issues by better addressing the constraints. The past and present policies, including strategy and legal instruments related to IWRM in particular are discussed in Chapter 6, along with the existing institutional set up in developing and managing water resources in Nepal. Chapter 7 describes the projects, past and present, and attempts at adopting IWRM in Nepal and is useful in understanding the status of IWRM in Nepal.

Chapter 8 concludes the report, summarizing the findings of the status of IWRM in Nepal and the need to urgently strengthen water resources management to respond to the impacts of climate change. This chapter also presents the government's assessment of status of IWRM implementation, in 2020, as reported to the UN in SDG 6.5.1 and its comparison with Bangladesh and Pakistan. Finally, additional CARE for South Asia reports on Nepal's water policies and a 'gaps and needs assessment' for strengthened water resources management are foreshadowed.

This report documents the IWRM status and is expected to be helpful to government especially the Water Energy Commission Secretariat (WECS), Ministry of Energy Water Resources and Irrigation (MoEWRI) and its associated departments as well as for non-governmental organizations working in the water resources sector in increasing their understanding of IWRM approach in Nepal, promoting IWRM as a priority and increase their efforts in furthering better water resource management for sustainable development and furthering livelihoods.

This report was prepared in 2021 and revised in 2023. Some of the recommendation mentioned later in the conclusion section of the report will be valid until the end of the project period and some will be in the medium-term time scale (3-5 years). The report was prepared with Nepal in focus, with reference to Integrated Water Resources Management and how the approach can address climate change impact on the water resources of Nepal.

2. INTEGRATED WATER RESOURCES MANAGEMENT

2.1 Concept and Definition of IWRM

Water resource development and management involves multiple stakeholders with multiple uses and development scenarios. It is characterized by uncertainties, complex interactions and conflicting interests of stakeholders. Countries are increasingly facing challenges in their social and economic development efforts related to water. Shortages of water, water quality deterioration, droughts and flood impacts as well as associated problems that limit growth, stifle livelihoods or generate conflicts require greater attention and prompt actions. Integrated Water Resources Management (IWRM) is a process which can assist countries in their efforts to deal with water issues in an acceptable, cost-effective and sustainable manner (GWP-TAC4, 2000).

Water resources management is also part of a larger set of interactions between humans and water within the larger domain of the environment. It is further compounded by associated socio- economic, political and cultural dimensions along with sustainability - not prejudicing against use of future generations. Since it involves allocations of public resources issues of inclusiveness, equity, efficiency and conservation are important. The traditional fragmented and isolated sectoral approach of governance and management has to be replaced by a more holistic system view approach. IWRM is such an approach widely accepted internationally as the best way forward for efficient, equitable and sustainable management of water and related resources.

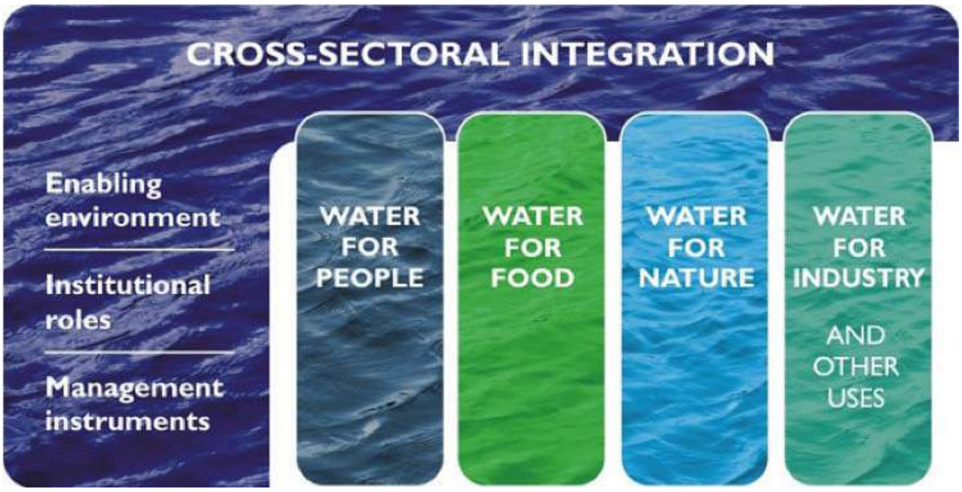

Figure 2-1: IWRM Comb depicting intersectoral integration (source: GWP, IWRM Toolbox, 2021)

IWRM is not a goal in itself. The specific goals, interest and challenges will vary from place to place depending on the specific ecological, social and economic situations. IWRM is the process of balancing and making trade-offs, in a practical and scientifically sound way, between: economic efficiency in water use; social justice and equity concerns; and environmental and ecological sustainability. All these aspects will have to be balanced in the IWRM process engaging stakeholders. Implementing IWRM is a political process that involves allocating resources between competing uses and users. Sometimes, it is possible to come up with win-win solutions. However, more often, compromises and trade-offs will have to be negotiated.

2.2 From Mar Del Plata Action Plan to Sustainable Development Goals

The concept of integration developed through the Mar Del Plata conference on water resources in 1977 in the Mar del Plata Action Plan: Recommendation No.2 on Policy, Planning and Management (Rahaman, Mizanur & Varis, 2005) stressed that institutional arrangement adopted by each country should ensure real coordination between all responsible for investigation, development and management of water resources.

2.2.1 Dublin Principles

The integration concepts of the Mar del Plata Action Plan were further refined through an international consultative process and declared in the International Conference on Water and the Environment in Dublin, 1992. Known as the Dublin Principles.

The four Dublin principles are (GWP-TAC4, 2000, p13):

Principle I. Fresh water is a finite and vulnerable resource, essential to sustain life, development and the environment.

Principle II. Water development and management should be based on a participatory approach, involving users, planners and policymakers at all levels.

Principle III. Women play a central part in the provision, management and safeguarding of water.

Principle IV. Water has an economic value in all its competing uses and should be recognized as an economic good.

These principles have found universal support among nations and the international development community as the guiding principles underpinning IWRM and have helped reshape the approach to development in the water sector.

2.2.2 Rio Summit and Agenda 21

The Dublin principles on understanding water resources gathered momentum and gained wider acceptance with the international community and became mainstream through the Earth Summit held in Rio de Janeiro, Brazil, 3 to 14 June, 1992. The UNCED, attended by 178 governments, adopted the Rio Declaration on Environment and Development., and the Statement of Principles for the Sustainable Management of Forests.

Agenda 21 is a comprehensive plan of action to be taken globally by organizations of the United Nations, governments and other agencies.. Agenda 21, as detailed in Chapter 18, talks about the need to protect water resources in meeting basic needs as well for safeguarding ecosystems.

All social and economic activities depend heavily on the supply and quality of freshwater and the UN resolution recognizes the contribution of water resources development to the overall economic productivity and social well-being. The overall objective of the UN initiative under Chapter 18 is to satisfy the freshwater needs of all countries for their sustainable development.

It goes on to describe IWRM under sub-chapter 18.8 as (Sitarz, 1993):

> *"Integrated water resources management is based on the perception of water as an integral part of the ecosystem, a natural resource and a social and economic good, whose quantity and quality determine the nature of its utilization. To this end, water resources have to be protected, considering the functioning of aquatic ecosystems and the perenniality of the resource, in order to satisfy and reconcile needs for water in human activities. In developing and using water resources, priority has to be given to the satisfaction of basic needs and the safeguarding of ecosystems. Beyond these requirements, however, water users should be charged appropriately."*

- It should be pointed out that the above statement does go beyond the anthropocentric view of water to encompass other ecosystem requirements such as aquatic uses and sustainability of water resources. The Agenda 21 and the targets set by it needed further improvements which led to the adoption of Millennium Development Goals (MDGs).

2.2.3 MDGs and SDGs – Agenda 2030

Millennium Development Goals (MDGs) were eight international development goals for the year

2015 established by the UN Millennium Summit in 2000 with the United Nations Millennium Declaration and later redefined by the UN Summit in 2005 (UNDESA, 2016). The MDG targets and action plans recognized that responsible water resources management is vital for the environment and improving the health and well-being of everyone in the community. It included IWRM as a solution to eradicate extreme hunger and poverty, reducing conflicts and developing partnerships. It recognized that risks of climate uncertainty and climate change can be mitigated by storing and distributing water wisely when it is scarce and by planning ahead to protect communities from floods.

The Sustainable Development Goals (SDGs) or otherwise known as Agenda 2030, are a set of further refined 17 goals and 169 global targets, agreed upon at the UN Sustainable Development Summit in 2015 by the member countries (UNDESA, 2016). These goals are set around the primary concept of the five P's – people, planet, prosperity, peace and partnerships.

The 2030 Agenda (UNDESA, 2016) recognized that IWRM practices would be needed to bring about availability and sustainable management of water and sanitation for all, as formulated under Sustainable Development Goal 6 (SDG 6). The goal states:

Goal 6. Ensure availability and sustainable management of water and sanitation for all

This goal includes the following plans of action (related to water resources) (UN DESA, 2016):

6.4 By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity

6.5 By2030, implement integrated water resources management at all levels, including through transboundary cooperation as appropriate

6.6 By 2020, protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes

6.a By 2030, expand international cooperation and capacity-building support to developing countries in water- and sanitation-related activities and programs, including water harvesting, desalination, water efficiency, wastewater treatment, recycling and reuse technologies

6.b Support and strengthen the participation of local communities in improving water and sanitation management

While the action plan described to achieve this SDG 6 includes IWRM, SDG 15 also intersects on IWRM requiring synergies with other sectors and subject areas. The SDG Goal 15 is:

Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss

So, it is essential to understand that IWRM is an agenda explicitly agreed to by governments and communities around the world, including Nepal.

2.2.4 SDG Implementation Monitoring of IWRM

The UN Summit's Agenda 2030 not only set the goals but also prescribed metrics and defined a mechanism to monitor progress. The UN system, as part of the broader framework for monitoring the progress on achieving SDGs, also monitors the implementation of IWRM activities. This is done through the SDG indicator 6.5.1 the degree of IWRM implementation. It assesses progress achieved by individual nations in implementing IWRM in their policies, actions and practice it operationally. The monitoring of progress on SDG 6.5, implementing IWRM, is judged by assessing the following four key components of IWRM:

- Enabling environment

- Institutions and participation
- Management instruments
- Financing

Data on the indicator 6.5.1 is collected through a questionnaire and responses which are further consolidated through consultations between relevant stakeholders, such as national and subnational line ministries and institutions involved in water resources management. It is done through the National Planning Commission in Nepal and the Water Energy Commission Secretariat takes the lead in furnishing the required information.

2.3 IWRM Process

The basis of IWRM is that different uses of water are interdependent and extra benefits can only be accrued or conflicts minimized when these different user groups are consulted from the planning stages and management of water programs. This section provides the basic concepts to be adhered to in an IWRM process.

Agreeing on a process of water allocation across different sectors is an important decision. The availability of water defines human health and quality of life, business prospects and prosperity. Natural ecosystems are under increasing threats and are diminishing . Drought, flooding, groundwater overdraft, water-borne diseases, land and water degradation, on-going damage to ecosystems, chronic poverty in rural areas, and escalating conflicts over water are all complex problems. The solutions to such complex problems fall outside the normal purview of single sectoral agencies. It requires the input and interaction of different agencies, civil societies, organizations and governments at all levels. An IWRM approach, in such instances, makes identifying and executing acceptable effective solutions better.

2.3.1 Norms and Values

The norms and values or the ideals that need to be upheld by IWRM are equity, economic efficiency and environmental sustainability. These 3 E's are the core principle values that need to be incorporated in any IWRM concept.

Equity means ensuring equal access for all users to an adequate quantity and quality essential for the general wellbeing at par with other users. Equal access must be guaranteed to all without any discrimination irrespective of class or location to all sections of the society including those who have been traditionally marginalized and discriminated against. It also includes the right to benefits from the use of water.

Economic efficiency describes prioritizing the options with the greatest benefit to a greater number of people with the available financial and water resources. The economic value is not only about price – it should consider current and future social and environmental costs and benefits as well. This means the overall benefits need to be analyzed, not merely fiscal profits.

Ecological sustainability requires that aquatic ecosystems (e.g., rivers and streams) are acknowledged as users and that adequate allocation is made to sustain their natural functioning. This criterion also requires that development actions and land-uses that negatively impact water bodies or the natural systems are to be managed properly. These norms and values to be upheld drive home the need for inter- sectoral coordination across different spheres of the society and government functions.

2.3.2 Governance structure and process

Implementing an IWRM process requires getting the following "three pillars" right as described in Figure 2 2 (GWP-TAC4, 2000).

i. Moving towards an enabling environment with formulation of appropriate policies, strategies and legislations for sustainable water resources development and management;

ii. Putting in place the institutional framework to implement these policies, strategies and legislation; and

iii. Setting up the management instruments required by these institutions to do their jobs.

These are governing structures and processes required for IWRM. The enabling environment sets the rules, the institutional roles and functions which define the players who make use of the management instruments. The management instruments also include agreed mechanisms for water allocations in terms of need, such as during a drought, or even adopting other means or methods to balance the needs. This can be for the present as well as making contingency plans for the future. Interventions such as restricting a particular use or sector such as lawn irrigation or recreational uses, conserving water, water harvesting, groundwater recharge, water reuse and recycling as well as storing water for future uses are some of the management options commonly adopted.

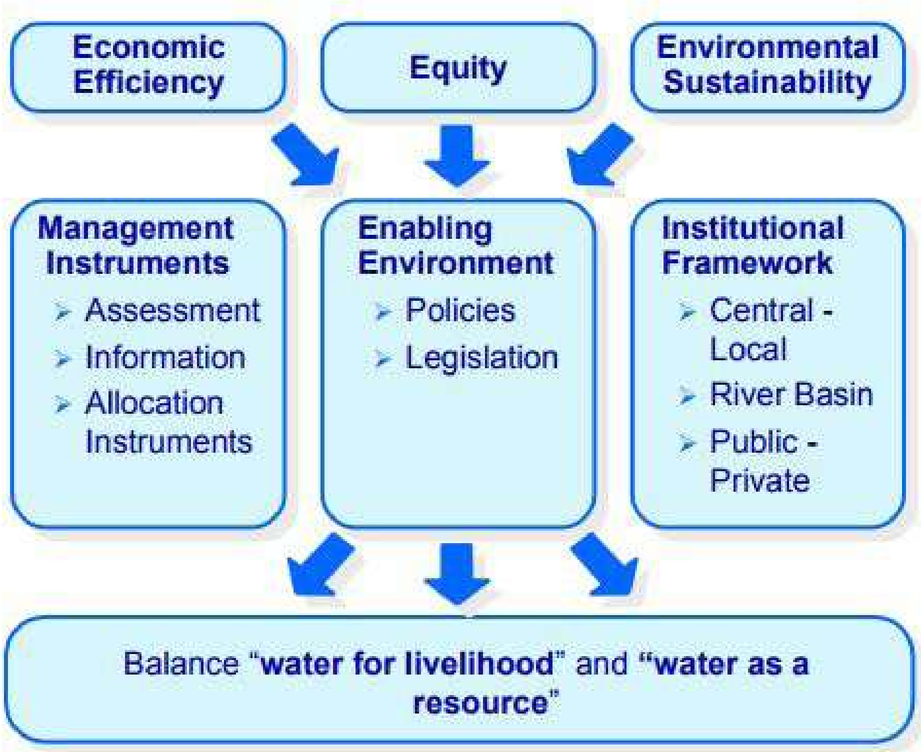

Figure 2-2: The three pillars of IWRM (Source: GWP-TAC4, 2000)

The governing process and structure should also cultivate and promote an inclusive stakeholder consultation that is transparent, just and logical in its participatory decision-making process.

2.3.3 Balancing Acts

The aim of IWRM or the product is to obtain a balance between water for livelihood, meeting needs of the users as well as obtaining economic benefits as a resource to help achieve the goals of eradicating extreme hunger and poverty. Often, the balance concept is elaborated further to mean balancing the 'triple bottom line' of economic, social and environmental trade-offs.

i. Balance between upstream and downstream demands. There should be a fair and equitable water allocation and water rights within the river basin including water-sharing between urban centers and rural areas;

ii. Balance between in-stream and off-stream demands. In-stream demands are those of the aquatic habitats; navigation; tourism and recreation, while off-stream demands include consumptive uses where the water is diverted off and consumed such as in domestic uses; irrigated agriculture; industries; and the service sector;

iii. Balance between immediate and long-term benefits, or that between current and future benefits, in support of a sustainable resource utilization.

The aim of balancing benefits or costs, is also placed on balancing the needs versus the demand. It includes the concepts of conserving water, water reuse and recycling as well as storing water for future uses.

2.3.4 Conditions for Implementation of IWRM

Some important conditions essential for implementing IWRM are presented below, adapted from the UN World Water Development Report 3 (Connor, 2015). These conditions help roll out IWRM and are general guidelines. True integrated water resource management will be location specific, as it includes the all-important dimension of the people, their expectations, socio-economic settings and cultural or behavioral norms and attitudes.

Political will and commitment: Political will is especially needed to seek cooperation if the proposed plan or arrangement requires changes in existing legal and institutional structures, or if the stakeholders are in strong disagreement and conflicts exist.

Clear Vision and Basin management plan: A clear vision is essential to streamline discussion and direction among different user sectors. The presence of a master plan enables concrete visualization of the various parameters and discussion on pros and cons to help reach a consensus. The plan should also have the details of the watershed, information on present land use and future development, spatial information on water use and discharges, or, the complete details of supply and demand scenarios as well as the socio-economic and environmental impact scenarios.

Participation and coordination mechanism: A mechanism that promotes information-sharing and exchange helps in generating understanding and reducing misconceptions. Meetings and interviews can facilitate sharing of ideas and gaining confidence. Baseline data, information on resource availability and use should be shared initially to establish a common ground and build upon that commonality with detailed information. The information should be clear, concise and unambiguous.

Capacity development: Capacity development and training priorities should be carried out at all levels, including that of decentralized local government, local users and communities. Participants who may be adversely impacted and/or socially marginalized may be enabled to participate meaningfully with a consensus-building strategy. Basic knowledge on the concept, terminology in discussions, information on the basin or catchment, types of uses and their demands with the timing of the demands etc. need to be shared with all involved.

Well-defined legal frameworks and regulation: It is necessary to have enforceable legal framework and regulations flexible enough to be practical and yet at the same time it should be clear and not ambiguous. So, the need will be to review existing laws and regulations and determine how these can be adapted or improved to accommodate desired objectives of water resources management and sustainability.

Water allocation plans: There should be an agreed allocation plan with approved modes of contingencies operation such as for the periods of shortages. Water rights should be accorded to users and these should be adaptable to availability of water on a preset set of standards to accommodate changes. The allocation plans and actual distributed amounts need to be transparent and accessible to all.

Financially sound: There should be adequate investment, financial stability and sustainable cost recovery for IWRM to be attractive to the users. IWRM activities often have long gestation periods and may require expensive infrastructure investments. Various funding instruments need to be considered and governments can look at it in terms of broader economic investments and viability including food, energy and general security also.

Suited for the location: The implementation should be based on a sound knowledge of the natural resources present in the basin. There should be a detail of demands and supplies inventories, future scenarios, and a suite of alternatives based on sound technical knowledge and acceptable to the population.

Monitoring and Evaluation: There must be mechanisms for continuous monitoring and evaluation to ensure that the management is headed in the correct direction, with assurances of success and corrected if required. Water audits as well as expenditure audits and the assessments of the impacts need to be done regularly, shared publicly and reviewed in time, improve learning and build trust among all partners.

2.4 Good Examples of IWRM Implementation

Some of the often-cited good examples of IWRM or related integrated projects include the following:

Tennessee Valley Authority

The Tennessee Valley Authority (TVA) is a federal agency in the United States that was created in 1933 to improve navigation on the Tennessee River, reduce flood damages within the Tennessee River system, and downstream on the lower Ohio and Mississippi Rivers, spur economic development of TVA's service area in the southeastern United States and produce electricity. The TVA services almost all of the area of the State of Tennessee, portions of Alabama, Mississippi, and Kentucky, and small areas of Georgia, North Carolina, and Virginia. Today, TVA operates the US's largest public power system supplying electricity to over nine million people. TVA uses its 49 dams to manage lake levels and river flows to balance the competing demands on the reservoir system. It has been the key to minimize flood damages in the region and provides environmental stewardship of the committed to providing clean air, clean water supply and recreation opportunities to the region. The TVA strives to maintain the balance between water use and conservation adopting the IWRM approach in identifying opportunities to optimize water use and reduce waste, engaging stakeholders in decision making and promoting sustainable development.

The impacts of the TVA include reliable and renewable source of energy creating jobs and boosting productivity, increased water quality in the Tennessee river and its tributaries. The TVA has formed stakeholder groups, including local communities, farmers, businesses, and environmental groups that provide input and feedback on TVA's water management plans. It has been successful in improving the region's economy and quality of life and is considered to be good example of IWRM implementation. The over-reliance of the TVA on fossil fuels is often cited as an example of an aerea where it needs to further improve.

City of New York water supply from the Catskill Mountains, Delaware, USA

The example of the City of New York's water supply system, sourced from the Catskill Mountains and the upper reaches of Delaware is a classic example of how IWRM can be instrumental in bringing the stakeholders together to preserve the watershed protecting the water quality and quantity as well as maintain the economic viability of the watershed communities[2]. It is an example of how the delicate balance between urban/rural and upstate/downstate interests in multiple watersheds can be maintained to ensure quality water supply (National Academies of Sciences, Engineering, and Medicine, 2020; National Research Council, 2000).

[2] https://www.nyc.gov/site/dep/news/22-040/newly-updated-filtration-waiver-confirms-success-ongoing-efforts-provide-highest-quality-nyc

Figure 2-3: New York City's water supply system (Left above, Source: www.nyc.gov/dep) includes 90% unfiltered water sourced from Catskill/Delaware watershed 100 miles away includes; Catskill watershed view from Twin Mountain south summit (Right above, Source: Wikipedia.org) and the Pepacton reservoir (Right bottom: Source: Wikipedia.org)

New York City's municipal water supply system provides about 1 billion gallons of drinking water a day to over 8.5 million people in New York City and about 1 million people living in nearby counties. This is an unfiltered water supply, one of the largest in the world, providing drinking water to the taps of residents. In the late 1990s, the water quality was observed to be deteriorating by development activities in the watersheds and the City of New York faced the challenge of funding six billion dollars for a filtration system to meet drinking water standards under the Surface Water Treatment Rule and the Safe Drinking Water Act monitored by the US Environmental Protection Agency. It could, also as an alternative, obtain the "filtration waiver" by meeting additional provisions complying with more stringent criteria as stated in Long Term 2 Enhanced Surface Water Treatment Rule (LT2). The City of New York chose the latter option of an integrated watershed management approach.

In 1997, partnerships were developed, with a memorandum of agreement between New York City; New York State; the US Environmental Protection Agency (EPA); watershed counties, towns and villages; and environmental and public interest groups to implement a New York City Watershed Protection Program. The program is designed to protect the watershed and ensure high quality water supply. The partnership can be analyzed to have instituted (i) an enabling environment with required policies and legislations, (ii) set up an institutional framework consisting of public entities, corporate bodies, farmer and business communities, and (iii) strengthened with suitable management instruments such as data, information, guidelines, studies and operating procedures. All of this was backed up by required funding from the City of New York. These are all hallmarks of an IWRM approach to sustainably solving issues related to water.

The Department of Environmental Protection (DEP) of the City of New York has developed programs to ensure a balance between agriculture, urban and rural wastewater and storm drainage infrastructure, and the environment while maintaining the quality of water in the nineteen reservoirs and three controlled lakes. These programs include acquisition of critical land for preservation converting them into forest or parks, developing best management practices for 450 farms incorporating pollution prevention measures and controlling runoff into water bodies, upgrading private and public waste water treatment plants to tertiary treatment along with repair of more than 6,270 septic-tank systems to prevent groundwater pollution. Works to control stormwater to improve water quality of receiving water bodies such as stream-side buffers, sediment control as well as the management of forests to soak up nutrients and prevent erosion were successfully carried out. DEP reviews and approves new development proposals in the watershed to ensure compliance with standards that protect watershed streams and reservoirs, particularly regarding wastewater and stormwater.

The watershed improvement program also offers opportunities and incentives to help watershed landowners and homeowners voluntarily protect water quality and become good environment stewards. The water quality has markedly improved, and the filtration waiver has been extended to another 10 years, while it has successfully leveraged investments in the area and created 4,900 jobs in the watershed, the population of the watersheds enjoys a better-quality environment.

This is an excellent example of collaborative approach on watershed management and regulation, monitoring and quality control. This showcases IWRM approach that could be relevant and applicable for developing upstream downstream linkages in Nepal too.

The Lesotho Highlands Water Project, Kingdom of Lesotho and the Republic of South Africa

The Lesotho Highlands Water Project (LHWP) is a transformative cross-border initiative between Kingdom of Lesotho and the Republic of South Africa. It is primarily aimed at providing water to South Africa's Gauteng region and generating hydroelectric power for Lesotho. Established through a 1986 Treaty, between the two countries the project's multi-phase approach involves constructing dams and infrastructure for mutual benefits of the two countries to improve water supply, achieve sustainable socio-economic development through regional cooperation. The first phase of the project was completed in 2004, at a cost of $4 billion. The second phase has started now with an estimated cost of $1 billion.

South Africa and Lesotho are socially and economically linked countries and the project further strengthens commitment for mutually beneficial development for promoting regional integration. The two countries entered a well drafted treaty with specific water allocation and cost-benefit sharing formulae protecting even other non-signatory riparian countries that allows for potential future adjustments to accommodate evolving water requirements and natural shifts in hydrological patterns.

It provides reliable water sources, the second phase starting soon will increase the supply from 780 million m^3/year to 1,260 million m^3/year, to benefit about 26 million people in South Africa supporting 60% of South Africa's economy. The water rejuvenates the Vaal River System providing for municipal supplies, irrigation, industries and mining and the ecosystem. In the upstream, it will benefit 85,000 people in Lesotho directly along with infrastructure growth, community development activities, private sector growth through improved infrastructure and contribute to Lesotho's socio-economic development from assured annual royalty payments of US$ 55 million from South Africa South Africa bore the full cost of development and O&M, except for the hydropower generation.

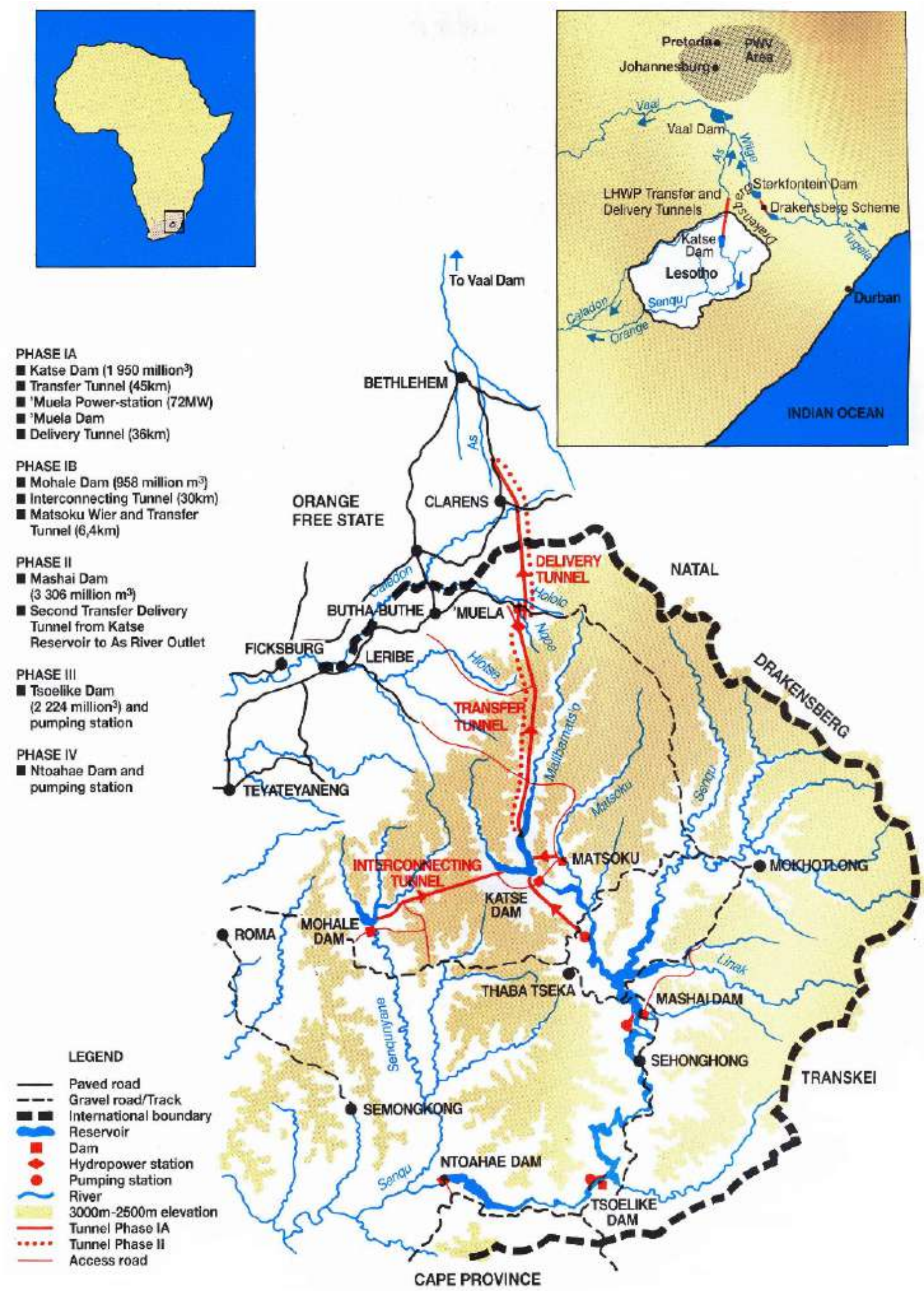

Figure 2.4: Schematic map of the Lesotho Highlands Water Project (Source: Wikimedia Commons)

These socio-economic objectives collectively aim to bring about positive changes in Lesotho's economy, infrastructure, social well-being, and regional relations, making the Lesotho Highlands Water Project a multi-faceted endeavor with far-reaching impacts.

Stakeholder participation and collective decision-making plays vital roles in the Lesotho Highlands Water Project. The project's design incorporates a structured framework for engaging various stakeholders, ensuring their voices are heard and their concerns addressed. This includes joint collaboration in implementing the project to ensure each countries' strategic objectives are met, community engagement to foster participation, promoting role of civil society and community organizations, developing capacity and expertise locally.

Collective decision-making mechanisms, such as joint committees, review boards, and public forums, facilitate open dialogue and collaboration among stakeholders. Regular communication, feedback loops, and transparent reporting ensure that decisions consider various perspectives and promote the project's sustainable development goals.

The LHWP stands as an exemplar of a "win-win" initiative, showcasing the advantages of collaborative bilateral government efforts in international river development, surpassing individual approaches and fostering enhanced political cooperation. The IWRM approach of coming together to solve a problem using water as a valuable resource to address water scarcity in regions of South Africa and accelerate sustainable socio-economic development in Lesotho fully addressing other riparian concerns is a major feat.

It must be noted that the communication, good public participation as well as putting in anti-corruption practices important aspects that need to be further strengthened to ensure transparency, social equity, efficiency and sustainability in the project. The project was plagued with corruption and criminal cases entered to against officials and vendors. Nonetheless, the successful completion of the first phase demonstrates that the institutional framework, enabling environment and the management instruments are already in place and these could be further enhanced to fulfill "water for livelihood" objectives. IWRM is a continuous and evolving process and the elements of water use priorities and public participation need to be made stronger.

Additional information and best practices

There are further examples of cooperation set up at the international level, such as the Mekong River Commission or developed countries managing water stresses better, such as the Murray Darling Basin in Australia. Local watershed level interventions or traditional sustainable practices are also often fit retroactively into the IWRM envelope such as the Hawaiian "ridge-to-sea" *ahapua'a* systems, the traditional water delivery and fountain systems of the Kathmandu valley (*Rajkulo-Hiti* irrigation systems) or the stepwells of Rajasthan.

Some discussions on IWRM implementation and examples are also available in the literature (Hassings, 2009; and Godinez-Madrigal et al., 2019). These above given examples to demonstrate the potential of IWRM to address the challenges of water resource management in a sustainable manner, by considering the interconnections between different water uses and the impacts of water management on the environment, economy, and society. The mega-projects stated above as good examples of IWRM are successful because these have tackled the complex problems of harnessing water by addressing physical challenges and societal expectations based on agreements for partnerships or treaties, good implementation mechanisms empowered with suitable information and sound tools.

The basic underlying relevance to South Asia and Nepal as the projects emphasizes the strong willingness to come together for different users, communities to understand the problem, set up some rules and boundaries of cooperation ensuring equity in participation and sustainability. These are all transferrable lessons to Nepal.

The example of the City of New York's water supply system, sourced from the Catskill Mountains is a relevant example of IWRM in terms of the stakeholders coming together to agree to preserve the watershed to protect the water quality and quantity supplying New York. This is an excellent example of collaborative approach, land management and regulation, monitoring and quality control are all relevant and applicable for upstream-downstream linkage in Nepal. The use of nature-based solutions and collaborative governance enforced with strict monitoring and control helped guarantee success and sustainability of a valuable resource can help many places in Nepal for a reliable and clean source of water. Chapter 7 further states some of the efforts in IWRM in Nepal.

The Global Water Partnership (www.gwp.org) provides extensive one-stop solutions for information, guidelines and toolboxes for IWRM, while there are a number of other manuals for training also available (Mekong River Commission, 2012; UNESCO, 2009).

3. IWRM AND CLIMATE CHANGE

IWRM establishes an acceptable procedure to manage water resources; which is, by its own intrinsic nature, is variable. Water operators or managers are always required to adjust their plans and operations with the amount of water available. They are regularly called upon to adjust operation or allocation when there is excess water or a water shortage occurs such as in droughts.

A well designed IWRM include options of managing both present and future scenarios. Climate change will also usher in or accentuate the extremes with each instance having either too much or too little water. The IWRM, is already designed to handle shocks and variabilities in water availability or demands. The IWRM processes, including the operation rules and decision support systems therein, are adequately adept at handling the changes or variations induced by climate change.

3.1 Non-Stationarity and the Changing Climate

The future scenarios and decision support systems are based on historical data which are often simulated through numerical models. Normal existing practices invoke the concept of stationarity - assuming that the future will be similar, of the same median value, and distributed with the same variance or standard deviation without having any trends. This simplifies a lot of analytical tools and is easier to comprehend and model.

Non-stationarity assumes that the median value is changing, and requires complex methods to forecast the future. The future could be substantially different from the past. This suggests that the parameters obtained from concepts of stationarity may not be reliable to predict non-stationary events.

While the non-stationarity of a changing climate may already be evident, or be more distinct in distant future, current water management practices and the operational guidelines built in them are often robust enough to handle near-future variations. Meteorological and hydrological phenomena are certainly variable or stochastic and all water management aspects are necessarily viewed in terms of how to address water resources variability. The climate change induced variability comes to the fore when the variabilities and the impacts caused by them exceed the natural expected variabilities. There may be trends with significant effects that will need to review approaches water resources management.

Integrated Water Resources Management (IWRM) and climate change are closely related and interconnected. Climate change impacts the availability, quality, and distribution of water resources, which are the very foundation of IWRM. IWRM is a holistic approach to managing water resources sustainably, taking into account social, economic, and environmental factors. It aims to ensure the coordinated development and management of water resources for multiple users and uses, while also preserving the integrity of ecosystems.

Here are some key aspects of the relation between IWRM and climate change:

1. Water availability and variability: Climate change affects precipitation patterns, leading to changes in water availability. Some regions may experience increased rainfall and flooding, while others may face prolonged droughts and water scarcity. IWRM can help address these challenges by promoting efficient water use, storage, and distribution systems that consider the changing climate patterns.
2. Extreme events: Climate change intensifies extreme weather events such as hurricanes, storms, and heatwaves, which can have significant impacts on water resources. IWRM can help mitigate the impacts of these events by implementing measures like flood control infrastructure, early warning systems, and disaster preparedness plans.

3. Water quality: Climate change can affect water quality through factors such as increased water temperatures, changes in precipitation patterns, and sea-level rise. These changes can lead to altered chemical and biological processes, affecting the quality of water sources. IWRM emphasizes the protection and restoration of water ecosystems, which are crucial for maintaining water quality.
4. Adaptation and resilience: Climate change require adaptation strategies to cope with the impacts and build resilience. IWRM provides a framework for integrating climate change considerations into water management practices. It involves developing strategies such as water conservation, water recycling, and efficient irrigation techniques to adapt to changing conditions.
5. Integrated approach: Both climate change and water resources are complex and inter connected issues. IWRM takes an integrated approach by considering the interactions between water, climate, land use, ecosystems, and socio-economic factors. This integrated perspective allows for comprehensive and sustainable management of water resources in the face of climate change.

In summary, IWRM and climate change are closely linked, as climate change directly affects water resources, and IWRM provides a framework to address the challenges posed by climate change in managing water sustainably. By incorporating climate change considerations into water management practices, IWRM can contribute to building resilience, adapting to changing conditions, and ensuring the availability of water resources for present and future generations.

3.2 IWRM Advantages in Responding to Climate Chang

IWRM is a reflexive evolving process - designed to allow for modifications as warranted. It is also suited to handle climate change. The future climate change scenarios could be managed adopting the same procedures the IWRM manages current variations in the weather systems. On can adopt any of the following practices to address changes brought in by the climate.

- Emphasize water use efficiency and demand side management for cases of increased drought or low flows in the source rivers or for lower precipitations.
- Adopt water rationing and curtailing lower priority uses according to the pre-agreed operational procedures.
- Experiences in handling other extremes of climate variability, floods or higher rainfalls through IWRM also helps in adaptation to similar climate changes.
- IWRM could also invoke existing management options to tap into aquifer reserves, which are more resilient to climate changes, or scaling up reservoir storage options.
- Increasing capture and storage of surface runoff, water harvesting structures to better handle uncertainties in future precipitation.
- Encourage reuse or recycle wastewater after treatment and conserve water.
- Carry out improvements to drainage systems to prevent flooding and water logging.
- As IWRM is built on aggregation of climate data and other hydrological, socio-economic data, the response can be better aligned according to the impending ranges of representative parameters with minimal impact to the bottom lines of the larger set of population.

It is evident that IWRM is likely to provide better adaptive responses to climate variability and is an advantage in the case of climate change adaptation. IWRM is better equipped in terms of data and predictive capacity of the immediate future or forecasting immediate future scenarios and set in motion the required adaptive mechanisms to address the anticipated change.

IWRM enables better land use management practices, watershed restoration, and stakeholder dialogues to better align climate responsive actions such as working towards nationally determined contributions (NDCs) (GoN, 2020), better implement local adaptation action plans, or better plan and implement other climate actions because of stronger stakeholder linkages and consensus building exercises existing amongst the stakeholders. IWRM is therefore an asset in the face of climate change.

4. WATER RESOURCES OF NEPAL

4.1 Background

Nepal is a mountainous country in the central Himalayan region, located between China and India in South Asia (Figure 4-1). It includes the high Himalayas in the north, and flat lands of Terai in the south (Figure 4-2).

Nepal has a total area of 147,516 km^2 with a large portion of it (~86%) covered by hills and mountains. Forests cover about 43.4% of the area of the country while agricultural land is 24.1%, almost half of the latter is in Terai, flat lands and valleys. The annual precipitation ranges from less than 200 mm to more than 5000 mm at places with the national average value estimated to be 1830 mm (MOFE, 2019). The distribution of annual values over the country is shown in Figure 4-3 from a DHM (2015) report.

The Terai plain (Figure 4-2) is the grain-belt of Nepal with a tropical climate occupying 14% of the nation's area. The annual rainfall averages 1100-3000 mm. The Siwaliks, also known as the Chure range, north of Terai, is a range of hills with elevations ranging from 200 to 1,500 meters above sea level (masl). It is the major recharge zone for Terai aquifers.

The middle mountain region (Figure 4-2), with elevation ranging from 1,000 to 3,000 masl and a temperate climate (275-2300 mm of rainfall) is intersected by large rivers flowing north to south. The High Himalaya region includes the Himalayan Range and the areas north of it. The climate here is of the tundra and arctic variety. The area has an extremely rugged terrain, with steep slopes and deep valleys. Precipitation is estimated to be 150-200 mm, though the weather instrumentation is rather scarce.

The Terai and the valleys in the middle mountains are prime areas of agriculture and residential areas. The Irrigation Master Plan (IMP, 2019), states that, out of the total net agricultural lands of 35,610 km2, about 64% of this land or only 22,650 km2 has potential for irrigation, while the rest is not irrigable.

The present population of Nepal is estimated to be about 29.192 million (Central Bureau of Statistics (CBS), 2021). Agriculture is the mainstay of Nepalese, 60% of the population listed agriculture as their prime occupation (CBS, 2012) contributing to about a quarter of the gross domestic product (GDP).

The GDP per capita is estimated to be US $1,085 for FY 2019/20 (CBS, 2020). Remittance is the next major contributor as a large portion of its youth go outside the country for work, mostly as unskilled workers. Seasonal or temporary migration of youth, mostly men, has often created a shortage of labor for farm work and this has put on additional responsibilities and burden on women at home. Rapid development of the agriculture sector x is essential to enhance productivity and increase employment. Water plays a pivotal role in supplying irrigation to enhance agricultural productivity as well as providing energy through hydropower generation. Safer cleaner energy is essential to mitigate climate change and meet the country's NDC requirements.

Figure 4-1: Administrative provinces and the river basins of Nepal

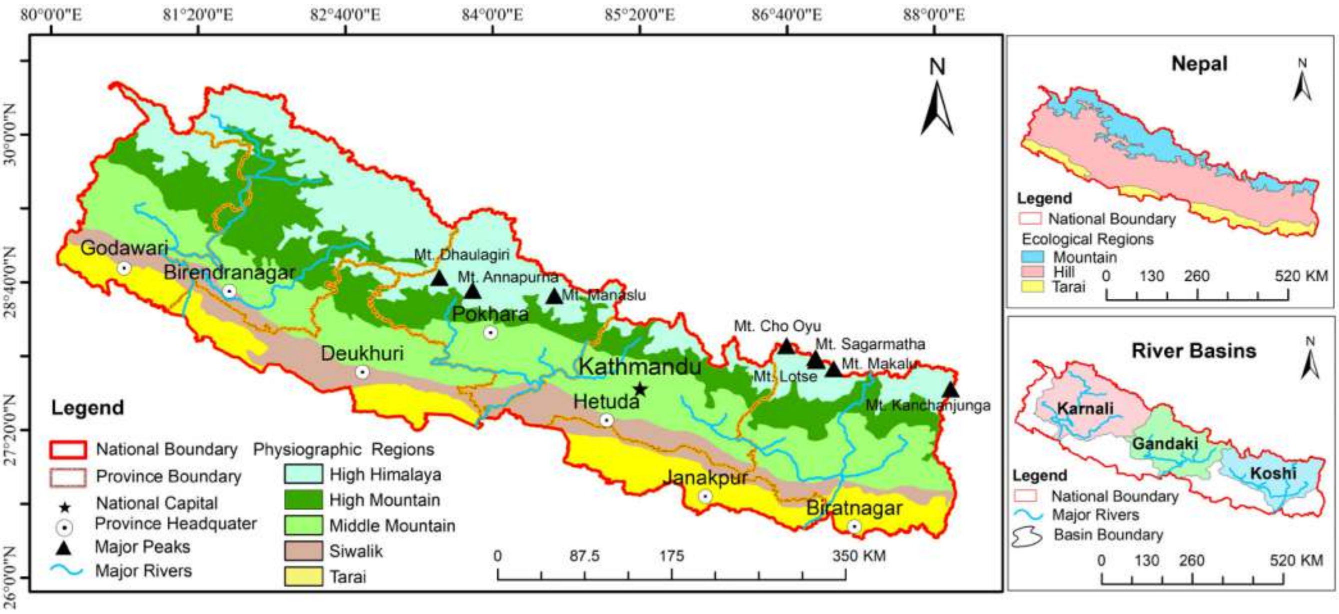

Figure 4-2: Physiographic regions of Nepal (Rai et al., 2023)

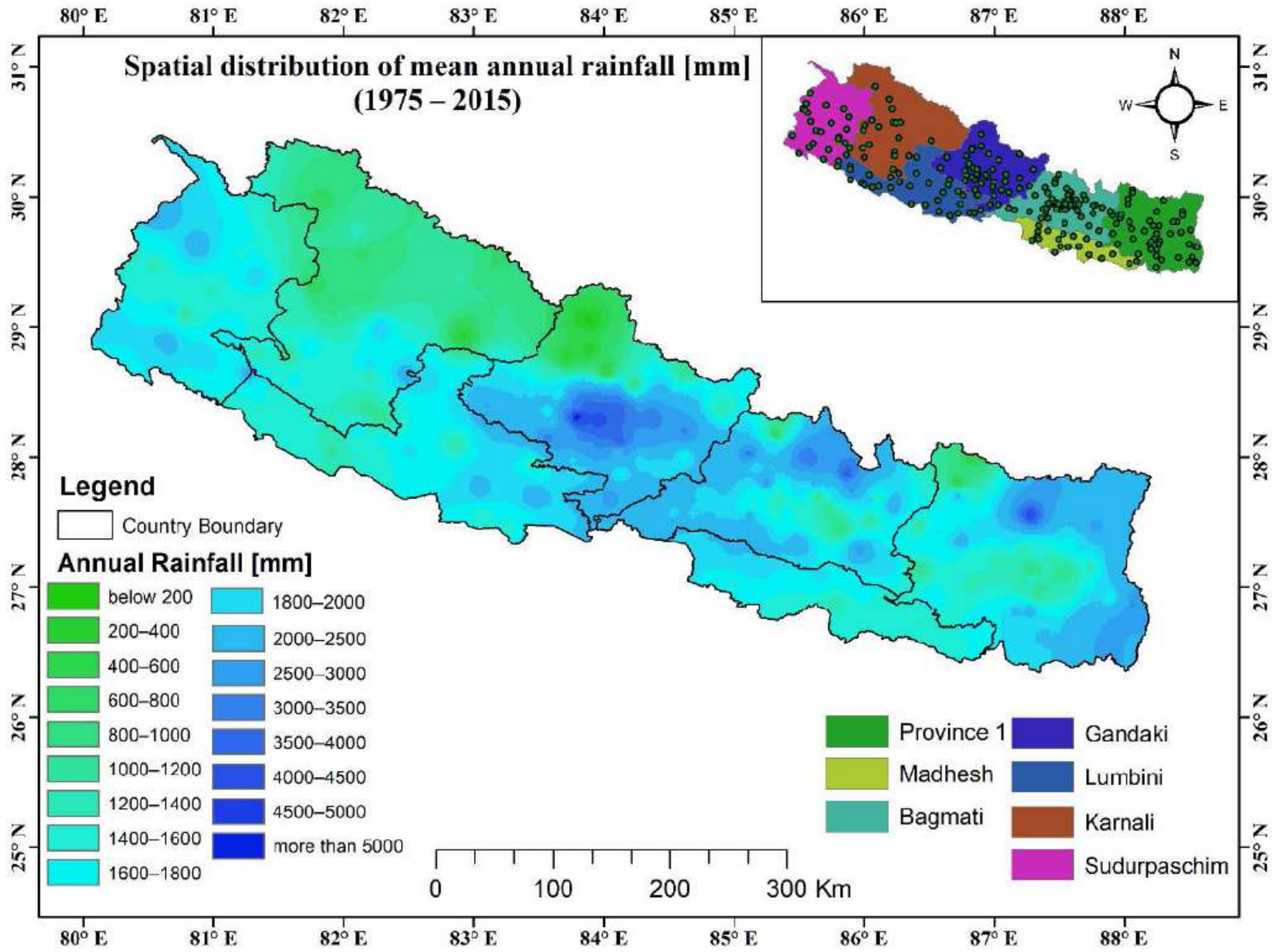

Figure 4-3: Mean annual precipitation of Nepal (Aryal et al., 2022)

4.2 Water Resources Supply

Surface water emanates from rainfall runoff, snowmelts, glacier-melts, accumulate in rivulets, ponds, lakes, and rivers and are also sustained by groundwater discharges. Groundwater is infiltrated subsurface water that are held in aquifers and can be shallow or deep. Groundwater in hills and mountains provides springs that are critical sources of water for drinking water and some irrigation. Groundwater in valleys and the Terai are important resources for the livelihood of the majority of the population.

4.2.1 Surface Water

The current estimate of the average annual total surface water available in the country is 225 billion m^3 per annum, equivalent to about 7,700 m^3/person/year at an average flow of 7,125 m^3/s, excluding groundwater reserves. Nepal's freshwater accounts for an estimated 2.27% of the total world supply (WB and ADB, 2021). The major river systems of Nepal are Mahakali, Karnali, Narayani (Gandaki) and Koshi. These rivers originate from the Himalayas and beyond, are fed from snow and glaciers and have appreciable dry season flow. Figure 4 1 shows the river basins of Nepal.

Table 4-1: Areas and runoff estimates of river basins of Nepal

SN	Basin (River) Names	Area of Basin		Average Annual Estimate		Specific discharge, $km^3/(km^2/yr)$	Fraction of total runoff from Nepal
		Overall (km^2)	Nepal Only (km^2)	Average Runoff (m^3/s)	Volume (million m^3)		
1	Mahakali	15,260	5,410	698	22,012	0.001442	78%
2	Karnali	44,000	41,890	1,441	45,443	0.001033	
3	Narayani	34,960	28,090	1,753	55,283	0.001581	
4	Koshi	60,400	31,940	1,658	52,287	0.000866	
5	Babai	3,400	3,400	103	3,248	0.000955	8%
6	West Rapti	6,500	6,500	224	7,064	0.001087	
7	Bagmati	3,700	3,700	178	5,613	0.001517	
8	Kankai	1,330	1,330	68	2,144	0.001612	
9	Other Rivers (Mechi, Kamala and Southern Blocks)	24,921	24,921	1,001	31,568	0.001267	14%
Total		**194,471**	**147,181**	**7,125**	**224,662**	**0.001155**	**100%**

Table 4-1 shows the basin areas, annual average runoffs and volumes of water discharged from the river basins of Nepal (WECS, 2003). This is the only official and approved information at present. The specific discharge of the river basins considering the total drainage area and the contribution of these rivers to the total runoff from Nepal are further calculated and shown in the last two columns. The water availability per unit area is given by the specific discharge and are the lowest for Koshi and Babai basin. The Koshi River basin, also called the Sapta Koshi at places, more than half the drainage area in Tibet, China, north of the Himalayan Range with very low precipitation, therefore the specific discharge for Sata Koshi appears low, it consists of higher specific discharge areas in Nepal. In real terms, Babai river basin is the driest and is the most deficit river basin corresponding to a specific discharge of 955 mm/year.

The first four rivers listed in Table 4-1 are major snow-fed rivers with sustained low flows contributing collectively to about 78% of the total runoff volume. These are water surplus basins. The other rivers have large flows during rainy seasons and very low to almost no flows in the dry season and are water deficit basins in the dry season.

Figure 4-3 shows the average annual precipitation distribution in Nepal (DHM, 2015) and the monthly averaged precipitation is shown in Table 4-2 (WECS, 2019). The rain-shadow beyond the Annapurna and Dhaulagiri ranges in the Mustang, Manang and Dolpo regions as well as the Mugu and Humla regions bordering China have very low precipitation - some averaging below 200 mm in a year. It must be noted that some pockets of areas even south of the Mid-hills, such as the Lower sub-basin of Tamor River (Terhathum areas), Ramechhap and Dolakha districts and some parts of the Babai river basin, have lower rainfall and hence low availability of surface water resources at the local level.

Table 4-2: Average monthly precipitation in river basins of Nepal in mm

Basins	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Average
Koshi	14.9	24.3	38.0	77.6	146.3	262.9	409.3	367.0	237.1	65.5	11.5	10.8	1,666.7
Gandaki	24.9	33.8	44.0	63.5	135.6	289.6	469.2	419.5	253.0	61.4	9.7	15.2	1,823.0
Karnali	36.8	44.0	42.2	37.6	66.6	155.2	310.2	300.9	156.5	41.4	10.0	16.8	1,225.1
Mahakali	44.1	60.5	56.6	54.8	105.9	249.7	519.7	488.7	262.3	50.0	7.3	19.5	1,924.8
Mechi	11.7	15.1	27.7	84.1	226.5	508.8	768.1	537.1	419.0	116.6	14.0	6.2	2,735.4
Kankai	12.8	17.0	27.6	73.3	172.6	356.4	534.5	411.0	293.1	85.9	12.1	8.0	1,998.9
Kamala	9.8	12.6	17.5	58.9	134.5	246.8	458.3	338.4	260.2	74.0	7.1	9.0	1,628.9
Bagmati	13.5	16.9	22.5	55.7	133.6	265.6	512.0	412.0	272.1	69.9	6.1	11.4	1,794.9
West Rapti	24.5	28.4	25.9	33.6	85.4	253.0	430.8	389.1	238.9	52.3	9.0	14.2	1,586.6
Babai	27.4	28.8	22.6	24.3	75.9	226.9	418.3	386.6	226.6	53.4	8.6	13.4	1,513.6
Southern Block 1	31.4	34.2	21.3	18.8	65.2	257.6	533.9	507.9	296.6	53.9	4.7	15.3	1,844.0
Southern Block 2A	18.2	23.3	20.9	28.5	87.1	287.7	547.4	439.1	284.5	67.8	7.4	14.4	1,825.3
Southern Block 2B	13.6	14.8	16.8	44.6	127.6	270.2	511.4	415.7	281.7	67.5	6.0	10.1	1,784.4
Southern Block 3	10.8	12.0	13.4	47.6	122.6	229.7	429.7	326.7	231.3	68.0	4.4	7.7	1,504.1
Southern Block 4	12.4	14.3	20.2	66.1	187.6	363.1	598.9	436.2	331.7	103.8	9.9	7.1	2,151.8

The Table 4-3 shows the monthly mean discharge in the major rivers of Nepal observed at their highest discharge measurement stations compiled from WECS (2019), the Table excludes the Mahakali and Mechi rivers as these form boundary rivers along most of their lengths. The southern block rivers in the Terai are also excluded as these do not flow as a single stream but are multiple flashy rivers. These excluded rivers have no data or measuring stations available.

Table 4-3: Monthly Mean discharge (m^3/s) of observed data of some major rivers of Nepal

River Basin	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Koshi	392	346	344	430	700	1,733	3,769	4,322	3,334	1,525	792	523	1,518
Bagmati	21	20	17	16	29	120	408	393	280	103	40	25	123
Narayani	338	279	256	321	554	1,574	3,892	4,590	3,179	1,443	717	447	1,466
West Rapti	30	27	21	18	22	70	319	394	270	123	51	34	115
Babai	24	19	16	13	21	71	286	307	292	114	42	28	103
Karnali	341	303	323	412	715	1,439	3,210	4,383	2,825	1,302	641	434	1,361
Kankai	15	12	11	13	25	73	202	202	142	64	30	20	67
Kamala	24	21	20	17	31	78	292	303	263	88	34	22	99

The mean monthly flows for Koshi River and Kamala River are calculated and shown in Figure 4-4 and Figure 4-5 respectively, as examples of a mixed snow-and-rain-fed river vis a vis a purely rainfed river. These figures portray the issues of "too much water and too little water" in the same river basin.

The mean monthly flows of Koshi River, a snow fed major river system in Nepal, is 1,518 m^3/s. The flow rises with the melting of snow in the months of May and June and picks up with the start of monsoon season in mid-June. It peaks in August and then recedes to near average annual flow in October and further. The river discharge is considerably higher than the annual average for three months July to September and considerably lower than average for the seven months from November to May. The lowest flow is in March, indicating a dry winter. The lowest average monthly flow is almost 13 times smaller than the highest average monthly flow in August. Similarly, for Kamala River, this ratio is larger, almost 17 (Figure 4 5), indicating that there is a large seasonal shortage of water, with possible flooding in the monsoon season. Instantaneous floods are much larger than this averaged monthly flow.

This seasonal nature of river flows suggests that optimum utilization of the water resources requires large investments in creating water harvesting storage or reservoir projects that store annual floods and provide water round the year to water deficit areas. The option could also be to divert from those basins with higher amount of water to basins scarcer in water. In fact, a diversion project from Bheri River, a distributary of the Karnali River, to Babai River basin has been identified to provide irrigation water to the seasonally water stressed Babai river basin.

This high fluctuations in monthly river flows create issues in constructing water diverting structures, head works and embankments for flood protection requiring large sized robust structures that appear redundant during low flows.

Koshi River d/s of Chatara

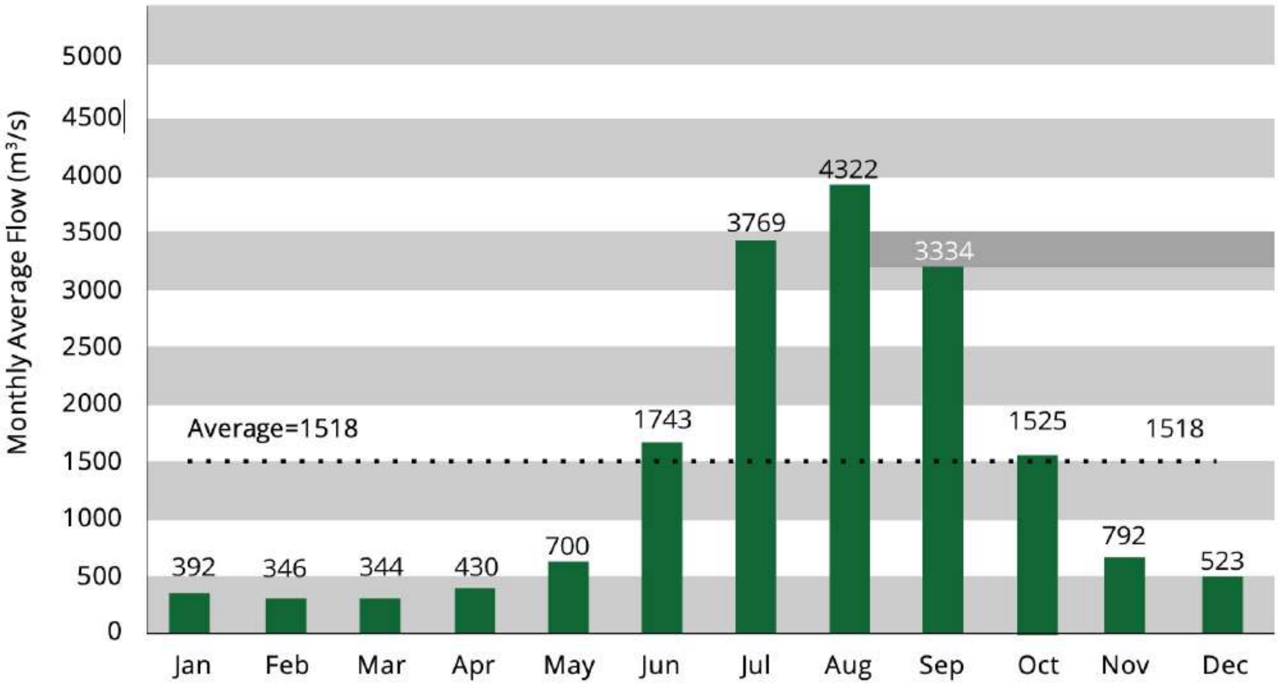

Figure 4-4: Mean monthly flow of Koshi River at downstream of Chatara

Kamala River at Nepal-India Border

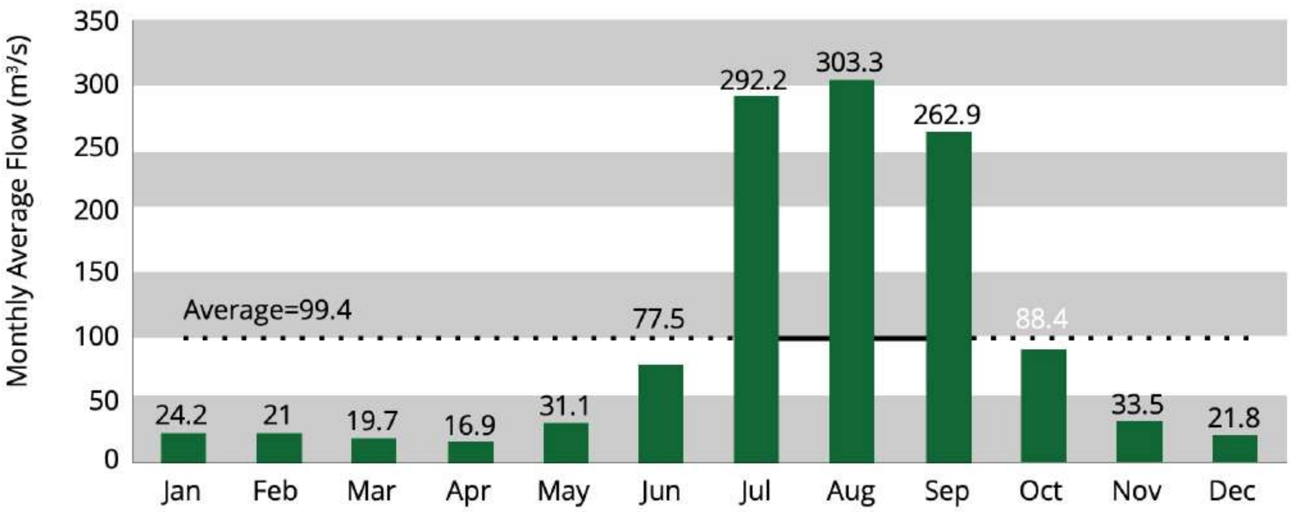

Figure 4-5: Mean monthly flow of Kamala River at Nepal India border

4.2.2 Lakes and Reservoirs

There are numerous lakes and reservoirs that possess significant religious, cultural and recreational values including tourism, water supply and aquaculture benefits. There are about 5,358 lakes located in different topographic regions in the country (CBS, 2019). To date, only one man-made reservoir exists, the Indra Sarovar, which is a water storage reservoir for power generation. Commercial fish farming is also done in the reservoir and provides benefits to the local population. Lakes such as Rara, Phewa, Phoksundo and Gosainkunda are all major tourist and religious destinations that need to be managed judiciously to preserve their pristine nature and ecosystem services. Jagdishpur Tal in Kapivastu, among others, is a major haven for migratory birds as well as a key source for irrigation for the local area. Table 4-4 lists the major lakes and reservoirs that are larger than 10 hectares.

Table 4-4: Major lakes and reservoirs of Nepal of area larger than 10 hectares

SN	Name of Lake	District	Northing	Easting	Area (ha)
1	**Rara**	Mugu	29°31'49.90"N	82° 5'24.86"E	1052
2	**Phoksundo**	Dolpa	29°11'51.82"N	82°57'6.38"E	440
3	**Phewa**	Kaski	28°13'1.54"N	83°56'47.46"E	383
4	**Begnas**	Kaski	28°10'26.07"N	84° 6'7.22"E	302
5	**Tsho Rolpa**	Dolakha	27°51'37.95"N	86°28'40.04"E	235
6	**Indra Sarovar**	Makawanpur	27°36'5.36"N	85° 9'35.28"E	186
7	**Jagdishpur taal**	Kapilbastu	27°37'19.66"N	83° 6'4.69"E	160
8	**Rupa**	Kaski	28° 9'0.94"N	84° 6'43.19"E	106
9	**Ghodaghodi**	Kailali	28°41'14.01"N	80°56'55.21"E	77.4
10	**Barhaiya**	Bardiya	28°11'46.89"N	81°30'58.04"E	70.5
11	**Syarpu**	Rukum	28°41'45.28"N	82°29'6.52"E	65
12	**Gokyo**	Solukhumbu	27°58'28.04"N	86°40'59.60"E	45
13	**Kubhinde**	Salyan	28°24'52.27"N	82° 3'28.88"E	25.8
14	**Surya Kunda**	Rasuwa	28° 4'48.18"N	85°24'27.41"E	15.9
15	**Dipang**	Kaski	28°10'49.69"N	84° 4'10.49"E	14.7
16	**Gosainkunda**	Rasuwa	28° 4'57.23"N	85°24'50.10"E	13.5
17	**Bish Hajari Taal**	Chitwan	27°37'2.65"N	84°26'15.06"E	12.9
18	**Chhoitai Tal**	Dolpa	29° 7'55.08"N	83° 0'45.69"E	12

4.2.3 Glacial Lakes

Glacial lakes exist in high elevations, generally above 3000 meters elevation. A recent inventory of glacial lakes by ICIMOD (Bajracharya et al., 2020) of those that were equal to or larger than 0.3 ha in the area were mapped in Koshi, Gandaki, and Karnali basins of Nepal, the Tibet Autonomous Region (TAR) of China, and India. The study found that 3,624 glacial lakes are located in the three basins, of which 2,070 lakes are in Nepal, 1,509 in Tibet (China) and 45 in India. Of these, 47 were identified as potentially dangerous lakes in the three basins(42 in Koshi basin, 3 in the Gandaki basin, and 2 in Karnali basin), while 21 were within the political boundary of Nepal. Twenty-five such lakes were in Tibet and one in India. Melting of permafrost, shrinking of snowfields and retreat of glaciers are accelerated with the climate change and glacial lakes need to be monitored for lake outburst floods. These present serious threats and risks to infrastructure, properties and settlements located downstream of the rivers originating from glacial lakes.

4.2.4 Groundwater

Nepal has good resources for groundwater in the Terai region. The region is an extension of the Indo-Gangetic plains - one of the most productive aquifers in the subcontinent. Groundwater has been used for drinking water and irrigation development through the use of shallow tube-wells (STW) and deep tube-wells (DTW). The development of these is primarily present in the Terai region where good formations exist to store, transmit and yield water. Some artesian wells, seasonal or perennial, occur at places, whereas mostly fossil fuel and electricity is used to run pumps to extract water from the aquifers.

Table 4-5: Groundwater potential (net annual recharge and area for development) of Terai region (Source: IMP, 2019)

District / Basin	Net total groundwater recharge [MCM/year]				Potential area for development (ha)
	Half of cultivable area irrigated with groundwater water				
	Bhaber Zone	Seepage Zone	Terai Zone	Total	
Jhapa	422	181	333	936	84,000
Morang	418	100	345	863	-
Sunsari	264	100	357	721	5,000
Saptari	342	197	250	789	-
Siraha	247	112	213	572	-
Dhanusha	168	59	202	429	-
Mahotari	237	49	200	486	-
Sarlahi	249	108	143	501	15,000
Rautahat	205	79	106	390	25,000
Bara	361	41	195	597	-
Parsa	470	37	154	661	31,000
Chitwan	222	63	262	547	20,000
Nawalparasi E.	205	196	231	632	31,000
Nawalparasi W.	130	121	146	397	
Rupandehi	143	131	326	600	15,000
Kapilbastu	240	155	197	592	17,000
Dang	130		185	315	32,000
Bardiya	211	185	363	759	-
Banke	320	167	145	632	24,000
Kailali	522	73	269	864	9,000
Kanchanpur	320	135	334	789	-
Total	**10,150**	**4,018**	**8,616**	**13,072**	**308,000**

The geological formations in the upper fringe of the Terai region are formed by outwash fans of rivers and the colluvium from the young sedimentary Siwaliks. These are called the Bhabar Zone. This zone is the main recharge area for the Terai aquifers with the formations having a very high permeability in the range of 100-150 meters per day (WECS, 2005), and the average annual recharge exceeds 450 mm. Another study (IMP, 2019) estimates that the average annual renewable groundwater resources for the Terai region is of the order of 13 billion m^3, and the Eastern Terai has a higher annual recharge and storage yield.

The groundwater potential of the areas in the Terai is shown in Table 4-5, which shows that there are considerable volumes of sustainable yield available in these aquifers that could be used for irrigation development. This groundwater is also the primary source of drinking water in the Terai Region and other valleys.

It must be noted that groundwater provides storage to water and is annually renewable, so it provides a buffer to climate change as long as the abstraction is below the renewable yield. Countries around the world are resorting to “Managed Aquifer Recharge” to store and abstract water when needed, recover drawdowns and even push back saline wedges in coastal areas (Dillon et al., 2019; Sharma & Ray, 2011).

It is evident from the above description of the water resources supply scenario that the surface water availability is about 225 billion cubic meters while the sustainable groundwater availability is estimated to be 13 billion cubic meters, with a total of 238 billion cubic meters of water available on an average in a year.

4.3 Water Resources Demand

The sectoral water demands available are rather outdated. It was estimated, in 2011, that 15 billion m^3 was consumed every year (WECS, 2011). The agriculture sector is the major consumer with around 95.9 % of the total consumption while 3.8% is used for domestic purposes and the remainder 0.3% is used up by the industrial sector. Another report (Kumar et al., 2016) states that the total consumptive use in 2002 was 13,880 million m^3 which was then estimated to grow to 38,980 million m^3 per year eventually. Newer data on demand is not available.

The water resources demand consists of the following uses.

1. Irrigation
2. Hydropower
3. Drinking water supply
4. Municipal uses
5. Industrial Uses
6. Religious and cultural uses
7. Aquaculture and fisheries
8. Recreation (such as parks, canoeing and rafting)
9. River environmental flow requirement

These demands can be intermittent or continuous, consumptive or non-consumptive and may even involve transfer of water from one location to another or temporary retention or storage altering the availability of water resources at any particular location. Though hydropower generation is considered non-consumptive, it does entail storage, diversion and dewatering of certain stretch of water bodies.

4.3.1 Irrigation Demand

Irrigation represents a major consumptive use of water resources. A preliminary analysis using water requirement ratio, cornered on the concept of annual irrigation efficiency, suggests that the irrigation use of water in 2002 was 9.32 km^3 per year (FAO, AQUASTAT, http://www.fao.org/aquastat/). This database shows that the annual total water withdrawal for the year 2002 was 9.536 km^3.

It must be noted irrigation water does have residual return flow and not all diverted water is lost. In hill slope irrigation, the systems are considered inefficient with large conveyance losses. In practice, it does not consume the whole diverted water, but significant seepage and return flows occur recharging lower canals, often running parallel along contours on slopes, draining into drains or streams downstream and also recharging the underlying groundwater. In a similar manner, diverted water for domestic water supply also returns back as grey or black water through the drainage and sewer systems.

All IWRM processes need to have information on current or future demands on water from the irrigation sector. The recently completed Irrigation Master Plan 2019 (DoWRI, 2019) has prepared an inventory of irrigation systems and the planned projects in the future. The Irrigation Master Plan carried out an assessment of land and water resources available for irrigation. A summary of irrigation area coverage is given in Table 4-6.

Table 4-6 Summary of Irrigation Coverage (Source: IMP 2019)

Category	Terai (ha)	Hill (ha)	Mountain (ha)	Total (ha)	% age of Agricultural Area (ha)
Agricultural Land (Net Area)	1,594,327	1,565,706	401,288	3,561,322	100
Total Irrigable Land (Net area)	1,479,768	626,513	159,198	2,265,479	63.6
Existing Irrigated Land Gross Area	1,209,406	199,083	46,128	1,454,617	40.8
Net Area	860,304	178,059	41,054	1,085,417	30.5
New to-be-Irrigated Land (Net Area)	613,464	448,454	118,144	1,180,062	33.1

The total agriculture land is more than 3.561 million ha and amounts to 24.1% of the total area of the nation. Of the total agricultural land, about 63.6% is potentially irrigable. The irrigation facility is extended to about 30.5 % of the agricultural area and the irrigation infrastructure could be further developed on an additional 33.1% of the agriculture area as per the Master Plan. The existing and future demands are estimated as described below.

The estimated irrigation demand is defined as the product of the unit area water demand and the area irrigated. The amount of water to be applied to a field is defined by the prevailing climatic conditions (primarily rainfall, temperature and wind), the crop and its stage of growth, soil properties (such as water bearing capacity and hydraulic conductivity), and the root zone of the plants. The irrigation diversion volume is dependent upon the crop water requirement, field efficiency, distribution and main canal efficiencies provided that there are no constraints on supply. The following (Figure 4-6) shows the typical irrigation requirements in different ecological regions of Koshi basin using data obtained from Irrigation Master Plan (2019).

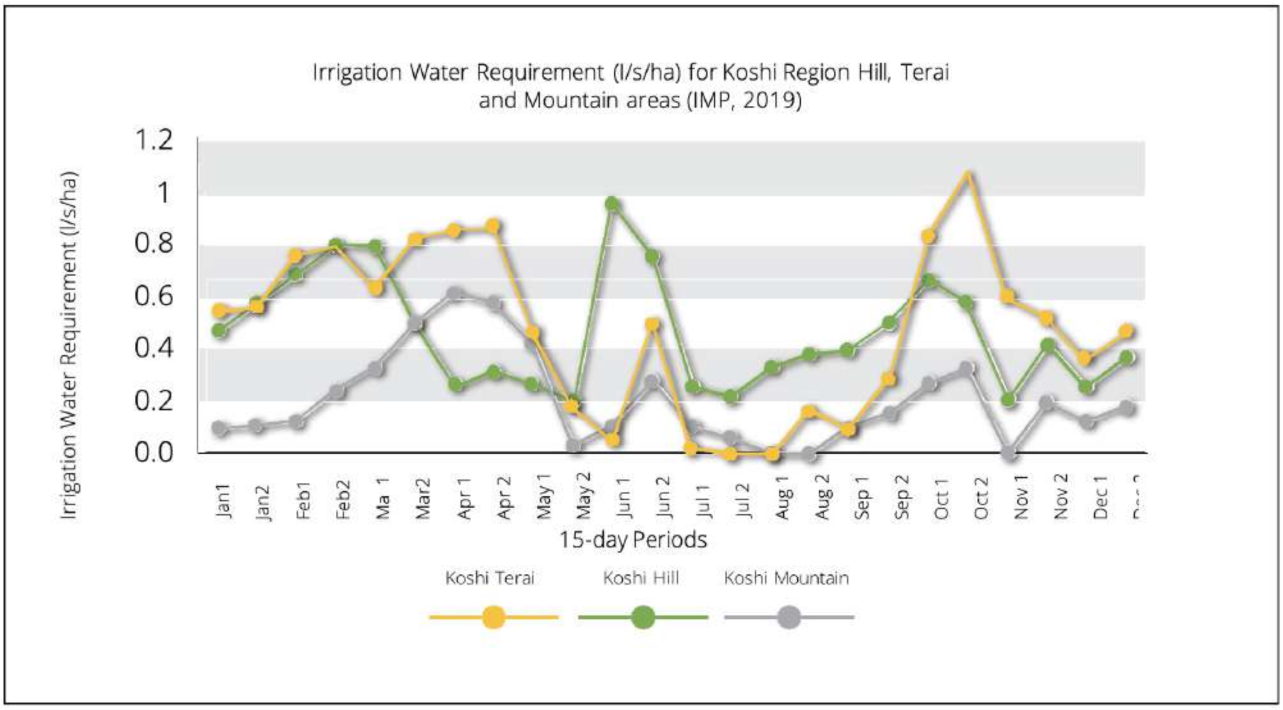

Figure 4-6: Irrigation water requirement (l/s/ha) for different ecological regions in Koshi Basin

4.3.1.1 Irrigation requirement from existing Irrigation schemes

The river basins of Nepal and the corresponding gross command area (GCA) of existing surface irrigation schemes within them distributed according to the ecological regions are shown below in Table 4-7. These areas are obtained from the GIS records of the database created for the Irrigation Master Plan. The total water required for irrigating the existing irrigated area is 17,452 million cubic meters per annum.

4.3.1.2 Irrigation requirement from priority-listed projects

The Irrigation Master Plan has prioritized some large irrigation projects for implementation and includes inter-basin diversion projects. These are called the Priority Projects. The irrigation water requirement in these schemes is presented in Table 4-8. The actual diversion may be larger as most of these prioritized schemes will have hydropower component too and will be optimized for net benefits as a multi-purpose project.

Table 4-7: GCA of existing irrigation schemes in different basins and regions (Source: IMP 2019)

Basin Name	Irrigation Area as per Ecological Region (ha)			Total Area (ha)	Estimated water Required (MCM)
	Mountain	Hill	Terai		
Babai	-	824	49,269	50,093	1,243
Bagmati	-	7,408	51,678	59,086	1,394
Gandaki	4,340	39,793	36,822	80,955	1,498
Kamala	-	3,619	30,996	34,615	522
Kankai	-	4,395	4,036	8,431	126
Karnali	10,335	15,420	23,991	49,746	884

Basin Name	Irrigation Area as per Ecological Region (ha)			Total Area (ha)	Estimated water Required (MCM)
Koshi	13,607	37,059	26,832	77,498	1,039
Mahakali	1,231	2,356	3,014	6,601	116
Mechi	-	346	7,653	7,999	121
Southern Block 1	-	-	103,143	103,143	2,579
Southern Block 2A	-	1,240	75,064	76,304	1,894
Southern Block 2B	-	478	71,403	71,882	1,792
Southern Block 3	-	-	100,567	100,567	1,522
Southern Block 4	-	724	144,902	145,626	2,204
West Rapti	-	3,716	18,626	22,342	517
Grand Total	**29,514**	**117,378**	**747,997**	**894,888**	**17,452**

Table 4-8: Priority list of projects for implementation (Source: IMP 2019)

Priority	Project	To be irrigated (ha)	Water Volume (MCM)	Remarks
1	Tamor Morang Diversion + Tamor 3 HPP	43,743	662	From Tamor River to Morang District
2	Sunkoshi Marin + Kamala + Sunkoshi HPP	132,244	2700	Irrigates southern basin 2B, 3 and Kamala basin
3	Naumure Dam, Rapti Kapilbastu Diversion	10,407	166	Dang Valley and Kapilvastu areas
4	Karnali Diversion	32,996	825	Kailali district area
5	Bheri-Babai Diversion + Nalsyauga dam	2,645	66	Babai and Dodhari IPs
6	Koshi Barrage	18,490	280	From Chatara to Koshi Right offtake
Total		**240,523**	**4700**	

4.3.1.3 Additional Areas for Irrigation Development

There are some additional irrigable areas, on top of the existing, areas considered under priority projects discussed above. Using spatial analyses including source and suitability of areas, the IMP has identified project areas to be taken up immediately as Category 1 and later on as Category 2 and 3 projects. The additional areas identified as Hill and Mountain irrigation areas cover a total of 520,000 ha and the irrigation water demand for these areas is estimated to be 4,700 million cubic meters.

4.3.1.4 Grand total of Irrigation demand

The following Table summarizes the estimated grand total water requirement or demand from existing and proposed irrigation schemes obtained as described above. These values would be dependent upon the choice of crops grown, irrigation methods adopted and cropping pattern adopted, and are preliminary estimates using current water requirements estimated in the Irrigation Master Plan 2019. (DWRI, 2019).

Table 4-9: Summary of total annual irrigation water requirement (MCM)

SN	Description	Area (ha)	Water Requirement (MCM)
1	**Existing**	894,887	17,452
2	**Category 1, 2 and 3**	520,000	7,613
3	**Priority Inter-Basin Diversion**	240,523	4,700
GRAND TOTAL		**1,655,410**	**29,764**

It shows that the current supply for irrigation is about 17,452 million cubic meters, assuming that the irrigation infrastructure was built to offtake adequate water to meet the typical crop-water requirement at the field. Future needs in irrigation, inclusive of the current supply, is about 29,764 million cubic meters. This is an estimate only, and the actual value will depend upon the cropping and irrigation practices actually adopted by the farmers. This, nonetheless, shows that the estimated future demand for irrigation is only 14% of - a lot less than - the total annual average water available of 224,662 million cubic meters. It appears that there is no shortage of water for irrigation if calculated at annual time scale.

4.3.1.5 Comparison between available water and irrigation demand

We have shown that the demand for irrigation, at an annual scale, can be easily met by the total water available in the rivers, but due too extreme seasonal fluctuations, described in Section 4.2.1, there could be a shortfall. Water available in the rivers and the water demand for irrigation was compared in semi-monthly timesteps and is presented for the first three and half months (seven 15-day periods) in Figure 4-7 when the available water appeared low. It shows that the irrigation requirements alone are higher than the total discharge available in the major rivers for the two months of February and March. With addition of other uses and required environmental flows, the deficit will be persistent for even longer periods. It shows that the river flow in major rivers is not able to meet the requirements even if 100% of the flows in the months of February and March are diverted for irrigation leaving the rivers dry.

Another estimate, through SWAT modeling, IMP 2019, stated a similar scenario in terms of shortage of water for the month of March. It computed the annual irrigation water availability, at a reliability of 80^{th} percentile, as 173,000 million cubic meters and concluded that it could irrigate, at an annual crop water requirement of 25,000 m^3/ha, an area of 6.9 million hectares, a lot more than the total available irrigable area of about 1.48 Million hectares in Nepal. However, since the flows are much less in dry season, the March flows were stated to sustain only an area of 750,000 hectares, about a third of the irrigable land in Nepal stated in Table 4-6. For other months, the available runoff exceeds the total irrigation requirements, though the actual requirements of environmental flows in the rivers and calculation of other water requirements will affect the surplus water status.

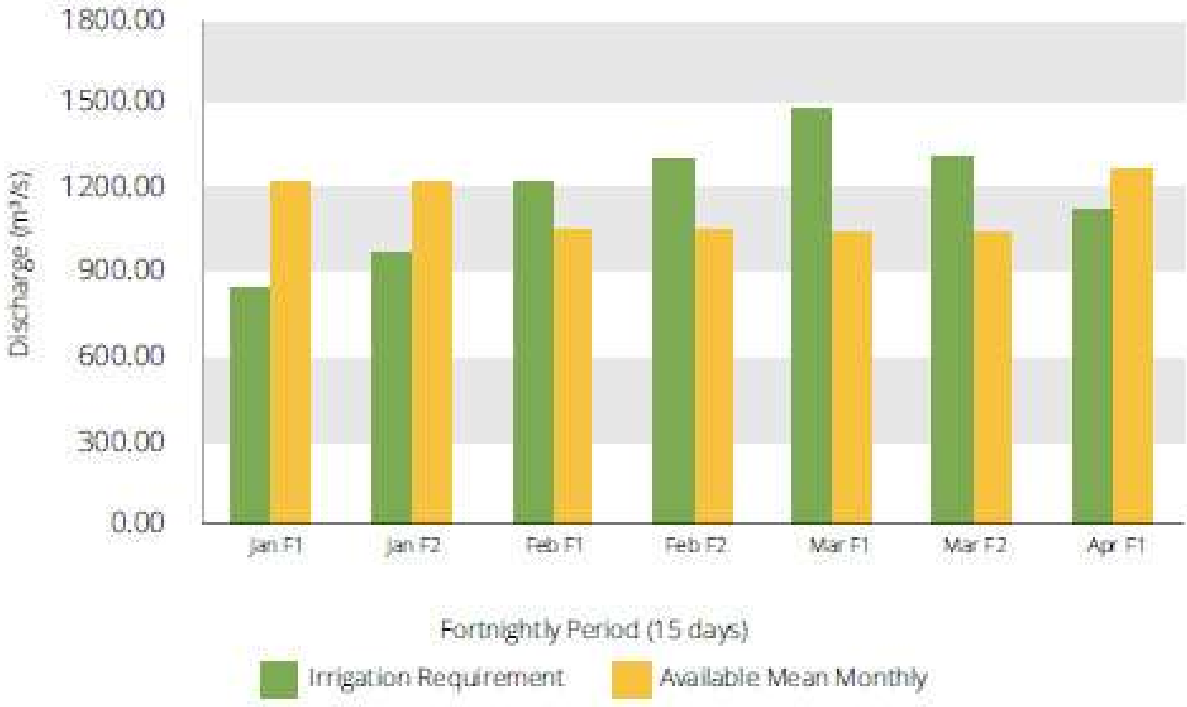

Figure 4-7: Comparison of available runoff in major rivers and total irrigation demand for the dry periods

4.3.2 Hydropower Demand

The hydropower sector in Nepal has been developing rather slow, despite being with one of the oldest hydropower stations in the region. Hydropower potential of Nepalese rivers are high. Since the 1960s, numerous documents have stated that the theoretical hydropower potential is 83,290 MW, whereas the economic potential is often cited as 42,133 MW (WECS, 2013), as summarized in Table 4-12.

The nation has primarily run-of-the-river hydropower schemes and only one reservoir (storage) hydropower scheme, the Kulekhani Hydropower Project with an installed capacity of 60 MW. Subsequent phases (II and III) of the project have added 32 and 14 MW respectively, utilizing tailwater and diverting water to downstream Rapti River basin, belonging to the Gandaki basin. The reservoir and dam are in Bagmati River basin.

Some power projects are peaking run-of-the-river schemes, storing water in the river for some time during the day and operating the plants for a shorter duration with a higher discharge and thus capacity to match with the demand curve.

Table 4-10: Theoretical and economic hydropower potentials of Nepal (source: WECS, 2013).

River Basin	Theoretical Potential (MW)			Economic Potential (MW)	
	Rivers with Basin Area >1000 km^2	Rivers with Basin Area 300-1000 km^2	Total (MW)	Number of Sites	Economic Potential Capacity (MW)
Koshi	18,750	3,600	22,350	40	10,860
Gandaki	17,950	2,700	20,650	12	5,270
Karnali and Mahakali	32,680	3,500	36,180	7	24,000
				5	1,125
Southern Rivers	3,070	1,040	4,110	2	878
Total Nepal	72,450	10,840	83,290	66	42,133

The Nepal Electricity Authority (NEA) is the main authority involved in power generation, evacuation, distribution, operation and maintenance including collecting of bills and revenue generation. The independent power producers (IPPs) have also been engaged in power generation activity and contribute significantly to the power capacity of the nation, though it is the NEA that carries out a power purchase agreement (PPA) and owns the national transmission and distribution system. The total grid capacity is 1,328 MW (NEA, 2020), including diesel and solar plants (54.76 MW). Some 4.5 MW of capacity is in isolated systems (NEA, 2020). The IPPs produce 696 MW, while NEA produces 582 MW.

There are 8 projects under construction by NEA (or through its subsidiaries) for an installed capacity of 943.10 MW, all of these are either run of the river (ROR) or peaking run of the river (PROR) projects. A further 9 projects are in the planning stage with NEA with a total installed capacity of 3,219. 20 MW and four of these are storage schemes.

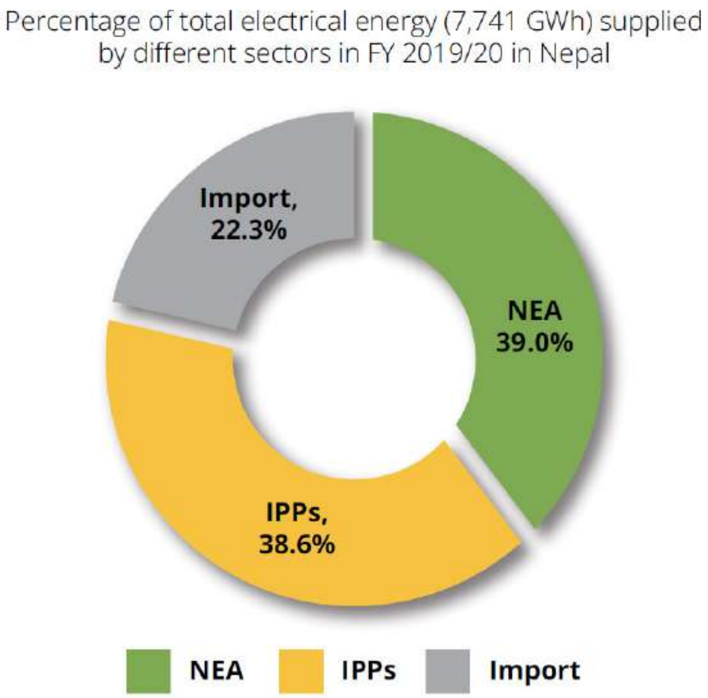

Figure 4-11: Supply breakdown (%) of the electricity for FY 2019/20 (Source: NEA, 2020).

It is interesting to note that, despite the large potential for development (Table 4-12), Nepal is still dependent upon India, which amounted to more than 22% (1729 GWh) in the Fiscal Year 2019/20. The electricity usage per capita is also one of the lowest in the world with about 225 kWh, though the government is trying to increase these figures. This is a very low consumption signifying low production.

These renewable clean energy sources should be expanded to replace the fossil fuels and energy imports from India that use coal-fired plants. The increased adoption of electrical energy in Nepal, in the household as well as in the industrial and transport sectors can help Nepal meet its NDCs and strive for a better environment and climate.

The general assumptions of the ROR or PROR schemes being friendlier to the river ecosystem and the downstream users have often not been the case in Nepal despite the policy recommendation stating that "Provision shall be made to release such quantum of water which is higher of either at least ten per cent of the minimum monthly average discharge of the river/stream or the minimum required quantum as identified in the environmental impact assessment study report" (Hydropower Development Policy 2001). It has been observed that the river health has been seriously impacted in most of the hydropower schemes such as in Modi Khola in the Gandaki River Basin (Jalsrot Vikas Sanstha, 2016). The impact of climate change will further affect the situation, if there are sustained lower flows in the river and the power producers divert more water not to lower their income generation.

The government had also completed the feasibility study of the Budhigandaki Hydropower Project with a gross storage capacity of 4,467 Mm^3, and a surface area of 63 km^2 at full supply evel. The scheme is a seasonal storage type, storing monsoon excess flows and releasing stored water during the lean flow season augmenting the normally low flow volumes. The rated discharge is 672 m^3/s and the storage scheme is to be operated for peak loads.

Similarly, the Dudhkoshi Storage scheme identified as a national priority project is a storage scheme with a dam height of 220 m and a generating capacity of 635 MW. The storage capacity is estimated to be 1,581 MCM. Its tail race, through a 13.3 km tunnel, will release water in Sunkoshi river downstream of the proposed Kamla diversion. This may be in conflict with the Sunkoshi-Kamala diversion as the storage project may render the diversion impossible.

4.3.2.1 Private Sector Participation

The IPPs have planned another 131 hydropower projects with a capacity of 3,157 MW under construction having completed financial closures to fund the projects. There are other 112 projects licensed at various stages, awaiting financial closure for development, with an aggregate installed capacity of 2,125 MW.

Apart from the above, the government has also utilized the offices of the Investment Board of Nepal (IBN) to streamline large projects in Nepal through a single door policy. The current projects in the hydropower sector taken up by IBN are Arun 3 HEP (PROR, 900 MW and 3466 GWh/ Yr) and the Upper Karnali Hydropower Project (PROR, 900 MW, 3466 GWh/Yr.

These hydropower development scenarios suggest that the hydropower development has evolved from a purely governmental niche and it requires the public-private involvement with heavy involvement of the banking and insurance sectors. Private sector involvement often prioritizes tangible benefits and direct profit accrual that is associated with hydropower development vis-a-vis irrigation. It also necessitates the requirement of a broad participatory approach in determining development portfolios and options for implementation considering trade-offs and building synergies.

It must be brought to notice that inter-basin diversions and storage schemes bring water conflicts to the fore, especially of that between upstream versus downstream. Upstream inundation, downstream dewatering and flood protection as well as benefit and cost sharing are some of the issues that need to be reconciled along with sentimental values attached to water. The current water governance policy landscape in the three-tiered federal governance structure requires much to be desired.

4.3.3 Drinking water

Drinking water supply is the most important requirement and the number one priority in water allocation or development as per the Water Resources Act 1992. The per capita drinking water requirement adopted in Nepal varies in rural and urban settings. It is set as follows:

1. For rural: 45- 65 liters per capita per day (lpcd)
2. For small town (municipalities): 66 – 90 lpcd
3. For urban (metropolitan cities): 91-160 lpcd

The water requirement increases with access to water and income generation. Assuming an intermediate value of 60 lpcd and 120 lpcd for rural areas and urban centers respectively, and multiplying these values with the respective population estimates, the current total drinking water requirement is estimated to be about 1,062 million cubic meters[3]. This is shown in Table 4-11 below.

Table 4-11: Estimation of existing drinking water requirement

Population settlement category	Population (CBS, 2021)	Requirement lpcd	Requirement lit/day	Requirement MCM
Urban Population	19,291,031	120	2,314,923,720	845
Rural	9,901,449	60	594,086,940	217
Total	29,192,480		2,909,010,660	1062

This value can be expected to be increasing in the future as the service levels as well as the income levels increase. The population in 2050 is estimated to be 37.5 million, according to the population statistics website https://www.populationpyramid.net/, about 95% increase from 2021. It can be estimated, therefore that the drinking water requirement will peak and almost double in 2050. The future demand will be then expected to be 2,000 million cubic meters for the year 2050 .

Industrial demand, currently is a small demand, compared to the drinking water demand. Lacking any specific details on the industrial water usage, it is estimated as 20% of the drinking water demand. The future demand can be taken to be similarly, 20% of the drinking water demands, and can be stated to be 400 million cubic meters in 2050.

Total household and industrial demands are estimated to be 1,262 MCM and expected to be increased to 2,400 MCM in 2050.

4.3.4 Environmental Flow requirements

The environmental flow (e-flow) requirement as required by the established policy is that provision shall be made to release such quantum of water which is higher of either at least ten per cent of the minimum monthly average discharge of the river/stream or the minimum required quantum as identified in the environmental impact assessment study report" (Hydropower Development Policy 2001). This provision has been further challenged by many in ascertaining the e-flow requirements to exceed the above recommendation to maintain the river bio-systems active as it is said that it does not fulfill habitat requirements for key target species of the riverine biosphere as well as river morphology.

[3] Disaggregated data for the cities and rural municipalities for each river basin was not available so the latest national census report of 2023 used for the national level information.

4.3.5 Other Uses

Water is an integral part of society and has other societal, religious and recreational uses also. Information related to these aspects is being sought, collected, and reviewed. This information is related to religious sites and requirements of minimum flow in the river, and the frequency of important religious days in such sites. Typically, river junctions or some stretches are considered holy and sacred with people performing their last cremation rites. This requires a certain flow to be present to enable bathing and water carrying away remnants of the funeral pyres.

There are recreational demands in lakes, ponds and rivers such as boating, sport fishing and swimming, etc. The primary commercial and recreational use in Nepal is white water rafting and canoeing. The rivers need a certain amount of flow and depth to enable rafting. Tourism industry also flourishes in /near lakes and water bodies. Communities along the river resort to fishing to supplement their income as well as their own protein sources.

Table 4-14: River Stretches with Rafting

SN	River Name	VDC	Start Northing	End Easting	Start Northing	End Easting
1	Arun	Khandbari	27.312772°	87.191853°	26.842638°	87.147042°
2	Bheri River	Devisthal	28.514691°	82.024985°	28.638289°	81.280474°
3	Bhotekoshi	Dhuyang	27.868732°	85.880829°	27.645857°	85.716617°
4	Kali Gandaki	Shivalaya	28.222468°	83.685082°	28.048521°	83.559659°
5	Karnali	Pokharikanda	28.749024°	81.546174°	28.634591°	81.277385°
6	Marshyangdi	Khudi	28.303386°	84.390854°	27.873153°	84.579724°
7	Seti	Byas	27.969178°	84.267948°	27.796804°	84.432871°
8	Sunkoshi	Dolal Ghat	27.641002°	85.705449°	26.843872°	87.147934°
9	Tamur	Khamlung	27.364554°	87.622801°	26.839484°	87.144603°
10	Trishuli	Beni Ghat	27.812903°	84.770253°	27.796719	84.433024

It should be noted that large scale development of irrigation and hydropower is concomitant with broader socio-economic and environmental issues involving construction of dams, reservoirs and often diversion of water from one basin to another. Suitable policies and safeguards need to be enforced to ensure good practices are adopted and it is expected that the IWRM approaches would help implement that process.

4.3.6 Summary of water uses and demand

The total current user and future, till 2050, demand for water including the irrigation, drinking water and industrial usages adds up to irrigation demand is 18,714 million cubic meters and 32,164 million cubic meters respectively. The existing irrigation demand is a mere 7.7% of the total average annual water runoff.

The existing irrigation use of 17,452 MCM is 93.3 % of the total demand. The drinking water requirement is 5.7% while industrial usage is a mere 1%. This does not include the e-flow requirements and the required depth and velocity of flow for rafting, navigation and religious or cultural uses, etc. As has been described in Section 4.3.1, the available water resources during the dry periods of March – April is not adequate to meet irrigation demands. This suggests that the nation needs to be identify suitable water harvesting or storage projects to meet the seasonal demands.

These multiple uses, priorities and the aspirations of the people as stated in the Constitution, policies and regulations all require a concerted integrated effort based on equity, efficiency and sustainability. These underpin the requirement of adopting a IWRM approach in Nepal.

5. RIVER BASINS - OPPORTUNITIES, ISSUES AND CONSTRAINTS

The river basins in Nepal are unique and possess characteristics that define the climate, temperature, water availability, volume of rainfall and discharge, as well as other socio-economic parameters. These basins demand proper water resource management approaches to maximize opportunities, minimize issues by suitably addressing the constraints. These also demonstrate that water resource management is not purely an engineering solution but rather a complex multidimensional problem requiring the attention of the society as a whole. These ideas provide entry points for the need of IWRM approach in Nepal where opportunities need to be capitalized, while the constraints are to be overcome managing the issues that arise.

5.1 Opportunities

The goal of developing water resources is primarily to build livelihoods, develop resilience, and enhance socio-economic conditions of the society as well as protecting riverine eco-systems. The primary opportunities that exist in river basins of Nepal to achieve the stated goals are the following:

- The nation is well-endowed in water resources on average on an annual basis.
- Water is available for irrigation of fertile lands to enhance crop productivity and food security.
- Hydropower generation is possible and essential in enhancing energy security, clean energy to provide impetus for economic development as well as exporting energy in the region.
- Aquaculture and maintaining traditional fishing livelihoods
- Freshwater for domestic and municipal uses
- River navigation at larger rivers and lower reaches with connectivity to the seas
- Preserving bio-diversity and the environment.
- Recreation suitability like rafting and water sports
- Enhancement of cultural and religious tourism activities
- Tourism, trekking, mountaineering
- Potential storage and reservoir sites for multipurpose uses including flood protection, water security, water supply and low flow augmentation.
- Long term benefits and returns, direct and indirect, in investments by hydropower development and irrigation development projects

5.2 Issues

Water resources development has a multiple dimension and has repercussions on the country's socio-economic, political, physical as well as international sectors. The common issues in water resources sector are:

- Extremely varying resource with problems of "too much and too little" water occurring in the same basin as well as across basins
- Low development till date in the water sector suggesting limited capability and raising questions on implementation capabilities.
- Low investment capital within the country with limited market absorbing capacity.
- Challenging investment environment with complex regulations and control.
- Floods, erosion and sedimentation during monsoon seasons.

- Possibility of glacial lake outburst floods (GLOF) and landslide block induced floods in upper reaches.
- Climate change impacts of increasing extreme events and associated complexities and uncertainties
- Complex geology and terrain often limiting access.
- Data availability and reliability preventing proper assessments of opportunities.
- Submergence of built infrastructure, agricultural and settlement areas by proposed large storage projects such that raised by indigenous people and their concerns of their native land.
- Differential impacts of development projects on gender and marginalized communities.
- Rehabilitation and resettlement issues with potential displaced populations.
- Water scarcity at some basins and locations during dry periods.
- Inter-basin water diversion and related issues such as water ownership, prior rights and usages.
- High seismic risks due to earthquake prone zone
- Long time required in project planning, development and accrual of benefits
- Capital intensive projects.
- Market guarantee for produced energy.
- Power evacuation problem due to limitations of transmission lines and right of way.
- Multidimensional problems often posing complex problems including sentiments, equity and diversity issues
- Water sector ownership, responsibility and liability issues among the three tiers of government
- Biodiversity preservation, forest and conservation areas
- Bilateral agreements with neighboring countries, their provisions and downstream water uses.
- Inundation caused by construction of hydraulic structures, flood protection embankments and road/rail embankments in the Indian side and submergence in Nepal.
- Skilled resources required in project design, financing and optimizing as well as negotiations and promoting public understanding.

5.3 Constraints

There are a number of constraints imposed by the physical nature of water resources, existing environment as well as that driven by public expectation, social welfare and environmental justice requirements.

- Maintaining balance between conflicting water uses, traditional practices and environmental flows
- Downstream water uses including within the basin as well across the border with riparian countries
- High cost of development of water resources projects with long gestation periods and time to realize benefits.
- Attachments and sentiments to ancestral practices, monuments and properties.
- Local indigenous peoples' objection for construction of high dams.
- High cost of compensation for the affected community and high expectations or demands to the developers or government by the local communities.

- Flooding and change of river course in the Terai, risk of embankment breaches.
- Benefit and cost sharing within the local communities, three-tiered governance system as well as the riparian countries.

Large scale developments of irrigation and hydropower are concomitant with broader socio-economic and environmental issues involving construction of dams, reservoirs and often diversion of water from one basin to another. It should be noted that the above listed opportunities, issues and constraints suggest the scale of water resource management problem and tools required to address it in a manner that is technically possible, economically viable, and socially acceptable to the society. Suitable policies and safeguards need to be enforced to ensure good practices are adopted and it is expected that the suitable water resource management approaches would help implement that process.

All river basins are unique and possess their characteristics that define the climate, temperature, water availability, volume of rainfall and discharge, as well as location specific parameters. The common issues are on floods, inundation, inter-basin transfers and rehabilitation and resettlement, while the opportunities include irrigation development, hydropower generation, tourism, recreation and well-preserved watersheds.

An IWRM approach, though appearing painstaking at the up front, would be the best approach to address the issues and constraints identified above, through a consultative process and help optimize the benefits.

5.4 Opportunity for IWRM in Addressing Basin Issues

IWRM provides a good platform and a framework for addressing issues in any river basin. Applying the principles of equity, efficiency and sustainability a coordinated approach can be provided by IWRM in addressing problem areas and maximizing opportunities.

IWRM implementation in Nepal offers the opportunity to improve efficient use of water resources, promoting equity in distribution or beneficial use of water resources. The problems related to deterioration of river water quality affecting the environment and the human health; conflicts of water use between different users, impacts on bio-diversity and ecosystem as well as decreased water availability in irrigated infrastructures are all important aspects that can be resolved and improved with IWRM approaches.

Section 2.4 list IWRM success stories from around the world and each one of those examples provide different stories how water scarcity, quality and sharing issues have been worked out amicably ensuring the sustainability of the resource.

Failure to implement IWRM in Nepal could result in significant environmental, social, and economic consequences and lost opportunities for growth. IWRM provides an impetus to come together and seek solutions that will also create other societal opportunities for the benefit of all in the community.

6. POLICIES AND LEGAL INSTRUMENTS RELATED TO IWRM IN NEPAL

6.1 National Water Policies / Guidelines / Acts / Laws

The constitution of any country is the major source of all policies, strategies and legal frameworks that defines how the country is to be governed. Communal activities in the water resources sector have gradually eroded and as the formal government activities emerged in the sector. Nowadays, development of the water resources projects is primarily a government activity. Hydropower is open to private investments. Some of the policies, e.g., the Water Resources Policy 2020 specifically propose IWRM while others are mostly in tune with the IWRM requirements.

6.1.1 Constitution of Nepal 2015

Nepal's new Constitution, adopted in 2015 ushers in the federal structure of the polity with three tiers of governance – federal, province and the local municipalities. It defines the functions, in terms of water and related areas of natural environment, that every citizen has the right to a clean and healthy environment - Article 30(1), and the right of access to clean drinking water and sanitation - Article 35 (4). It also decrees that the State policy shall, among other matters, be the following related to water.

- To carryout multi-purpose development of water resources, while according priority to domestic investment based on public participation.
- To ensure that reliable supply of energy is affordable and available with ease, and to make good use of energy, for the fulfilment of the basic needs of citizens, by generating and developing renewable energy.
- To develop sustainable and reliable irrigation, controlling water-induced disasters, and adopting good river management (Article 51).

The above points show that the Constitution does indeed support the basic principles underlying the foundation of IWRM – participation, equity, efficiency and sustainability. IWRM can be adopted as a suitable approach to address the path directed by the Constitution. The provisions or articles of the Constitution, need to be elaborated and supported by necessary Acts, regulations and policies to achieve the desired targets. For example, Schedules 5 to 9 of the Constitution delineate the exclusive and concurrent responsibilities and authorities of three levels of governments, but how to manage the concurrent or joint responsibilities has been a confusing aspect and is seen to undermine the principles of devolution as all look up to the federal offices for support and guidance.

6.1.2 Water Resources Strategy 2002

The Nepal government, had earlier in 2002, formulated a National Water Resources Strategy whose goal was defined as "living conditions of Nepali people are significantly improved in a sustainable manner."

The policy principles that drove the strategy formulation included adoption of IWRM principles based on conservation of resource and protection of the environment understanding that the river basin should be managed holistically. It further stressed the belief in decentralized, autonomous and accountable agencies underpinned on the ideas of economic efficiency as well as social equity. The process of building the strategy was also consultative. It identified strategic directions and set the background for the National Water Plan 2005.

Even in 1996, when the Phase 1 of the Water Resources Strategy Formulation project began, extensive consultations across various disciplines and sectors in the society were carried out to make it participative introducing concepts of sustainability, social equity and gender mainstreaming as well as economic efficiency; these happen to be the three principles of IWRM. The strategy laid ten outputs under three categories of security, uses and mechanisms. The points under the mechanism category of the Strategy are of special relevance to IWRM with their striking resemblance to the

3-pillars of IWRM discussed in Sub-Section 2.3.2 on governance structure and process. These points are:

1. Enhanced water-related information systems are made functional.
2. Appropriate legal frameworks are made functional
3. Regional cooperation for substantial mutual benefits is achieved.
4. Appropriate institutional mechanisms for water sector management are made functional.

6.1.3 National Water Plan 2005

The National Water Plan 2005 (WECS, 2005) built upon the broad objectives of the strategy and adopted the overall national goals of economic development, poverty alleviation, food security, public health and safety, decent standards of living for the people and protection of the natural environment. These are all in principle, the same targets of the IWRM.

Furthermore, the water plan had identified enabling areas of improvement - legal and institutional frameworks and these could not be implemented and thus have rendered the national plan incomplete. Furthermore, the challenging political scenario with the upheavals that followed, pushed the focus away from water into general governance, repeated elections and the formation of the new constitution.

One important positive thing that has happened is that the Plan did set off a series of motion to revamp the legal and institutional aspects of water and also put water resources in in the mainstream agenda of the public. It did set the ground for accepting integrated water resources management approaches as the key to water resources management and drafting a new Water Resources Policy and Bill to redefine the government's approach as well as revise the older Water Resources Act 1992.

6.1.4 Water Resources Act 1992

The existing legal framework for water resources management in Nepal is still set out in the Water Resources Act, 2049 (1992) as completed by the Water Resources Rules, 2050 (1993). Article 7 of the Act defines the priority order of utilization of water resources as follows:

1. Drinking water and domestic users
2. Irrigation
3. Agricultural uses such as animal husbandry and fisheries
4. Hydroelectricity
5. Cottage Industry, industrial enterprises and mining uses
6. Navigation
7. Recreational uses
8. Other uses.

This is the umbrella Act governing water resource development and management in Nepal which vests ownership of water in the State. It establishes a system of licensing for water usage, provides a mechanism for formation of water users' associations and prohibits water pollution by the government prescribing tolerance limits.

This current Act has become outdated and is currently in need of reform. In particular, it does not provide a sufficient basis for the implementation of IWRM in that inter alia it makes no provision for river basin management planning or of institutions or the setting of minimum/ environmental flows. Moreover, experience clearly shows that attempting to address water pollution on the basis of standards alone, in other words without making provision for site specific wastewater discharge licenses, is in practice inadequate and unworkable. There is no clear modality set for regulation, monitoring and ownership of the river as such.

The Act, does not provide for customary rights of fishermen who are traditional fishermen and their livelihoods are dependent upon fishing, instead it makes them illegal if they do not have licenses. Also, there is a provision permitting the licensee to sell the license. This may promote the risk of license brokering rather than advancing the beneficial use of water resources. The regulatory framework should therefore be amended in order to discourage license brokering.

A key reason why the Water Resources Act needs to be substantially reformed is primarily due to its pre-existing nature, which renders it inadequate in addressing the provisions set forth in the new constitution. Since the Act was established before the enactment of the current constitution, it fails to consider the updated legal framework and the evolving needs and priorities of the country. As a result, various aspects of water resource management, allocation, and governance outlined in the new constitution are not adequately addressed by the existing Act. Therefore, comprehensive reforms are essential to align the Act with the constitutional requirements and ensure effective and sustainable management of water resources in Nepal.

6.1.5 Water Resources Bill 2020

The government has tabled a revised Water Resources Bill 2020, to repeal and replace the existing Act. The Bill has been prepared by WECS, and has been sent to the MoEWRI, as the Minister is the only one who can table that as a proposal at the "Cabinet," the Council of Ministers, which needs to approve it before it can go the Parliament.

A primary issue that has been contentious in the Bill is the authority, responsibility and liability regarding the ownership of the water resources. The bill says, like the previous Water Resources Act that the ownership lies with the State (the nation). The constitution says that there will be ownership with the Federal, Provinces and the local levels for the water bodies as specified. So, the delineation of the ownership and authority needs to be ascertained better so that there will be no confusion later on.

Nonetheless, it was seen that this Bill is important in terms of the acceptance and adoption of the IWRM approach in development and formation of river basin offices as well as adhering to the principles of IWRM and states the strengthening of the Water Energy Secretariat and having these basin offices as their field offices.

Questions may be raised on why the office that basically prepared the Bill is proposing to increase its own sphere of influence and authority as the Bill proposes to establish basin offices under WECS to monitor, regulate and sanction use of water.

Efforts to find out about the exact status (as of Dec 2021) of this "Bill" revealed that it has not yet been approved by the MoEWRI for submission to the Cabinet and had been commented upon the draft critically by the Ministry of Law and Parliamentary Affairs as well as the Ministry of Finance. It has been reported recently, March 2020, that the MoEWRI and WECS are reworking paragraph by paragraph on the Bill and get it approved as a priority.

6.1.6 Water Resources Policy 2020

The government of Nepal recently, Dec 2020, released the new Water Resources Policy, which has adopted the principles of IWRM and the river basin organizations to advance the management of water resources. The goal of this new policy is "to sustainably conserve, manage and to carry out multipurpose development of the available water resources contributing to the economic prosperity and social transformation of the country."

There are 7 objectives targeted by the policy. These include the following:

1. To judiciously use water resources to fulfill multisectoral demands with ease
2. Contribute to enhanced productivity of the nation
3. To make science and fact-based decisions

4. Ensure a coordinated effort amongst the State, provinces and local levels
5. Fulfill citizen demands of water and water related products
6. To develop the water resources with minimal negative impact to the environment
7. Reduce water induced disasters and related risks reduction.

The policy has further specified 11 working strategies to achieve these targets and the goal. Each strategy is further described by action plans. The strategies are briefly stated a (unofficial translations):

1. Water resources utilization and management shall be done on the basis of a river basin master plan.
2. IWRM and multipurpose uses shall be given priority in developing and managing water resources
3. Suitable institutions shall be developed for conservation, development, management and regulation of water resources.
4. The participation of related stakeholders and the private sector shall be encouraged and increased for the conservation and development of water resources.
5. Study and research in the water sector shall be increased with assimilation of knowledge and data, analysis and uses of them.
6. Institutions and human resources in the sector shall be further developed.
7. The roles and responsibilities of the federation, provinces and the local municipalities shall be clearly laid out for coordinated effort in water resources development
8. The water resource project affected areas and people shall be cared for and protected
9. The basic necessities of the people of the project area in terms of energy, drinking water and irrigation benefits shall be awarded with ease and accessible to them on the principles of equity.
10. The water resources shall be developed by minimizing the negative impacts on society, culture and the environment.
11. Watershed or basin management shall be made effective with control and reduction of water induced disasters and risk reduction.

Therefore, the new water resource policy of Nepal seems adequately incorporating IWRM principles and adopting the basin as a unit of water administration. It is said that, action plans describing the strategic plans, water accounting, allocation as well as auditing shall be done with the adoption of river basin plans. It describes a science and fact-based approach in planning and management.

There still remains, a difficulty, as it has not spelled out in clarity the roles and responsibilities of all the tiers of the government – federal, provincial and local – that may pose problems and raise concerns.

6.1.7 Irrigation Policy 2013

The Government of Nepal's strategy for irrigation development and management is builds upon the Water Resources Strategy (2002), National Water Plan (2005), Irrigation Development Vision and Action Plan (2006), and recently, the Irrigation Policy (2013). The main vision described in these documents is to integrate agriculture and irrigation development in order to realize the full benefits from investment in irrigation and provide sustainable services to the agriculture sector through well-operating irrigation facilities, based on local resources mobilization through a partnership of the users and the government.

The objective of the Irrigation Policy is for the fulfillment of the following:

- To provide round the year irrigation facility to the irrigation suitable land by effective utilization of the current water resources of the country.

- To develop institutional capability of Water Users for sustainable management of existing system.
- To enhance the knowledge, skill and institutional working capability of technical human resources, water users and non-governmental association/organization relating to development of irrigation sector

This irrigation policy predates the new Constitution and should be revised to incorporate the essence and the direction dictated by the Constitution. It has been reported recently that the Irrigation Policy 2013 has been replaced with a new Irrigation Policy 2023 which is not yet made public.

The new policy, builds upon the previous policy and incorporates aspects of the three-tiered federal government system in seeking a regionally balanced irrigation growth making the best use of the water resources available for increasing the productivity of land as well as the total production. The policy is also said to be a significant one in terms of paving the way for private sector involvement in irrigation development and management, establishment of an Irrigation Development Board as well as to discourage conversion of agricultural land of under irrigation command areas and preserve land for agriculture production.

The policy also follows the IWRM principles, seeking to fully utilize available water resources to develop the irrigation sector, increase irrigation coverage by developing new infrastructures, maintaining older one and modernizing irrigation systems. The policy is further stated to stress on service delivery, recovery of irrigation service fees, greater attention to be gender inclusive and promote access to all sections of the society. It is said to direct to adopt climate resilient and climate adaptive irrigation systems, prioritize multipurpose, storage and inter-basin transfer projects and promote conjunctive uses of groundwater and new-technologies in the irrigation sector.

6.1.8 National Climate Change Policy 2019

The National Climate Change Policy supersedes the old Climate Change policy of 2011. The policy, in terms of water resources and energy states that energy security will be ensured by promoting multiple use of water resources and production of low carbon energy. The policy strongly upholds the principles and values of IWRM.

The policy says that the following strategies and working policies shall be included:

- Technologies for storage, multiple use and efficient use of water will be developed and promoted in risk-prone areas and settlements considering the effects of climate change on availability of, and access to, water.
- Rainwater harvesting ponds will be constructed for groundwater recharge and their multiple use.
- Standards will be developed and implemented for sustainable use of groundwater resources in urban areas.
- Production and use of renewable energy and use of energy efficient technologies will be encouraged.
- Selection of environment friendly sites will be made and climate friendly technologies will be used while constructing infrastructures including that of hydroelectricity, drinking water and irrigation.
- Measures to mitigate adverse impacts on river ecosystems will be adopted while generating hydroelectricity.
- Safe outlet will be managed by decreasing the water level for reduction of glacial lake outburst risks.
- Dissemination of information relating to weather will be systematized by expanding weather stations in various geographical regions and their capacity will be enhanced.

In relation to irrigation, it states that Water efficient irrigation technology will be promoted and selection of environment friendly sites will be in project designs as well as adoption of climate friendly technologies will done while constructing infrastructures including that for hydroelectricity, drinking water and irrigation.

6.1.9 Irrigation Master Plan 2019

The Department of Water Resources and Irrigation has developed an Irrigation Masterplan, following on the Master Plan of 1990, to develop a long-term strategy to develop the irrigation sector based on available resources and policies as well as to develop and implement an investment program that is consistent with the strategy. This new Master Plan, in the pipeline for approval, has also prioritized research and development areas and includes the following:

- Mainstreaming climate change adaptation in irrigation planning and management, and
- Sustainable storage development in the Greater Himalayan Region.

It is important to note that the Master Plan identifies the possibility of utilizing water storage capacity in the Greater Himalayan region for adaptation to climate change. It may be possible to harness the natural systems in the biosphere through initiatives such as wetland conservation and improved watershed management in the hills and mountains, as well as groundwater aquifer recharge in the foothills. Small ponds and tanks for rainwater harvesting could also be built on hill farms and around hill communities. The construction of large dammed reservoirs on the downstream plains is a further option and has been carefully considered in this Irrigation Master Plan. It also states that the knowledge gap concerning such sustainable water storage structures will have to be addressed through fresh research studies.

6.2 Institutional Structure and Coordination Mechanism for Water Governance

The institutional structure and the coordination mechanism are currently being redefined to some extent after the promulgation of the new constitution and could be divided into four categories (Kumar et al., 2016). These are:

1. Policy/planning and coordinating bodies,
2. Sectoral policy and planning and programming organizations,
3. Regulatory bodies, and
4. Service providers with autonomous nature, including local governance bodies.

6.2.1 Policy Planning and Coordinating bodies

In Nepal there are high level policy and planning bodies, either sectoral specific or overall national level. These are:

1. National Planning Commission (NPC),
2. National Development Council (NDC)
3. Investment Board Nepal (IBN)
4. Environment Protection and Climate Change Management Council (EPCCMC),
5. National Water Resources Development Council (NWRDC),
6. Water and Energy Commission (WEC).

The NPC and the NDC are general national policy formulating and planning bodies, while the IBN is in promoting direct international investments into large projects in Nepal. EPCCMC is an environment and climate related council that will definitely influence water and water related development. These first four organizations are chaired by the Prime Minister. The NWRDC and the WEC are directly related to water and are authorized to carry out policy planning and other related studies. The Water and Energy Commission (WEC) was established by the Government of Nepal in 1975 with the objective of developing the water and energy resources in an integrated and accelerated manner. Consequently, a permanent secretariat of WEC was established in 1981 and was given the name, Water and Energy Commission Secretariat (WECS). The primary responsibility of WECS is to assist the Government of Nepal, different ministries related to water resources and other relating agencies in the formulation of policies and planning of projects in the water resources sector.

Among these institutions, the National Water Resources Development Council (NWRDC) has been relatively inactive and characterized as a top-heavy organization, with a substantial presence of political figures on its council. Rarely does it come to light that the NWRDC convenes or holds meetings. On the other hand, the Water and Energy Commission (WEC) and its secretariat, the Water and Energy Commission Secretariat, are comparatively more active. Led by a government Secretary and supported by other bureaucrats, the WEC engages in various activities. However, it does encounter frequent changes in leadership, which can impact its continuity and effectiveness.

6.2.2 Sectoral policy and planning and programming organizations

There are sector specific ministries, which are specifically designated to carry out activities related to that sector. These offices carry out sectoral policy and planning activities as well program development and implementation. The implementation activities may be done through its subsidiary organizations, usually the departments.

Ministries and Departments

1. Ministry of Agriculture and Livestock Development
2. Ministry of Energy, Water Resources and Irrigation
3. Ministry of Federal Affairs and General Administration
4. Ministry of Forest and Environment
5. Ministry of Water Supply

The activities or the subject purview of the Ministries are self-evident from their names. The Ministry of Land Management, Cooperatives and Poverty Alleviation and the Ministry of Urban Development are also two other ministries that could have some bearing on water resources development and management in terms of setting policies on land use or zoning and municipal outfalls impacting water bodies.

The departments under these ministries that carry out the relevant works throughout the nation are through their field offices and project offices are:

1. Department of Agriculture
2. Department of Electricity Development
3. Department of Water Resources and Irrigation
4. Department of Hydrology and Meteorology
5. Department of Local Infrastructure
6. Department of Forest and Soil Conservation
7. Department of Environment
8. Water Resource Research and Development Centre (WRRDC)
9. Department of Urban Development and Building Construction (DUDBC)
10. Department of Survey

11. Department of Land Management and Archive

Furthermore, all provinces carry out province level development activities and the local bodies (municipalities) also implement their own programs.

Regulatory Bodies

1. Electricity Tariff Fixation Commission (ETFC)
2. Drinking Water Tariff Fixation Commission (DWTFC)

Service Providing Autonomous Bodies and Local Governance Bodies

1. Nepal Electricity Authority (NEA)
2. Ground Water Resource Development Board
3. Municipalities (urban, rural and various metropolises)

6.2.3 Provincial Level Institutions

The new constitution's federal set up has provided for 7 Provinces . The provinces from east to west are: Koshi Province (renamed from Province 1), Madhesh Pradesh (previously Province 2), Bagmati Province (previously called Province 3), Gandaki Province (previously called Province 4), Lumbini Province (previously called Province 5), Karnali Province (previously called Province 6) and Sudurpaschim Province (previously called Province 7).

The Provinces have their own unicameral provincial assembly (Pradesh Sabha) which elects the executive Chief Minister of the province. The following institutional structures are listed below.

1. Office of the Chief Minister and Council of Ministers
2. Provincial Policy and Planning Commission
3. Ministry of Economic Affairs and Planning (MOEAP)
4. Ministry of Internal Affairs and Law (MOIAL)
5. Ministry of Industry, Tourism, Forestry and Environment Committee (MOITFE)
6. Ministry of Land Management, Agriculture and Cooperatives (MOLMAC)
7. Ministry of Physical Infrastructure Development (MOPID)
8. Ministry of Social Development (MOSD)

Review of the institutional system at the provincial level shows that the water sector activities are executed by Ministry of Physical Infrastructure Development (MOPID)[4], while the overall multisectoral planning would be done by the Provincial Policy and Planning Commission. Climate Change Division is located within the Provincial Ministry of Industry, Tourism, Forest and Environment while agriculture is looked over by another branch - Ministry of Land Management, Agriculture and Cooperatives (MOLMAC). It must be noted that these institutional frameworks are currently under flux due to re-organization of the provincial governments and bifurcation of certain ministries. It was further noted that the capacities of these province level offices are rather limited in terms of personnel and expertise to understand complex issues of climate change adaptation and resilience building, apply newer and innovative approaches in seeking solutions, and lack information to plan ahead. For example, the provincial offices do not have the necessary personnel and the capacity to plan, manage and execute hydropower projects despite of it being within its purview and declared tasks. The case deteriorates further at the local governance units of municipal levels.

[4] Since the first draft of this report, the provincial structures have evolved differently at different provinces. For example, in Koshi Province (previously called just Province 1) established Ministry of Water Supply, Irrigation and Energy and the Madhesh Pradesh (Province 2) created Ministry of Energy, Irrigation and Water Supply.

Our observations at the provincial level and the consultations with government officials revealed that these institutions need to be strengthened in planning, implementing and monitoring of projects along with attracting capital in the water sector. Specific strategies to address seasonal and spatial shortages, build climate adaptation and resilience are required. Water harvesting, inter- basin transfers, water use efficiencies and reuse, and groundwater development can be adopted for the sustainable development of water sector in Nepal. Essential capacities for analyses, negotiations and dialogue required for international or bilateral cooperation also need to be developed.

6.2.4 International Players in IWRM

It should be noted that the principal motivators and actors in getting IWRM adopted in Nepal has been the international community through their multilateral agencies and special programs. The Global Water Partnership, the World Bank and Asian Development Bank, in particular, have been the flag bearers of the IWRM program in Nepal, accompanied at times by the UN organizations, WWF, USAID, AusAID and Canadian development aid organizations.

The World Bank has always pursued IWRM as a policy and process for a better management of water resources and help in sustainability of water projects. It has furthered the IWRM aspect as an adaptive tool for climate change adaptation and building resilience (Hirji, Nicol and Davis, 2017). The WB group points out, in their Country Partnership Framework (World Bank Group, 2018, p 18) for FY 2019-2023, that multiple government agencies are involved in developing and managing natural resources and this needs closer coordination. It cites that despite adopting a policy of integrated water resources management, its implementation has been hampered by the need to coordinate across multiple agencies, which may be further made more complex with federalism. The WB intends to continue with the policy dialogue by providing Advisory Services and Analytics on land governance, environment sector diagnosis, and a forest engagement note. The WB is said to be establishing a Water Sector Strategic Platform to coordinate and bring together the range of initiatives to improve water resources management, which is critical given the competing demands in water use.

ADB promotes IWRM to facilitate sustainable development of hydropower, irrigation, water supply, and wastewater treatment. ADB's Country Partnership Strategy (2020-2024) (ADB, 2019) has adopted, under its country partnership strategy framework, Strategic Objective no.3. Environmental Sustainability and Resilience that ADB will promote the establishment and operationalization of river basin management systems. ADB will help mainstream climate change and disaster risk reduction, along with environmental sustainability, in development activities with support to (ADB, 2019, p 12)

i. build green, resilient infrastructure such as flood-resistant roads in the Terai and all-weather roads in the hills;
ii. implement integrated water resources management;
iii. manage surface and groundwater resources, particularly in the agriculture sector; and
iv. enhance knowledge and capacity for management of the environment, climate change adaptation, and disaster risks.

These activities, coupled with ADB's assistance for renewable energy and energy efficiency, agriculture practices that are resilient to climate change, and sustainable transport and urban services, will help Nepal implement its intended nationally determined contributions.

The WB and other benefactors have through the Global Water Partnership, which has partnered with Jalsrot Vikas Sanstha (JVS), are actively involved fostering dialogue and interventions to promote IWRM.

6.2.5 Water sector stakeholder map

The above listing of the government institutions and bodies as well as the various boards and commissions represent the larger group of stakeholders from the government sector. Of these the primary stakeholders whose area are directly and actively related to policy, planning and implementation of water sector activities are:

1. Ministry of Energy, Water Resources and Irrigation
2. Water and Energy Commission Secretariat
3. Department of Water Resources and Irrigation
4. Department of Hydrology and Meteorology
5. Department of Electricity Development
6. Water Resources Research and Development Center

Other additional government stakeholders that would be key players in the integrated water resource management are:

1. Ministry of Forest and Environment
2. Ministry of Water Supply
3. Ministry of Federal Affairs and General Administration
4. Ministry of Finance

These ministries through their respective departments and project offices as well as corresponding offices in the provinces are or should be directly involved in the project level.

Apart from these government mechanisms, the stakeholders also include the following from the civic and private sectors:

1. Water Users Group or Farmers Groups or their representative organizations
2. Forestry Users Groups or their central bodies
3. Hydropower Producers and their representation such as the IPPAN
4. Local organizations of businesses and commerce
5. Other community-based organizations, such as those related to GESI, social welfare, etc.
6. Academic and research institutions in the country related to, water, environment and governance.
7. International bilateral and multilateral agencies and donors involved in the sector and active in Nepal.

The Ministry of Energy, Water resources and Irrigation, is the overall executive office of the government that is exclusively involved in policy formulations, planning, program implementation, monitoring and evaluation in the water sector. The Ministry devolves some of its power to the departments or subsidiary organizations for program implementation and feedback. These are responsible for federal level programs.

The Water Energy Commission Secretariat is, as described before, is a "think tank" for formulation of policies and planning of projects in the water resources sector. With the recent introduction of Water Resources Policy 2020 and the proposed Water Resources Act that is under consideration, the role of WECS is going to be even bigger as the custodian of the river basin information and all data related to water resources planning, allocation and monitoring usage in the basin. It will also be developing as the clearing house for all related projects that require water or discharge into water bodies eventually.

7. WATER PROJECTS ATTEMPTING IWRM

Nepal's approved strategy and Water Plan had both adopted IWRM and attempted to set in motion the implementation of the process by making enabling legislations and policies. It took a long time, with the government's commitment appearing diluted at times, for the new Water Resources Policy be adopted by the government. The attempt for the umbrella Water Resources Act petered out 10-15 years ago and a new effort has been made again.

In the meantime, some projects have been initiated or completed in Nepal that have some bearing |on the IWRM process. These efforts give an idea on the attempts made and can be starting points for water sector professionals interested in IWRM or advocating it in Nepal. This will be most important to the government officials and decision makers in the water sector in Nepal.

7.1 Koshi River Basin Management

The Koshi River Basin Management (KRBM) was one of the first initiatives of implementing the recommendations of NWP 2005 by piloting IWRM approach in water and related resources management of the Koshi River Basin. Water and Energy Commission Secretariat (WECS) took up this project with support from WWF Nepal and IWMI Nepal. Unfortunately, the government's literature available online and in the mainstream seem to have forgotten the project.

WECS and WWF Nepal started working together in 2006 and signed a Memorandum of Understanding (MOU) on 22 June 2007 to formalize their effort and commitment towards implementation of the KRBM program. The WWF was to support the Government of Nepal "National Water Plan". WWF Nepal helped pilot the integrated management of river basins in the Koshi River Basin with objective to achieve critical balance between the water requirement for socio-economic development and sustainability of the vital ecosystems.

The KRBM's target was to make the optimum use of Koshi basin's water and related resources for promotion of socioeconomic development of all people in the basin. It focused on the poorest and targeted to maintain ecological balance. The conceptual framework for implementation of IWRM, which consisted of three levels –

1. River Basin Management – Water and Energy Commission at central level,
2. Inter District and District Water Resources Committee at district level, and
3. Sub Basin Committees at local level consisting of users' groups, CBOs, NGOs, etc.

The project had a number of consultative workshops at the national level as well as at the sub-basin levels, established sub-basin offices (2 or more unknown) and developed an implementation framework for the Project with targets at the strategic, program, district and local project levels. It envisioned a River Basin Office along with District Water Resource Committees, comprising of water users' groups, local governmental and non-governmental organizations, community organizations, and local people.

The Project wrapped up and closed after the WWF funds ran out, even after having established sub-basin offices and carried out a lot of work establishing local participation, suggesting issues of project sustainability.

7.2 Bagmati River Improvement Project

Bagmati River drains the Kathmandu Valley flows through the Terai to India. The basin is considered the most water-stressed basin in Nepal, due to anthropogenic reasons of excessive water extraction, sewage disposal, watershed degradation and irrigated agriculture. The river is biologically dead in the Kathmandu valley, and endangers the health of the capital's population and downstream water users.

Throughout the basin, frequent floods and river bank erosion are the main threat to infrastructure, agricultural land, people's lives, and their livelihoods.

The traditional segmental approach to problems in the capital city was not working so the IWRM principals were embraced in attempting to tackle it. The Bagmati River Basin Improvement Project (BRBIP), with the Bagmati Action Plan in 2009 with a vision of "a clean, green and healthy river system that is full of life and valued by all" recognized the importance of IWRM and established the need for a holistic and systematic management and development of water resources.

ADB is helping Nepal improve water resources management at the Bagmati River Basin. The project will invest in setting up a river basin organization with the capacity to plan and manage the basin water resources in a fully integrated manner. Other improvements include an upstream water storage dam system to increase the river flow in the dry season and riverbed oxygenation weirs.

It was also hoped that the project would be a turning point in the valley civilization and an example to other rivers and authorities in rejuvenating the river basin. Work began on the BRBIP by supporting efforts in developing enabling legal and institutional frameworks for operationalizing the IWRM approach.

The High-Powered Committee for the Integrated Development of the Bagmati Civilization (HPCIDBC), the main agency in charge of the restoration of the river, has not been able to implement many of the planned implementation due to lack of capacity and funds.

The BRBIP established a flood forecasting and warning system for the entire Bagmati Basin through ADB's support. The ADB's capacity development Technical Assistance prepared a basin strategic investment road map and initiated studies aiming at resolving critical priorities. In particular, it produced a water balance and quality model to assess the interventions that are required to restore the environment in the Upper Bagmati River and achieving bathing standards at Pashupatinath and Gokarna.

Interventions identified include:

i. physical restoration of the urban riparian environment and social mobilization to reconnect riverine communities with their river;
ii. increasing water availability in the river during the dry season to raise the river's assimilative capacity; and,
iii. strategic placement of wastewater treatment facilities with higher treated effluent standards. The need for a flood forecasting and early warning system was also identified as a critical priority, particularly in the lower basin where communities are regularly suffering from extreme flood hazards.

The objectives of the project in "Output 1" includes preparation of an Integrated River Basin Plan through a participatory process. It also includes the formation of a River Basin Organization enabled by a Central Water Resources System and a Decision Support System (DSS).

Output 3 of the project seeks to increased dry season water availability in the basin and carry out watershed conservation. The measures included as a water harvesting structures at Dhap with construction of a dam with a storage capacity of 850,000 m^3 to increase environmental flows in Upper Bagmati during the dry season, design of another Nagmati Dam with the potential capacity of 8 million m^3, installation of household rain water harvesting as well as recharging groundwater. Watershed protection works of erosion control, river beautification as well as mobilizing the community and raising awareness are also going on.

The project is still going on. This too has faced some sustainability and dedicated personnel issues as the DSS system that was built and handed over is non-operational, the River Basin Organization that was established is non-functional. This consultation effort at finding the Central Water Resources System and its existence and functioning was not successful.

7.3 Other Efforts

There are other efforts mentioned cursorily in some literature and reports, however, comprehensive information regarding the projects was not accessible or readily obtainable. It should be noted that the IWRM or concepts of it are usually mentioned or included in World Bank or Asian Development Bank funded projects such as the Irrigation and Water Resources Management Project and Water Resources Project Preparatory Facility respectively.

7.3.1Nepal Water Partnership and Local Water Parliament

It is reported that the Global Water Partnership South Asia in partnership with Jalsrot Vikas Sanstha, had carried out works on Nepal's Local Water Parliament to promote IWRM striving for good governance, equity, access, adequacy, quality, productivity and sustainability in the water sector (Global Water Partnership South Asia, 2010). A Local Water Parliament was reportedly formed, in Ilam District in the eastern Nepal in the Mai River Basin area, from among the stakeholders of the water resource of the basin at the local level. It was said to have made people at the grassroots aware of basin level management and motivated them to develop plans, strategies and setting priorities for the long, medium and short term.

Unfortunately, no records and evidence of the works are seen and these local water parliaments are either defunct or non-performing, perhaps were unsustainable once the external funds dried up.

7.3.2 Mega Dang Valley Irrigation Project

The Department of Water Resources and Irrigation has initiated the Mega Dang Valley Project with the primary aim to increase irrigation supply and enhance production. The Dang Valley is drained by the Babai river and it has one of the lowest annual water availabilities, at 0.89 million m^3/km^2 (see Figure 4 4), compared to other basins in Nepal. The project is implementing plans to innovative ways to store wet season runoff for dry season use across all the streams in the valley. For this purpose, the project has identified some small dams and lowland storage schemes to store water and make it available later when required (WRPPF Study Team, 2016, p 14). Some of the lessons learnt till date are that the region being young geologically, the rivers would be carrying larger volumes of sediment in floods would fill up the storage of some dam sites and careful planning is required.

The project has identified smaller 20 dams for storing water and providing for irrigation. These are combined with construction of small ponds, maintenance of wetland, rainwater collection, sprinkler and drip irrigation, flood water storage and utilization to enhance water utilization and resiliency against droughts. Some of the small dams or storage options have been recently completed.

The project activities also include construction of small reservoirs, maintenance of wetland, rainwater collection, groundwater development, sprinkler irrigation and drip irrigation, flood water storage and utilization to enhance water utilization and resiliency against droughts. These systems also recharge the groundwater and help in raising groundwater tables for pumped tube-well irrigation also. Eight earthen-dammed reservoirs have been completed till date providing water for supplementary irrigation and increasing crop intensity and productivity.

The efforts in implementation of IWRM has not been consistently followed up backed by concrete institutional mandates and activities. Piecemeal efforts at implementation of some projects have not made any sustained impacts in the actual implementation of IWRM implementation in Nepal.

8. CONCLUSION

Water resource development and management involves multiple stakeholders with multiple and often conflicting uses and development scenarios of a unitary resource that is characterized by inherent uncertainties and complex interactions. Countries are increasingly facing challenges in their social and economic development efforts related to water as shortages of water, water quality deterioration, droughts and flood impacts limit growth, stifle livelihoods or generate further conflicts. Integrated Water Resources Management (IWRM) is a process which can assist countries in their efforts to deal with water issues in an acceptable, cost-effective and sustainable manner (GWP-TAC4, 2000).

Issues of inclusiveness, equity, efficiency and sustainability require that a system approach be adopted. The traditional fragmented and isolated sectoral approach of management has to be replaced by a more holistic system view approach. Water resources management and the policies are primarily a responsibility of the Ministry of Energy, Water Resources and Irrigation while that of the policies is also mandated to the Water Energy and Commission Secretariat. The government of Nepal's water plan and policies incorporate and appear conducive to practicing IWRM as a process of assuring sustainability. This report targets the existing Water Resources Act 1992, building up on the National Water Plan 2005, for improvement and adoption of an Act that incorporates the IWRM approach. The proposed new draft water resources Act is based on IWRM principles.

The priority action addressed by this exercise is to support enactment of this Act. The study also supports the National Water Resources Policy 2020. The following are the findings from the assessment analysis.

A. Supply and Demand Analyses

Supply: The availability of surface water resources in Nepal is apparently high, 225 billion m^3 per annum, equivalent to about 7,700 m^3/person/year at an average flow of 7,125 m^3/s, but the sum of flows in the major rivers dwindles to about a thousand m^3/s in the months of February and March which is not able to meet the irrigation demands alone. These low flows, correlate to the sparse rainfall periods. The spatial and temporal distribution of rainfall also varies extremely within Nepal with irrigated agriculture requiring supplementary irrigation for healthy and productive crops. There are other demands on the water sector including drinking water, environmental flow and industrial and municipal uses.

Current Demand: It is estimated that the annual use in irrigation, drinking water and industrial uses are presently about 18,714 million cubic meters, which is only about 7.7% of the total average annual water runoff. Irrigation uses is the prime consumptive use with current demands being about 17,452 million cubic meters – a 93.3 % of the total demand. The drinking water requirement is estimated to be about 5.7% while industrial usage is estimated to be about 1%, as there are no data available on it.

Future Demand: The water demand is expected to grow up to 32,164 million cubic meters in 2050. These values do not include the e-flow requirements and the required depth and velocity of flow for rafting, navigation and religious or cultural uses of the society.

The water supply and demand analysis, Chapter 4, reveal that the seasonal shortages of freshwater exist now and will widen in the future. The option to supply water to deficit areas and deficit seasons can be by storing and holding on to water in watersheds. The recommended options would be to practice water harvesting, construct water storage reservoirs and implement inter-basin diversion of water to augment water flow in scarce areas.

B. Other IWRM analyses

Governance: It is identified with this study that, with the adoption of the new Constitution in 2015 and the adherence to the federal system of governance and more power devolved to provincial and local governments, the ground work required for empowering and enabling local institutions has been set. The new federal structure ensures greater autonomy and decision making to the lower grass roots level. This is in tandem with the participatory approach envisioned in the IWRM process.

<u>Delineating roles and responsibilities</u>: Furthermore, it is concluded, from the status described in Chapter 7 in general and the role of institutions in particular, that the confusion set by the varying roles prescribed by the Constitution with exclusive and concurrent roles and responsibilities of the Federal, Provincial and Local governments, sanctioned under Schedules 5 to 9 of the Constitution, need to be clearly defined agreed to and the roles and jurisdictions be stated clearly. The provincial and local officials were not clear own powers but were found by this study team to be looking up to the federal offices for support and guidance.

<u>Implementation issues on IWRM</u>: The Water Resources Policy 2020 does embody the principles of IWRM, but it is concluded that the integrative approach envisioned in policy is not translated in practice. Sectoral integration is often narrowed down to the cooperation between closely related ministries or sections. Evidence of integration is scarce, and often done on ad-hoc personal levels rather than being institutionally built in. Vertical integration and horizontal integration are both desirable and need to be strengthened.

<u>Cost of inaction:</u> Not implementing the IWRM approach can lead to mismanagement and inefficient usage of water resources, shortages of water at the places and times required, deterioration of water quality and impacting the eco-system, biodiversity and the general health of the population.

This report identified that the existing Water Resources Act 1992 needs to be updated, as directed by the National Water Plan 2005 and embodying the IWRM principles that the new National water Resources Policy has supported. This report concludes that the revision of the National Water Resources Act 1992 is required to give fruition to the aspirations of a water resources management system that is based on equity, efficiency and sustainability. The policy directions in the National Water Resources Policy 2020 need to be adhered to in enacting the new water law.

The actual institutional set up required for IWRM implementation, such as the setting up of river basin authorities; identifying stakeholders, gaining their confidences and defining stakeholder coordination frameworks; and carrying out technical preparatory works such as inventory of water resources and uses, water accounting in terms of supply and demands and, etc. is still in early phases. Most important of all, there is a need for political will to change the current system and for the line agencies to let go of their prejudices and cooperate in seeking integrated solutions to the complex problems of managing water resources.

It must be pointed out that Suhardiman et al. (2015) argue that, in Nepal, “IWRM concept was introduced as an ideal set of concepts into national policy documents without reflecting on its relevance, applicability, or desirability” stating that no noticeable changes in institutions and practices had been observed. Nepal et al. (2019) also state the slow implementation of the IWRM approach and suggest the requirement of water-energy-agriculture nexus-based approach to improve water, energy, food security in Nepal. Since 2015, the new Constitution and adoption of the three-tiered governance system have changed the water governance and policy fronts and Nepal needs to use this opportunity to revamp its policies and Acts at all levels of governments focusing on implementation of IWRM, improving service delivery and addressing everyone’s expectations.

8.1 SDG Indicator of IWRM Implementation

The monitoring and evaluation of SDG 6.5 is done through the indicator SDG 6.5.1- Degree of integrated water resources management implementation. As described in Section 2.2.4, this evaluates the degree of IWRM implementation and is shown in Figure 7 1.

The current status of IWRM implementation in Nepal is rather low, the overall score being 37%, while 100% shows fully functional IWRM. The Figure 7 1 only shows that the overall score is higher for both Bangladesh and Pakistan with 58% and 56% respectively.

The enabling environment score for Nepal is rather low, at 27%, perhaps drawing from the absence of the Water Resources Act that was compliant with IWRM, but the institutional sector is marginally acceptable at 51%. It needs improvement in all fronts.

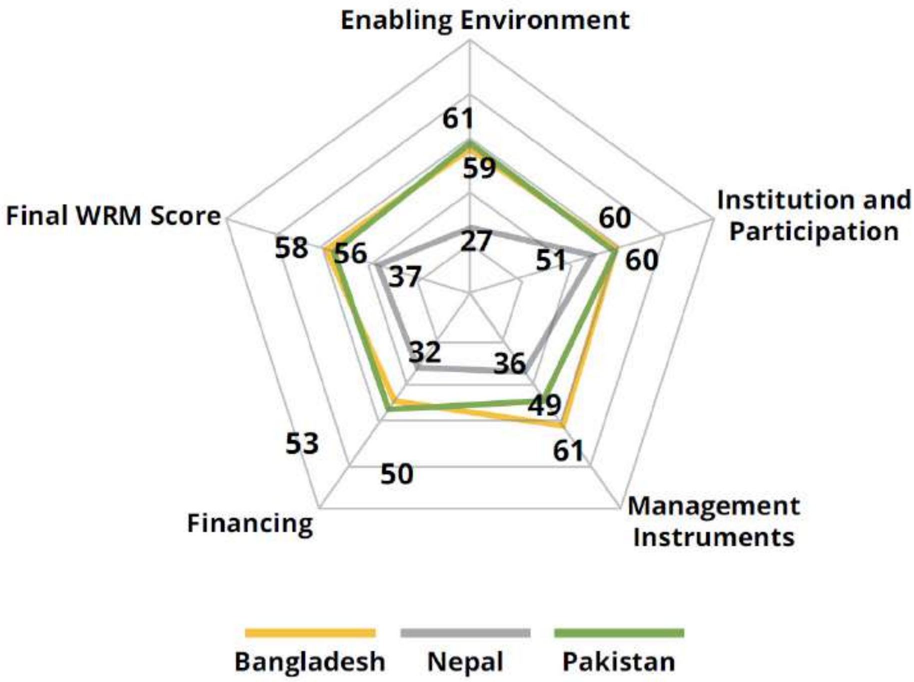

Figure 8-1: SDG Indicator 6.5.1 – Degree of IWRM implementation in percentage

If Integrated Water Resource Management (IWRM) is not implemented in Nepal, it could result in several negative impacts, including: Inefficient use of water resources: Without a proper management plan, water resources may not be used efficiently, leading to a shortage of water in certain areas and waste in others; Deterioration of water quality: Lack of proper management and treatment can result in the degradation of water quality, affecting both human and environmental health; Conflicts over water use: Unmanaged water resources can lead to disputes and conflicts between different stakeholders, such as farmers, industries, and urban areas; Impacts on ecosystems and biodiversity: Unmanaged water resources can have negative impacts on ecosystems, wildlife, and biodiversity; and decreased agricultural productivity: Inadequate water management can affect the availability and quality of irrigation water, leading to decreased agricultural productivity. Overall, failure to implement IWRM in Nepal could result in significant environmental, social, and economic consequences.

8.2 The Way Forward

The above monitoring results, Figure 8-1, definitely show that there are still lots of improvement required before IWRM becomes fully operational. Nepal needs to work in the following domains:

1. Enabling environment: enacting suitable policies and legislations at the federal as well as other levels of governance. Provincial and local level regulations need to be stated and aligned with national perspectives. (Short term and regular updating/streamlining adapting to situations at a medium to long term scale of 5 – 10 years.)
2. Institutions and participation: developing institutions at the central, river basin, provincial, and local governments levels; and initiating dialogues and creating synergies is of prime importance. Institutions need to have clear-cut mandates and operational procedures to

implement, manage and regulate water resources management in Nepal adopting IWRM principles. (Immediate action)

3. Management instruments: Preparing basin plans with proper assessments of resources, needs and supplies, future scenarios of development include the strategy to address temporal and spatial water shortages, water harvesting and storage schemes, developing databases of water usages and demands, climate change and related information, hydrological and other science-based information on floods, watersheds and 'talking" with and sharing information with stakeholders, developing DSS playing out future scenarios with concrete action plans. (These domain activities need to be addressed from immediate to short term)
4. Financing: All these activities require resources and generating resources to implement IWRM. (This is an ongoing process, but the preparatory work begins now, identifying climate funds, checking eligibility, developing partnerships and collaborations, preparing primary document and subsequently proposals, negotiations and agreements, etc. are all cumbersome processes requiring extensive work and resources).

It must be recognized that the IWRM is an ongoing process of improvement and the nation is committed to it as one of the SDGs. The option of implementing IWRM could start at the grass root level. It could even start from small domains and not necessarily encompass a whole basin or the nation if the resources are a constraint. Simple tangible actions such as improving the water quality of a stream, or the equitable distribution of water in an irrigation system, rejuvenating hill springs, recovering groundwater levels or even better manage the floods in a stream could be taken up. These have direct identifiable indicators of success and require simpler technological interventions, if at all, and can be done in a participatory manner. The knowledge and demonstration can be scalable or transferable also.

Gradually, more resource intensive actions or larger scales can be taken up with better data, tools and science-based approach, water accounting, demand and supply scenario analyses and decision support systems. Primary action to be done is to ensure participatory approach from planning to execution with equal benefit sharing, including all the marginalized communities, persons and gender sensitive approach. Communication, record keeping and standards of operating needs to be defined along with transparency and zero tolerance in graft. Strong political will that champions water and puts it high on the agenda is needed.

It is to be noted that the CARE for South Asia project supports the government of Nepal as it is aligned with the four domains described above within the envelop of the Technical Assistance. Sub-component 2.1, a primary work under the project, aims at creating an enabling environment with suitable policies and instruments. The management instruments aspects, related to sub-component 2.2, is also the target area of intervention for ADPC for promoting climate resilient design and standards. Under sub-component 2.3, ADPC will support in implementation of climate-risk management solutions such as capacity building and technical supports

ADPC will support the government of Nepal, through this project, in the water sector in carrying out the prioritized interventions of water governance and improving adaptation to climate change impacts by identifying ways to make designs in the water sector more resilient to climate change. Capacity building activities related to understanding of climate change uncertainties and how best to plan for adaptation and resilience building in the water sector will also be carried. All these activities of the project are slated to be completed by December 2024.

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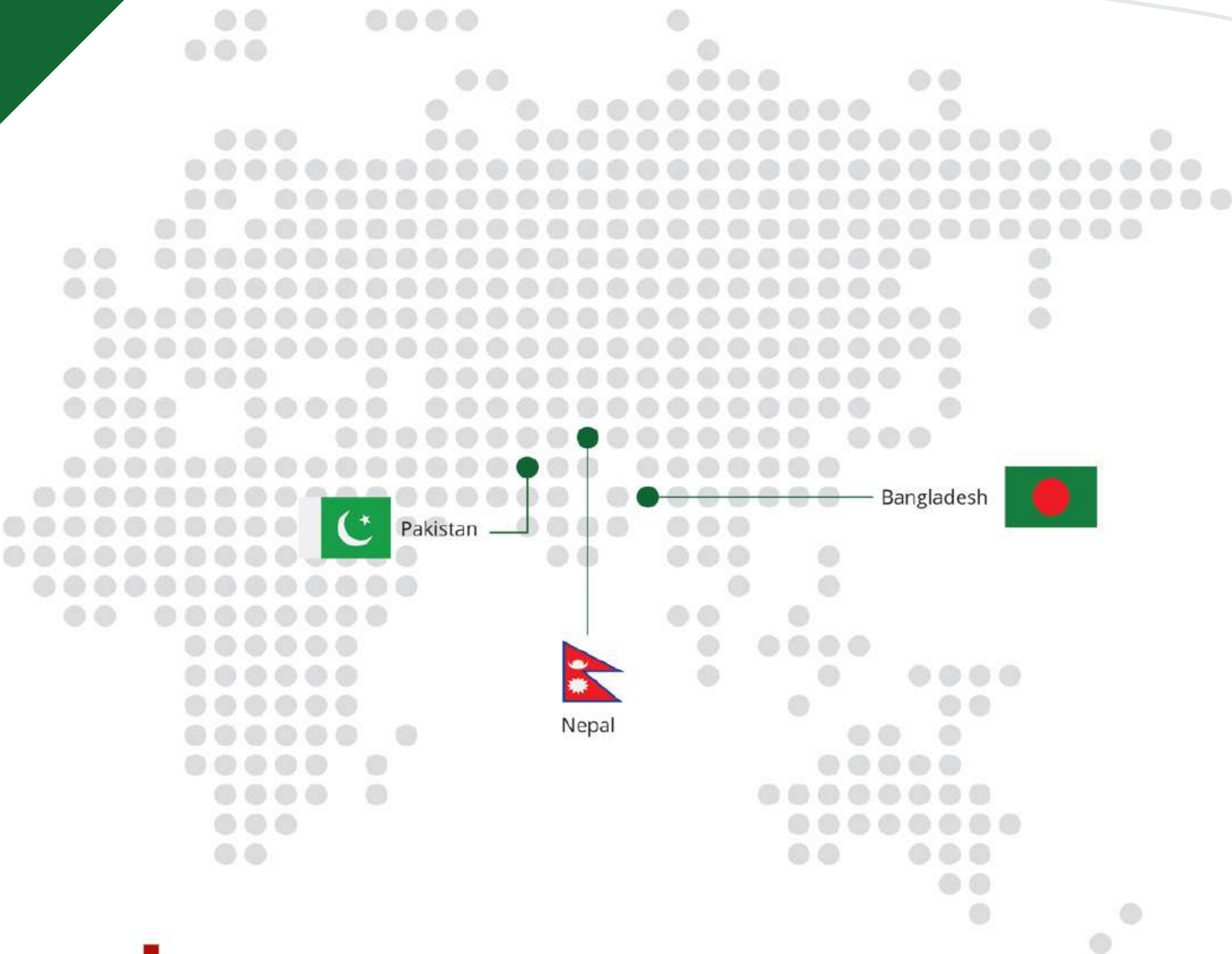

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