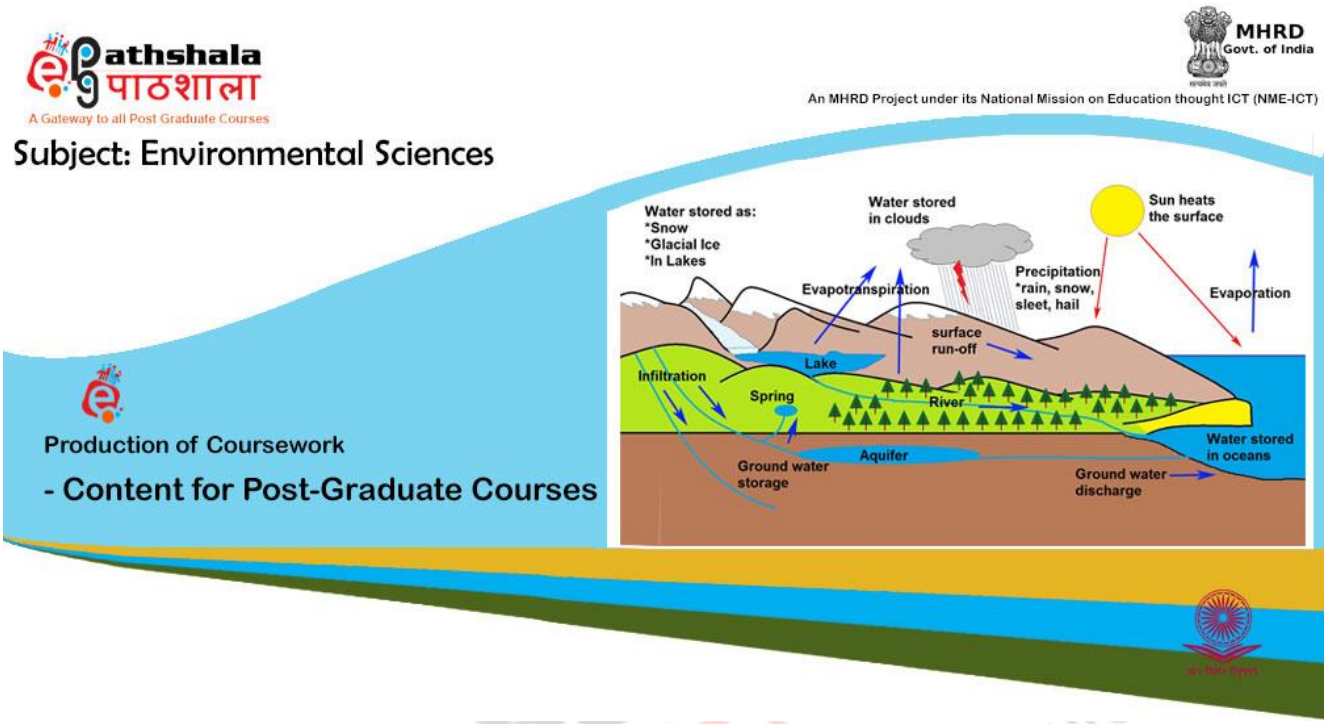

Paper No: 5 **Water Resources and Management**

Module: 35 **Integrated Water Resources Management-I**

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Development Team

Principal Investigator & Co- Principal Investigator	**Prof. R.K. Kohli** **Prof. V.K. Garg & Prof. Ashok Dhawan** **Central University of Punjab, Bathinda**
Paper Coordinator	**Dr Hardeep Rai Sharma** **Kurukshetra University, Kurukshetra**
Content Writer	**Dr. Sharda R. Gupta, Ex Professor, Botany Department , Kurukshetra University, Kurukshetra**
Content Reviewer	**Prof. (Retd.) V. Subramanian, SES , Jawaharlal Nehru University, New Delhi**
Anchor or Institute	**Central University of Punjab**

Description of Module	
Subject Name	**Environmental Sciences**
Paper Name	Water Resources and Management
Module Name/Title	Integrated water resources management-I (Concept, principles and cross sectoral integration)
Module Id	EVS/WRM-V/35
Pre-requisites	
Objectives	To learn about Integrated water resources management: Concept, principles
Keywords	Water Cycle and Global Water Resources, Water Use, Integrated water resources management (IWRM), IWRM Principles, cross-sectoral integration, Sustainable water management, Water Policy in India,

Module Name : Integrated water resources management-I (Concept and Principles and cross sectoral integration)

Objectives

1. Why we need better water management?
2. Water cycle and water resources
3. Water use and its impacts
4. to explain integrated water resources management (IWRM)
5. Water policy and IWRM in India
6. IWRM and the role in sustainable development

Introduction

Water is key driver of economic and social activity as well as maintaining the integrity of the natural environment. Freshwater resources are under increased pressure to satisfy the needs of water users globally. Since 1800, the world's population has increased from 1 to 7.2 billion, but freshwater is finite upon which we all depend for our survival. The amount of freshwater on Earth does not change, yet the use of freshwater has increased nine-fold in the 20th century. Water maintains resource base of surface water and groundwater, sustains aquatic biodiversity, and the ecological integrity of the natural environment (www.gwp.org). Freshwater water is used for food production in agriculture and meeting the needs of people for water supply and sanitation. There is delicate balance between water for livelihood and water as a resource. Water is a powerful indicator of ecological sustainability, economic prosperity, and human well being. However, the knowledge about water systems and change is still insufficient. Population growth, economic growth, and other competing demands on water resources have more demands on water resources.

Population growth has increased demands for water, and produces more waste water and pollution. Migration from rural to urban areas increases the current level of difficulty in water delivery and waste water treatment. Economic growth, mainly in developing countries with large populations, contributes to increased demand of water for economic activities. Inter linkages among sustainable water management components as shown in Figure 34.1. Freshwater is a scarce resource and humans are changing the water system without adequate knowledge of the system.

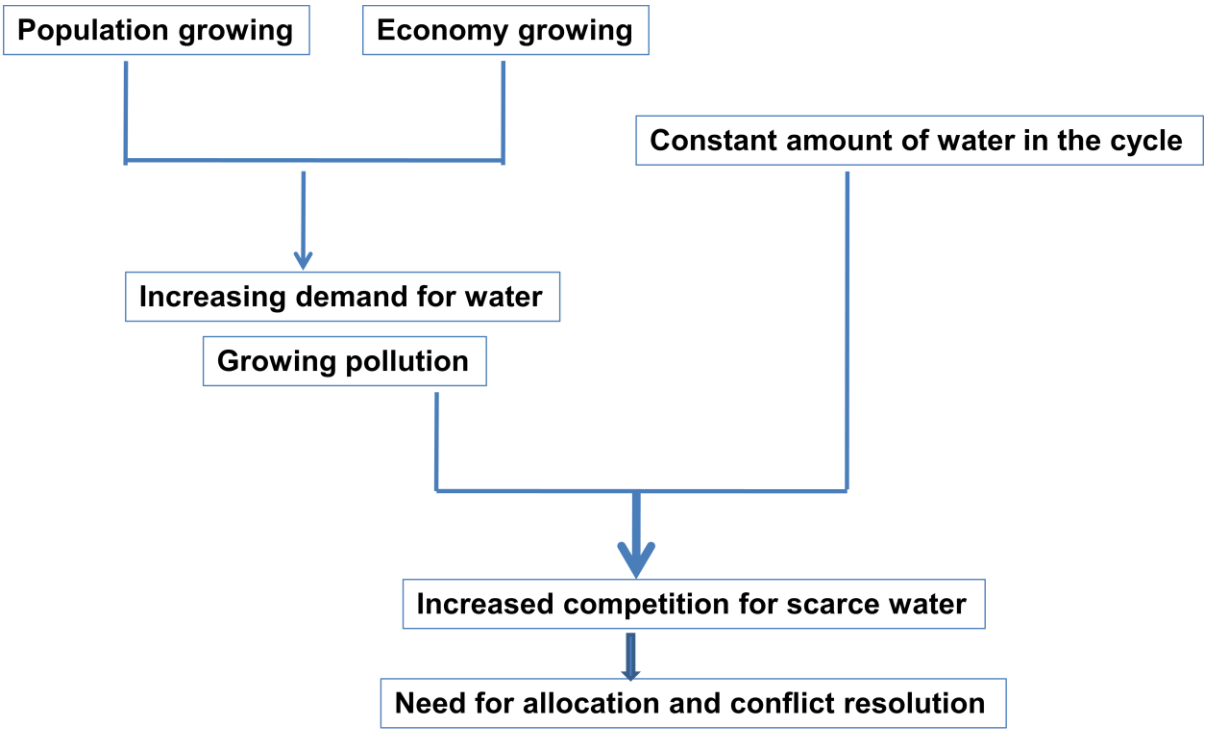

Figure 34.1 . Why is water resources management critical ? (based on Global Water Partnership www.gwpforum.org)

35.2 Water Cycle and Global Water Resources

Only a few studies have provided a synthesized, quantitative view of the global water cycle (Trenberth et al., 2007; Oki and Kanae, 2006). The major pathway of water cycle involves an exchange between earth surface and atmosphere via precipitation and evaporation, and is in study steady-state (Figure 34.2). It is evident that more water evaporates than returns through precipitation in oceans (precipitation-evaporation ratio, P/E ratio about 0.9), while in the case of land the reverse is true (P/E = 1.5). Thus, some of the rainfall that occurs on the land is due to the evaporation of water from oceans. Changes in the hydrological cycle are an expected because of anthropogenic climate change. Under changed climatic scenarios, the major impacts include melting of glaciers, sea level rise, submergence of islands/coastal areas and erratic rainfall patterns, a greater annual variability in the monsoon's precipitation levels (IPCC, 2007). Climate change will have implications on river flows and water availability throughout the world (Palmer et al., 2008).

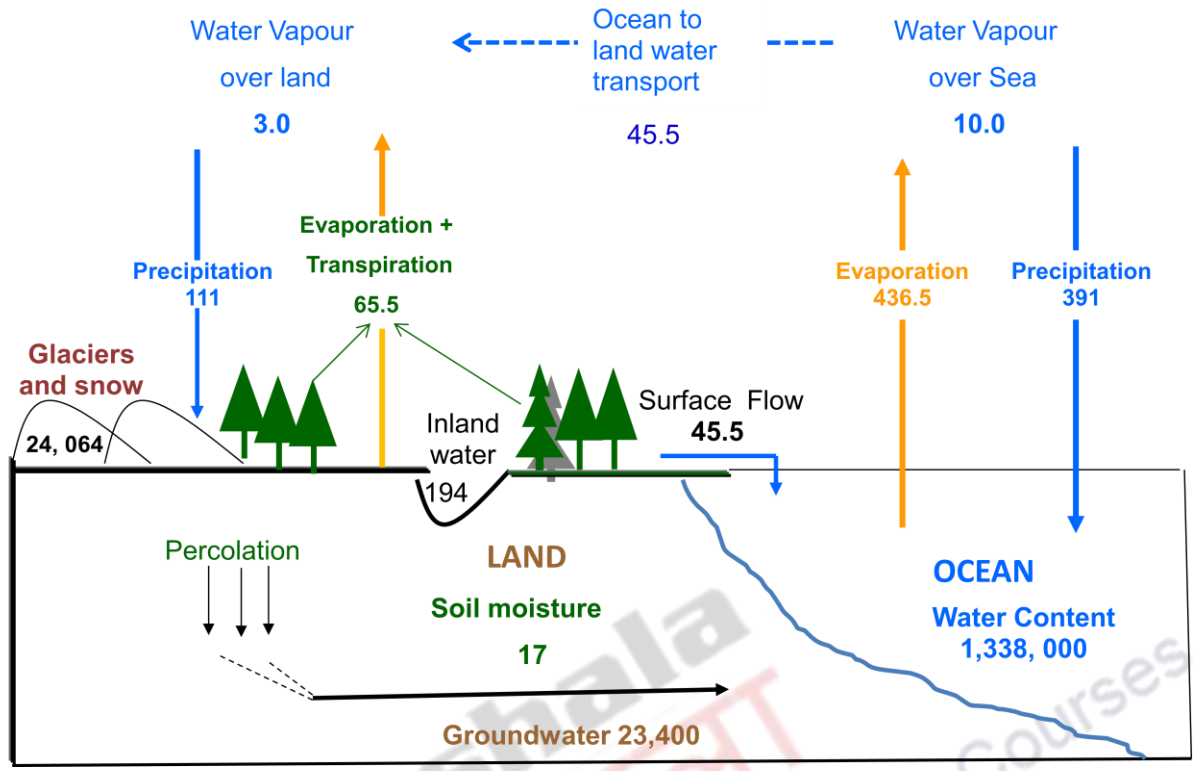

Figure 35.2. Global hydrological fluxes (1000 km^3/year) and storages (1000 km^3) with total annual precipitation and evapotranspiration over land and ocean (1000 km^3/year) (based on Oki and Kanae, 2006)

Water is a key resource for humanity and sustainability of natural ecosystems. The Earth has nearly 1386 million km^3 of water, out of > 96.5% is stored in the oceans and another 1% is saline or brackish groundwater (Shiklomanov, 2000). Out of the only 2.5% of global freshwater, about 69.5% is frozen in glaciers, polar ice caps, snow and permafrost, and more than 30% occurs constitutes the groundwater. Less than 0.3% of all freshwater on the Earth occurs in the lakes, rivers and wetlands and is utilizable by humans for their diverse needs (Shiklomanov, 2000).

The stocks of fresh water are not uniformly distributed over the Earth's surface and show marked spatial and temporal variability (Gopal, 2012). For example, Lake Baikal in Russia alone contains more than 20% of all the freshwater on the Earth. The rivers such as Amazon, Ganga, Brahmaputra, Yangtse, Mississippi, Congo, and Nile account for more water than all other rivers occurring in different regions of the world (Gopal, 2012). The Amazon River alone carries far more water than all major rivers together all over the world.

It is also important to make a distinction between **"Green water"** and **"blue water"**. Water that is used directly for biomass production by plants and "lost" in evapotranspiration is referred to as **"green water**". The portion of rainfall water that flows in rivers and recharges ground water is called **"blue water"**. The Blue, or renewable freshwater that is used amounts to 3800 km^3/year (Oki and Kanae, 2006), out of which 2,660 km^3 constitutes withdrawal of water for irrigation, 770 km^3/year withdrawal for industry , and 380 km^3/year withdrawal for domestic use. This accounts for less than 10% of the maximum available renewable freshwater resource in the world. The withdrawal of water that is consumed is 55%, whereas 45% constitutes the drainage and wastewater, most of which is polluted. Terrestrial ecosystems are "green water" dependent, whereas aquatic ecosystems are "blue water" dependent. Most of the studies on IWRM tend to focus on the "blue water". Management of Green water use has a key role in global food security.

35.2.1 Global Water Crisis – Some Facts

Water quantity and water quality are important issues in water management. Some facts about the way we use our water globally are given in Box 34.1. An estimated 1.8 billion people live in areas affected by water scarcity. Recently, it has been reported that two-thirds of the global population (4.0 billion people) live under conditions of severe water scarcity for at least one month of the year; nearly 50 percent of those people live in India and China (Mekonnen and Hoekstra, 2016). Half a billion people in the world face severe water scarcity all year round (Mekonnen and Hoekstra, 2016). Women in developing countries have to walk long distances collecting and carrying water.

Box 35.1. Water Crisis – Some Facts (UNDP, 2005 and various other sources).

- Only 0.3% of total of global water in the world is available for humans.
- 2 billion people are affected by water shortages in over 40 countries.
- 286 river basins are shared by two or more nations.
- 2 million tonnes per day of human waste are deposited in water courses.
- Half the population of the developing world are exposed to polluted sources of water that increase disease incidence. 1.4 million children die every year because of water borne diseases.
- 90% of natural disasters in the 1990s were water related.
- The increase in numbers of people from 6 billion to 9 billion will be the main driver of water resources management in the next 50 years.

1.**663 million people don't have access to safe drinking water.**

35.2.2 India's Water Resources

India has an average annual rainfall of 120 cm, receiving 392 million ha-m (Mha-m = 10 km^3) of water besides 8 Mha-m snow melt from the Himalaya and 20 Mha-m surface runoff from neighbouring countries (see Chaturvedi, 2011; Gopal, 2012). The total average annual flow in all rivers is estimated at 1953 km^3 (Jain et al. 2007). The utilizable surface waters are estimated to be 690 km^3 of which only 399 $km^3$is being utilized (Kumar et al., 2005). The annual renewable groundwater resources are estimated at 431.89 km^3. Some of the water concerns in India are presented in Box 35.2.

Box 35. 2. Some of the water concerns in India (Kumar and Bharat, 2014)

- India is facing a freshwater crisis, has just 4% of the world's fresh water but 17.85 % of the global population,
- Leakage and inefficiencies in the water supply system waste nearly 50% of usable water,
- Over 70% of surface water and ground water resources are contaminated,
- The ground water level is declining at the rate of 10 cm per year,
- Threat of climate change may have complex implications on the availability of water resources.

35.3 Water Use and its Impacts

Humans use water mainly for food production, producing industrial goods and energy, and for the disposal of wastes. For millions of organisms, water provides the only habitat for their living and functioning, which in turn are crucial for human well-being. Some of main water users are discussed as follows:

Agriculture is by far the largest global water consumer accounting for 70% of freshwater withdrawals from rivers, lakes and aquifers; the water withdrawal being unsustainable in many places due to unbalanced long-term irrigation water budgets.

Industry and energy account for 20% of water demand. More-developed countries have a much larger proportion of freshwater withdrawals for industry than less-developed countries.

Domestic use of water accounts for 10% of total water use.

Urbanization: More than half the world already lives in urban areas. In future, most of this growth will happen in developing countries, which have limited capacity to deal with inadequate water and sanitation facilities.

35.4 Integrated water resources management (IWRM)

All life and all sectors of the economy depend on water. The concept and development of integrated water resources management (IWRM) emerged because of increasingly problems of acute freshwater facing the world. IWRM approach is now accepted internationally for efficient, equitable and management of limited water resources as well as coping with conflicting demands (UN water, 2008). The Global Water Partnership (GWP) and several other programmes have developed and promoted IWRM over the past 25 years as a means of increasing water security. IWRM is a conceptual framework that still has to be applied to the societal and natural needs of the region concerned (Leidel et al., 2012). Integrated Water Resources Management (IWRM) has been designed to provide solutions and is one of the leading concepts for a holistic management of water resources (Ibisch et al., 2016).

35.4.1 IWRM Definition

The classic Global Water Partnership (GWP) definition of Integrated Water Resources Management (IWRM):

The Global Water Partnership (GWP, 2000) defines IWRM as "a process which promotes the coordinated development and management of water, land and related resources, in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems".

35.4.2 IWRM Components and Framework

Integrated water resources management is a systematic process for the sustainable development, allocation and monitoring of water resource use in the context of social, economic and environmental objectives (www.gwpforum.org).

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The IWRM framework and approach recognizes the three pillars of IWRM (Figure 34.3) which includes :

- **The enabling environment** – the general framework of national policies, legislation and regulations and information for water resources management stakeholders;
- **the institutional roles** and functions of the various administrative levels and stakeholders; and
- **The management instruments**, including operational instruments for effective regulation, monitoring and enforcement that enable the decision-makers to make informed choices between alternative actions.

IWRM is thus a set of common-sense suggestions as to what makes up important management aspects with a flexible approach that can adapt to diverse local and national contexts. It requires policy-makers to make judgments about which set of suggestions, reform measures, management tools, and institutional arrangements are suitable in a particular cultural, social, political, economic or environmental context (Hassing et al., 2009).

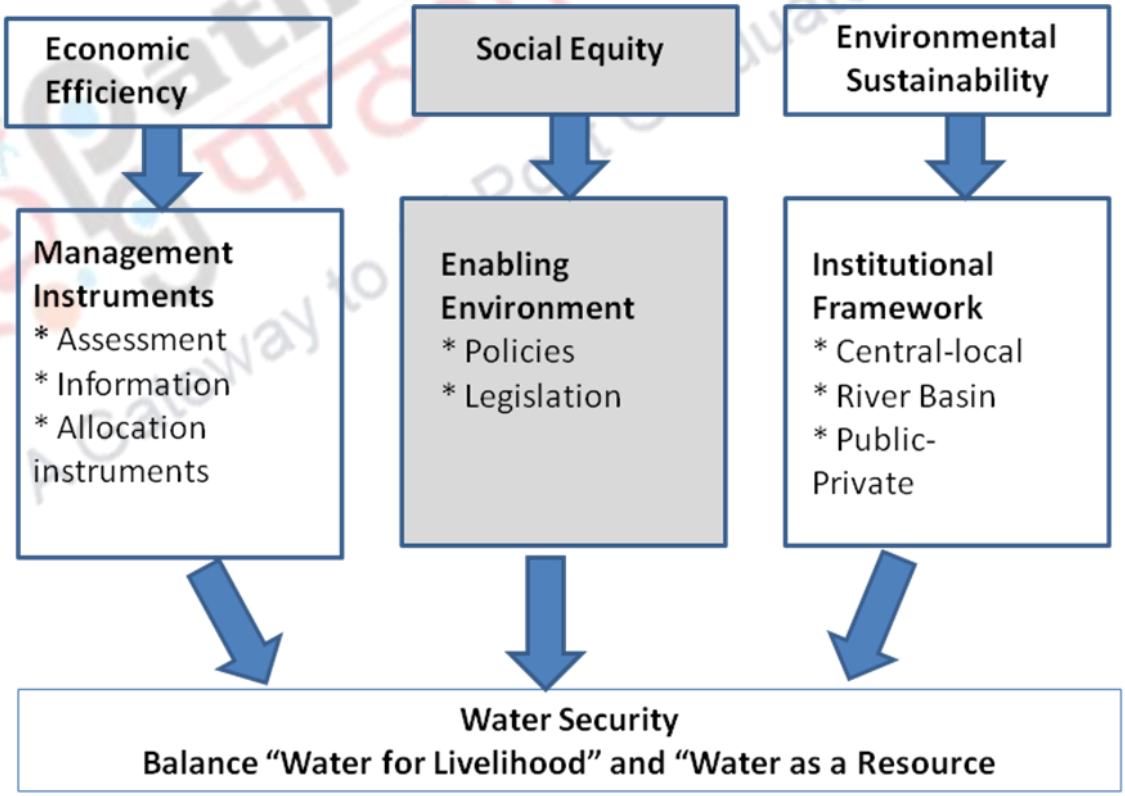

Figure 34.3. The three pillars of IWRM : a enabling environment, institutional framework and management instruments (Based on Hassing et al 2009)

The term IWRM has become popular with most organizations, governments and individual researchers. Some workers have criticized the IWRM concept as it lacks a clear and precise

definition making implementation difficult. Biswas (2004) argues that one single concept may not be applicable in different contexts, i.e., in different cultures, economies and climatic regions. The definition of IWRM seems to be amorphous, and the various fundamental issues need to be agreed upon considering if integration in a wider sense is possible.

35.4.3 IWRM Principles

A meeting in Dublin in 1992 gave rise to four principles, the **Dublin** principles for IWRM that are presented as:

1. Freshwater is a finite and vulnerable resource, essential to sustain life, development, and the environment involving an holistic approach.
2. Water development and management should be based on a participatory approach involving users, planners, and policy makers at all levels.
3. Women play a central part in the provision, management, and safeguarding of water. Involvement of women in decision-making is important.
4. Water has an economic value in all its competing uses and should be recognized as an economic good. We must consider the following points:

35.4.4 History of the IWRM

IWRM is a constantly evolving subject, and its development and application have received wide attention from many parties, national authorities, international and intergovernmental bodies, and academic and nongovernmental organizations. Some significant developments in the field of IWRM are summarised in Box 34.3.

Box 35. 3: Main events of the historical development of IWRM (compiled from Shah, 2016)

1977- The UN Conference on Water was held in Mar del Plata, Argentina in 1977 emphasised rapid irrigation development to minimise hunger and integration of water resources development into national planning .

1992- The International Conference on Water and the Environment (ICWE) was held in Dublin, Ireland during 26–31 January 1992. In this conference, the concept of Integrated Water Resources Management (IWRM) was accepted.

1992 – The United Nations Conference on Environment and Development (UNECD) in Rio de Janeiro in its Agenda 21 emphasizedthe application of integrated approaches to the development, management and use of water resources.

2000-EU Adoption of Water Framework Directive inspired by IWRM principles

2000- Millennium Target 10 of the MDG's commit themselves to: "*halving, by 2015, the proportion of people without sustainable access to safe drinking water*."

2002- The call for better management and development of water resources through IWRM approach were repeated during the Johannesburg World Summit on Sustainable Development

2004-World Bank water strategy. IWRM is accepted but needs a 'pragmatic but principled approach'

2014-GWP vision and mission: for water secure world by advancing governance and water management for sustainable development.

2015- UN adopted 17 SDGs including the Water Goal SDG 6 and Target 6.5 on IWRM.

35.4.5 Cross-Sectoral Integration through IWRM

The various sectors that make use of freshwater are: agriculture, water for people (water supply and sanitation), water for nature and tourism, and various other uses including mining and industry, fisheries, tourism, hydropower, transportation, and urbanization (Figure 34.4). There is competition for water among different sectors at different levels. There is water governance crisis because of sectoral approaches to water resources management. Integrated Water Resources Management is a cross-sectoral policy approach, which has been designed to replace the traditional, fragmented sectoral approach to water resources and management that has led to poor services and unsustainable resource use. A cross-sectoral policy approach is useful in the following ways:

1. Globally accepted and makes good sense.
2. Key element in national water policy.
3. Incorporates social and environmental considerations directly into policy and decision making.
4. Directly involves multiple sectors and the stakeholders.
5. Is a tool for optimizing investments under tight financing climate?
6. Various institutions involved , and decision making collective

IWRM is a multi-sectoral approach in assessing and managing all the developmental issues that includes securing food production in irrigated agriculture, better management of water quality thus reducing health risks, assists disaster preparedness, water management of shared basins and assists appropriate planning of water use with better resilience.

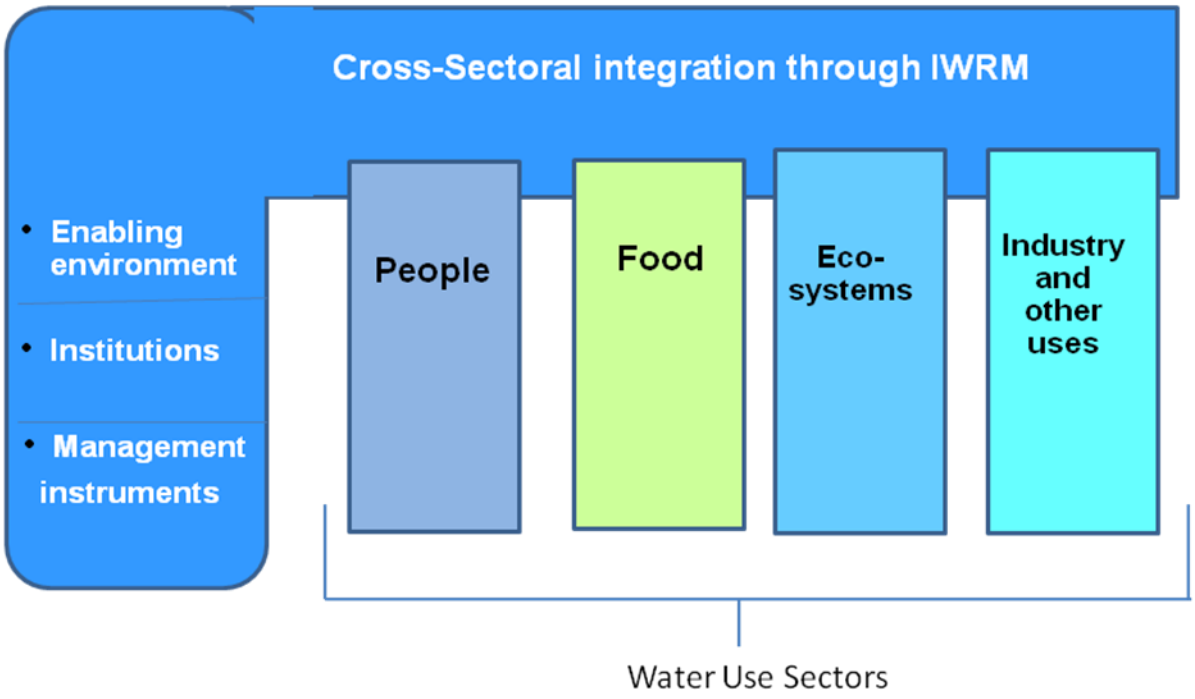

Figure34.4 Managing competing uses of water (based on UNDP 2005; www.gwpforum.org)

35.5 IWRM and the Role in Sustainable Development

The key development issues and a number of institutions and agencies that have adopted the IWRM approach to address water issues are summarised in Table 35.2. Sustainable water management may be defined as meeting current water demand for all water users without adversely affecting future supply for meeting the objectives of society and maintaining the integrity of natural ecosystems. Agenda 21 of the United Nations Conference on Environment and Development ensures a more holistic objective of water management which states that "adequate supplies of water of good quality are maintained for the entire population of the planet, while preserving the hydrological, biological and chemical functions of ecosystems, adapting human activities within the capacity limits of nature and to combat vectors of water-related diseases" (UN, 1992). Sustainable water management is a key component of sustainable development, and focuses on similar issues as sustainability (UNEP, 2012). Water is at the core of sustainable development and is critical for socio-economic development, healthy ecosystems and for human survival. It is vital for reducing the global burden of disease and improving the health, welfare and productivity of human populations. Water is also at the heart of adaptation to climate change, serving as the crucial link between the climate system, human society and the environment.

Table 35. 2. Key development issues, usefulness of IWRM, and its adoption by different organizations (compiled from Hassing et al., 2009).

Key development issues	How IWRM helps	Examples of the adoption of IWRM
Securing food production	Assists the efficient production of food crops in irrigated agriculture	FAO Round Table in Rome. 2003 agreed that all African countries should improve efficiency in irrigated agriculture for food production by adopting IWRM approach
Sustaining a healthy aquatic environment	Supports the maintenance of environmental flows and ecological reserves	The UNEP freshwater programme promotes and assists ecosystem management to be an integral part of national and regional IWRM reform processes.
Reducing health risks	Better management of water quality	UNECE Protocol on Water and Health considers IWRM as an indicator for improved water management
Planning transboundary collaboration	Assists water management within national boundaries or shared between two or more countries	The Mekong River Commission (MRC) adopted IWRM Strategy through the Basin Development Plan jointly by Laos, Cambodia, Viet Nam and Thailand
Adapting to climate change	Assists appropriate planning of water use, with better resilience and/or larger safety margins	IWRM approach based on the concepts of flexibility and adaptability

The Agenda 2030, has been agreed by 193 countries, which calls for an "all-of-society engagement and partnership" to address development challenges in a transformative and inclusive way, with the intention of "leaving no-one behind". SDG 6: "Ensure availability and sustainable management of water and sanitation for all". Target 6.5: "by 2030, which aims to implement integrated water resources management at all levels, an approach championed by Global Water Partnership (GWP).

35.6 Water Policy and IWRM in India

The National Water Policy of India (2002) states that in the planning and operation of systems, water allocation priorities should be broadly defined as: (i) drinking water, (ii) irrigation, (iii) hydropower, (iv) ecology, (v) agro-industries and non-agricultural industries, and (vi) navigation. The 2002 Policy is now to be replaced with the National Water Policy 2012. The Policy calls for a common integrated perspective to govern the planning and management of water resources considering local, regional, and national contexts and the various environmental concerns (GOI, 2012). As per India National Water Policy-2012, Integrated Water Resources Management (IWRM) should take river basin / sub-basin like a unit as main principle for planning, development and management of water resources. The departments / organizations at Centre / State Governments levels should be restructured and made multi-disciplinary accordingly.

Many States have adapted the National Water Policy with few changes into State Water Policies. It has been clearly stated in The National Water Policy that water needs to be managed as a common pool community resource that is held by the State under the public trust doctrine to ensure equitable and sustainable development for all. Further, the 2012 National Water Policy considers water as an economic good which must be regulated by the state, beyond the basic needs, through differential pricing and incentives for recycling water (see Kumar and Bharat, 2014). Two case studies relating to possibility of incorporating IWRM as part of the Policy are given in Box 35.4 and Box 35.5.

Box 35.4 IWRM in New Rajasthan Water Policy (*www.cwp-india.org*)

The New Rajasthan State Water Policy which came into force on 18th February, 2010 has incorporated Integrated Water Resource Management (IWRM) as part of the Policy under the India Water Partnership programme. The policy emphasizes on multi-disciplinary, multi-sectoral, water planning, allocation and management; establishment of a regulatory framework for managing water resources, including the full range of sector environment issues; reorientation of government water institutions, coupled with increased participation of the private sector through farmers' managed WUAs and other private sector entities; enhancing technical services through training and education. Under the new policy, the state wants to create Water Users Organization/Groups (WUGs) in each village and seek active participation of water users.

Box 35. 5 Sustainable water resources management approaches to address adaptation to climate change in villages of Jharkhand (*www.cwp-india.org*)

To use IWRM approaches for effectively addressing adaptation to climate change and other emerging changes at national level, India Water Partnership with its network partner; Action for Food Production (AFPRO) undertook the this study in selected districts of Jharkhand. Networking with local agencies/organizations/institutions, research organizations was done to understand the practices of using low cost water saving technologies to address adaptation to climate change.

There are a number of issues that need to be considered for successful implementation of IWRM in India (Tiwari and Chaube, 2015) which are summarized as follows:

1. Most river basins in India are interstate.
2. Water is a state subject as per Constitution of India; each state is developing and managing water resources within its jurisdiction ignoring/giving lesser priority for the national perspective.
3. Water Acts, Rules and Regulatory conditions are not conducive to establishing organizations that require a cross disciplinary and integrated approach to resource management.
4. The data availability and information exchange between sectors is poor.
5. There are varying conditions of climate, water availability, geographical conditions and natural hazard scenarios across the nation.

On the basis of experience from other developing countries, Shah and van Koppen (2016) are of the view that it would be difficult to implement IWRM in India because of dispersed users who draw water directly from natural sources, besides population pressure and prevailing poverty. However, IWRM philosophy can provide useful guidance with emphasis on participation of different stakeholders, resource management, and evolving appropriate water governance structure in accordance with local conditions.

The National Workshop on Integrated Water Resources Management highlighted important aspects of IWRM in India keeping in view that IWRM is an evolutionary process (Box 35.6). IWRM implementation in India will require improved technology and management systems. The IWRM projects should include data management and information generation, in addition

to human resources management. Producing quality data and verification of existing data will be crucial.

In India, the Central Water Commission, the Ministry of Water Resources, River Development and Ganga Rejuvenation, and National Institution for Transforming India (NITI) Aayog have important roles to play for IWRM success.

Box.35. 6. Important aspects of IWRM in India (National Workshop on Integrated Water Resources Management; World Bank, 2015)

- A basin management plan and vision,
- Participation and coordination mechanisms, fostering information sharing and exchange, Capacity development ,
- Well defined flexible and enforceable legal framework and regulation,
- Water allocation plans,
- Adequate investment, financial stability and sustainable cost-recovery,
- Good knowledge of natural resources present in the basin,
- Comprehensive monitoring and evaluation,
- Political will and commitment.

35.7 Summary

i. Global water cycle is an important part of the earth system.

ii. Water resources are an integral component of the ecosystem, a natural resource, and a social and economic good. Out of the only 2.5% of global freshwater, less than 0.3% of all freshwater on the Earth occurs in the lakes, rivers and wetlands and is utilizable by humans for their diverse needs

iii. There is constant amount of water in water cycle, and freshwater is a scarce resource. Out of the only 2.5% of global freshwater, Only 0.3% of total of global water in the world is available for humans for their diverse needs

iv. India is facing a freshwater crisis, has just 4% of the world's fresh water but 17.85 % of the global population,

v. Inadequate freshwater availability is affecting the economy and health of people.

vi. Humans use water mainly for food production, producing industrial goods and energy, and for the disposal of wastes.

vii. An integrated approach aims to link the biophysical environment with economy, livelihoods, socio-cultural conditions and institutional framework.

viii. The IWRM principles were the basis for the Rio Agenda 21 and for the Millennium Vision-to-Action.

ix. IWRM is a multi-sectoral approach in assessing and managing all the developmental issues

x. IWRM focuses on more coordinated decision making across different sectors of water use.

xi. UN adopted 17 SDGs including the Water Goal SDG 6 and Target 6.5 on IWRM.

xii. The National Water Policy of India calls for a common integrated perspective to govern the planning and management of water resources

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