United Nations Educational, Scientific and Cultural Organization

International Hydrological Programme

World Water Assessment Programme

A contribution to the United Nations World Water Assessment Programme

NARBO
Network of Asian River Basin Organizations

IWRM GUIDELINES at River Basin Level

PART 2-4

THE GUIDELINES FOR MANAGING ENVIRONMENTAL SUSTAINABILITY

Introduction

The Guidelines for Managing Environmental Sustainability is intended for practitioners involved in IWRM[1], particularly for the management of environmental sustainability, within the context of IWRM. It can be used as introductory guidance for those tackling IWRM for the first time, or as training material for intermediary practitioners and trainers of IWRM.

This booklet is the new addition to the *IWRM Guidelines at River Basin Level* series initially published by UNESCO in 2009.

Previously, the following Guidelines have been published:

Part 1 : Principles
Part 2-1: The Guidelines for IWRM Coordination
Part 2-2: The Guidelines for Flood Management
Part 2-3: Invitation to IWRM for Irrigation Practitioners

The Guidelines consist of two parts: Part 1 and Part 2. Part 1 deals with the overarching principles of IWRM at the river basin level. It provides basic principles of IWRM, mainly targeted to policy-makers, and explains the benefits of IWRM at the river basin level and the need to promote it at the policy level. It also proposes a spiral model of IWRM, which illustrates the evolving and dynamic nature of the IWRM process. Part 2 on the other hand deals with practical examples intended for use by practitioners of IWRM at the river basin level.

This booklet is the fifth volume of the *IWRM Guidelines at River Basin Level* focusing on the management of environmental sustainability through the IWRM process at the river basin level. As ecosystems depend on water flow, the proper management of the public water area[2] ensures the sustainability of both human livelihoods and the natural ecosystem or environment. In order to adequately exercise management of environmental sustainability, it is essential that the balance between human utilization of the natural environment and environmental conservation/protection is secured so as to maintain biodiversity as well as ecological functions and services. Furthermore, the appropriate management of ecological quality, particularly of water resources measured as water quality, quantity and variability, is the primary objective in this volume of the Guidelines, not least because water is a fundamental component of the natural environment and the controlling factor of habitat quality in a river basin.

This booklet is primarily targeted to water resource planners and managers who are responsible for environmental sustainability, though other sectors whose activities are related to environmental sustainability in the river basin will also find this booklet useful.

This booklet contains many observations and ideas that will help practitioners achieve management of environmental sustainability in the most relevant and appropriate way through the application of the IWRM process. The contents have been illustrated and organized in the same way as previously published volumes of the Guidelines. Each section can be read separately whenever specific information on a subject is required. The Guidelines have been designed to enable the user to find the information needed without necessarily reading through all the pages.

IMPORTANT NOTE

While each document is intended as a stand-alone volume, the reader is advised to first read Part 1: Principle of the Guidelines in addition to the relevant volume(s).

1 Integrated Water Resources Management (IWRM) is explained by the Global Water Partnership (GWP) as 'a process which promotes the coordinated development and the management of water, land and related resources, in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainablility of vital ecosystems.'

2 'Public Water Areas' is the term used to refer to water areas of public use such as rivers, lakes, ports and harbours, coastal seas and so on and includes such waterways connected thereto as public waterways, irrigation waterways and other waterways subject to public use. Due to public dependency on public water areas, the sustainable use of public water areas is essential for the health and welfare of societies. Moreover, historically, it is the area susceptible to environmental degradation because of the highly intensive use of public water.

ACKNOWLEDGEMENTS

The *IWRM Guidelines at River Basin Level Part 2-4 The Guidelines for Managing Environmental Sustainability* were jointly developed and quality assured by Steering Committee members. We acknowledge the essential and gracious support of the following Steering Committee members from around the world for their contributions and attendance at the meetings.

Co-chairs
Eugene Z. Stakhiv (International Center for Integrated Water Resources Management, ICIWaRM)
Yasuro Nakajo (Japan Water Agency, JWA)

Members
Johannes Cullmann (International Centre on Water Resources and Climate Change)
Kuniyoshi Takeuchi (International Centre for Water Hazard and Risk Management, ICHARM)
Mochammad Amron (Network of Asian River Basin Organizations, NARBO)
Shahbaz Khan (UNESCO IHP)
Shelley McMillan (World Bank)
Simla Yasemin Özkaya (Ministry of Foreign Affairs, Turkey)
Victor Pochat (IHP for Latin America and the Caribbean UNESCO Montevideo)
Wouter Lincklaen Arriens (Asian Development Bank, ADB)
Yoshimi Murai (Ministry of Land, Infrastructure, Transport and Tourism, MLIT, Japan)

The contributions of several other individuals and their organizations towards the development of the Guidelines are also gratefully acknowledged.

Contributions to various stages of the draft
Reviewer: Maciej Zalewski, (European Regional Centre for Ecohydrology, ERCE)
Research and analysis: CTI Engineering Co., Ltd.
Editor: Cathy Lee
Designer, typography and layout: Oriata Création

Secretariat (UNESCO IHP)
Toshihiro Sonoda
Mao Takeuchi

The Guidelines can be downloaded from the UNESCO Website (http://www.unesco.org/water/)

TABLE OF CONTENTS

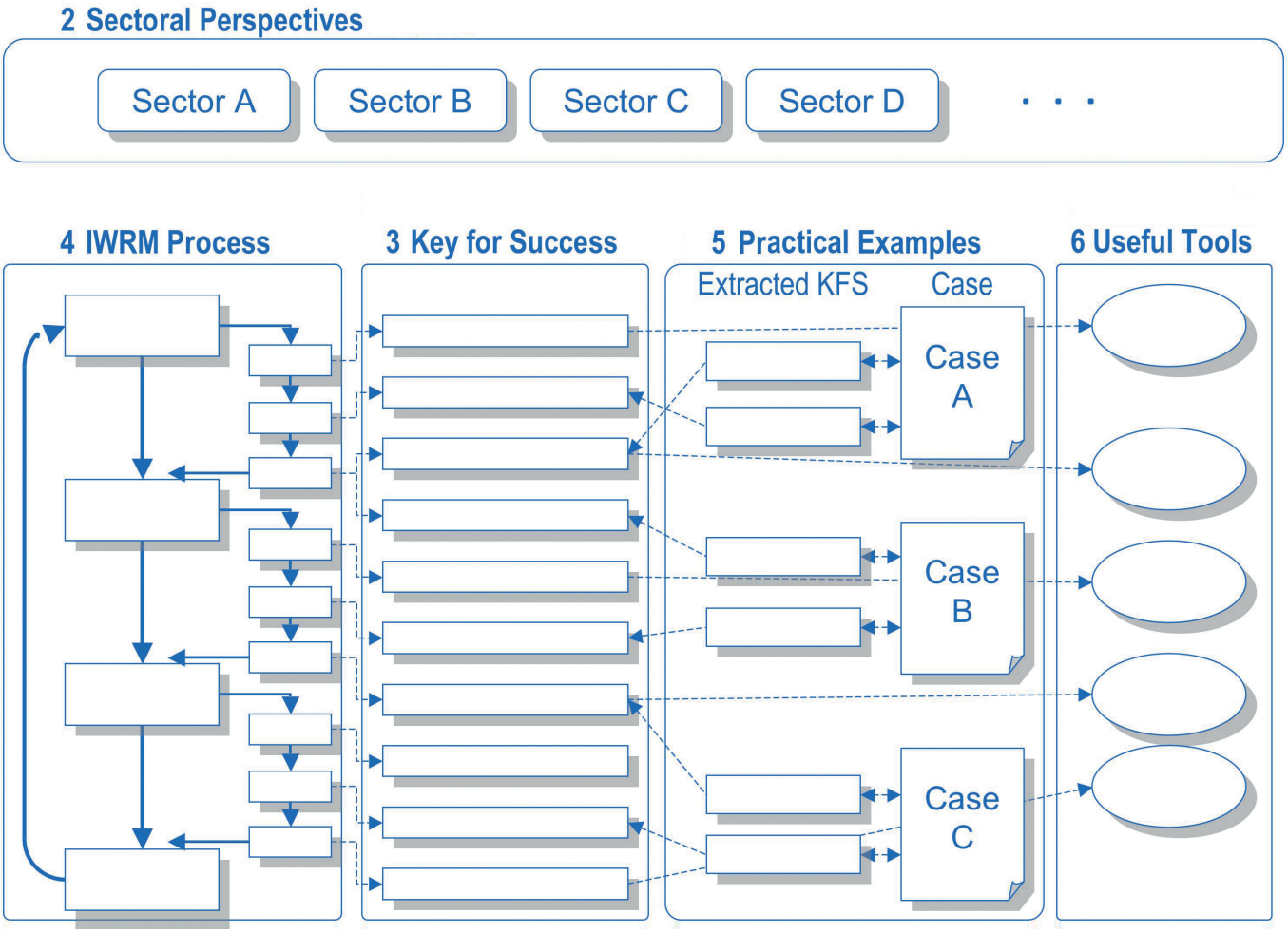


Fig. 1.1 Structure of the Guidelines

1. Overview and Structure of the Guidelines

1.1 OVERVIEW

'The Guidelines for Managing Environmental Sustainability' has been designed for IWRM practitioners who are involved in the management of environmental sustainability, with the environmental sector as the primary target sector. It is intended to be used as introductory guidance for those tackling IWRM for the first time, or as training material for intermediary practitioners and trainers of IWRM. For IWRM experts, it can be used as a reference guide to tackle the various issues and problems they face in their IWRM activities.

It is important to realize that the management of environmental sustainability is one of the objectives within IWRM, which is defined by the Global Water Partnership (GWP) as 'a process that promotes the coordinated development and the 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.'

1.2 STRUCTURE

The Guidelines consist of five parts: Chapter 2-Sectoral Perspectives, Chapter 3-Key for Success, Chapter 4-IWRM Process, Chapter 5-Practical Examples and Chapter 6-Useful Tools. These elements are linked by reference indices, which allow you to move from one to another in the way most convenient to you.

Chapter 2/Sectoral Perspectives for managing environmental sustainability in IWRM

This chapter illustrates the principles of actions and interests of the environmental sector as well as all sectors related to environmental sustainability in IWRM. Each sector values water and interacts with water differently. This chapter provides information on how individual water-related sectors tend to think and act, how these sectors typically relate to the management of environmental sustainability in IWRM, and what they might want to convey to other sectors.

Chapter 3/Key for Success to manage environmental sustainability in IWRM

A 'Key for Success' is a tool that can be used in practice to help make IWRM successful by learning from other examples. It is a key to enable breakthroughs in challenging situations, opening the door to better IWRM. Many of them have already demonstrated their worth in practice. Some are generic, i.e. they apply to every successful example of IWRM, others may apply only to specific situations, and some may not be in place as yet.

Chapter 4/IWRM Process

The 'IWRM Process' chapter describes a typical process for IWRM implementation. It also illustrates keys for success relevant to each phase or step of the process. These will help you to orient through the process and serve as a map for finding directions or the correct 'key' for enhancing water resources management.

Chapter 5/Practical Examples

This chapter includes practical examples of IWRM at the river basin level in the form of: 1) case stories illustrating actual IWRM efforts, and 2) 'Extracted Key for Success' highlighting elements of success in enhancing IWRM. Furthermore, they are action-oriented guidelines. Practical examples included in the Guidelines are collected through actions, by visiting sites and conducting interviews with local resource persons.

Chapter 6/Useful Tools

'Useful Tools' provide useful ideas or materials that can be used to explain or understand complex issues encountered during IWRM implementation. Good utilization of these tools will enable effective and efficient implementation of IWRM.

2. Sectoral Perspectives for managing environmental sustainability in IWRM

This chapter illustrates some of the typical perspectives of water-related sectors. The perspectives included here are not complete, however, they cover much of the information useful for IWRM.

This chapter provides information on how individual water-related sectors tend to think and act, how the sector relates to water management and IWRM, what the sector wants to convey to other sectors, and the organization or person responsible for coordinating IWRM efforts.

It is important to know the perspectives of other sectors when implementing IWRM. The same 1 m^3 of water is valued differently depending on the sector because each sector treats and uses water in their own different ways. Water is also valued differently depending on when and where it can be obtained, and at what quality.

Even though the sectoral perspectives illustrated in this chapter are essentially the same as those explained in other volumes of the Guidelines, environmental viewpoints are added in each sector's perspective. It is because all sectors in IWRM interact with the environment that it is important to understand the relationship between each sector's activities so as to ensure the appropriate and effective management of environmental sustainability.

2.1 GOOD UNDERSTANDING OF SECTORAL PERSPECTIVES AND THEIR RELATIONSHIPS IS KEY FOR IWRM

Implementation of IWRM means proposing a plan to individual sectors – who tend to think of their own benefit as their first priority – that is close to their ideal plans, and obtain compromises if necessary by making proposals that present advantages to them. It is also important that as many sectors as possible are satisfied with the plan before a consensus can be reached. For this to occur, managers in charge of coordination should not force their restricted management objectives upon the sectors but should take a consultative approach in order to obtain the perspectives of the coordinated sectors, so as to deepen their level of understanding and trust.
The coordinators must understand the goals of the activities undertaken by the sectors or stakeholders, and how they relate to water resources and the basin in order to appropriately implement IWRM. Furthermore, good understanding by the coordinators on the benefits of IWRM to the individual sectors as far as understanding the importance of ecosystem distribution in the catchment, and the functioning and use of ecological resources by societies, will facilitate efficient, appropriate and socially justifiable consensus-building. Thus, it is important to establish a good understanding of 'sectoral perspectives' in implementing IWRM.

2.2 ENVIRONMENTAL SECTOR PERSPECTIVES

- Ensuring ecological diversity and social consensus

Water managers need to take into account the multiple interests of the environmental sector toward achieving ecological diversity and social consensus.

2.2.1 Interests of the environmental sector

(Restoration and maintenance of a sustainable environment to an acceptable ecological state)
The principal interest of the environmental sector is to ensure a sustainable environment over a long-term perspective. Their role is to prevent excessive, short-sighted development and call for the restoration and maintenance of basic functions of the natural environment. In other words, the environmental sector pursues environmental restoration and maintenance to an acceptable ecological state, striving for the preservation of forests or rivers without the impact of human influence. From their perspective, over-extraction of water or drainage from and to

rivers that result in insufficient water for the environment, or dams or weirs that change their flow-variability in rivers and thus impact on fauna and flora, are considered as problems. Consequently, they demand and display requests to other water-related sectors. If these demands are social demands the coordinator will have to determine if social consensus can be obtained for such demands, including its cost allocation.

(Environmental conservation in harmony with human activities)
In areas where communities have developed gradually around irrigated agriculture, a new ecological state has evolved. Such an environment is not without human influence. Some are of the opinion that such environments with some level of human influence should be managed to an environmentally acceptable state.

For example, shallow riparian waters, tributaries and streams are providers of ecological habitats for fauna and flora. Man-made water infrastructures and irrigation networks that are developed with due consideration of environmental sustainability, or that are assimilated into the surrounding environment, can also provide habitats for species.

(Added value of the environment – ecosystem services)
In recent years focus on the added value of the environment has increased through the concept of ecosystem services. It is in the interest of the environmental sector to raise the overall value of the environment in a basin-wide manner, together with ecotourism and recreational oppotunities. Communities benefit from a multitude of resources and processes that are supplied by environmental aquatic ecosystems. Collectively, these benefits are known as ecosystem services. The following lists represent examples of water related ecosystem services:

Provisioning services
- food (including seafood and game), crops, wild foods and spices
- water
- energy (hydropower, biomass fuels)

Regulating services
- carbon sequestration and climate regulation
- waste decomposition and detoxification
- purification of water and air
- sustaining ecological life and maintaining bio-diversity

Supporting services
- nutrient dispersal and cycling
- seed dispersal
- primary production function of the ecosystem

Cultural services
- cultural, intellectual and spiritual inspiration
- recreational experiences (including ecotourism)
- scientific discovery

2.2.2 How other sectors may impact the environment

Environmental sustainability is an important objective of IWRM for developing a sustainable society. Environmental perspectives should exist in every sector and should be coordinated in order to realize IWRM.

It is important to recognize that every water use that changes water flow in terms of quantity and quality, as well as seasonal variability, can have a diverse influence on the environment. In this section, some examples of the impacts given by the relevant sectors are illustrated. Understanding environmental impacts by the various sectors should help clarify ideas regarding what should or could be done to improve environmental sustainability as well as understand its importance.

(Impacts by water-use sectors)
- The abstraction of water from rivers impacts the environment downstream of the intake location. Excessive water abstraction, for example for rice cultivation, will prevent the river downstream from receiving adequate amounts of water flow, which may cause the river to dry up or a worsening of water quality, leading to a deterioration of the aquatic environment. Discharge of wastewater or used water into rivers will increase flow quantity but may deteriorate river water quality. Also, it is important to recognize that groundwater may be an important factor in the overall water budget and in terms of environmental sustainability.
- Over-abstraction of groundwater by water-use sectors will lead to ground subsidence, groundwater salination or changes in groundwater quality or the drying up of wetlands causing loss of groundwater dependent ecosystems.
- Structures placed in rivers for water-use purposes may impact the environment, for example, by directly disrupting the surrounding environment, by preventing fish passages, or by reducing the river flow downstream. The construction of large-scale structures such as dams or intake weirs in particular, will alter the seasonality of

flows and thus significantly affect the natural environment. The environmental sector demands that all water-use sectors minimize their impacts to the environment or implement alternative measures. For example, the installation of an intake weir for water usage will prevent fish species from moving upstream or downstream. The environmental sector will demand the installation of fish ladders, or ensure that the passage of fish is adequately secured and thus provide for environmental flows.

- Overuse or improper use of pesticides and fertilizers in agricultural practices may negatively impact on water quality and/or ecological habitats.
- Inland navigation and recreational boating/tourism may impact on the environment, for example, activities such as the construction of harbours and wharfs, and dredging of river channels can directly modify habitats of both aquatic and riparian species. Also, oil leaks from engines and other mechanical ship parts can degrade environments making them less suitable for habitat use.
- Both commercial and recreational fishing can also cause environmental impacts including those similar to inland navigation/recreational boating since, in many cases, fishing calls for the use of ships and boats. In addition to those impacts, commercial and recreational fishing may lead to a reduction of the fish population, which can result in the degradation of biodiversity and the extinction of some species.

(Impacts by flood management sector)

- Structures placed in rivers for flood management purposes may impact the environment, for example, by directly disrupting the surrounding environment, preventing fish passages, or altering the river flow downstream. The construction of large-scale structures such as dams or river improvement works including dykes, river excavation and the straightening of river channels in particular, may cause the natural environment to be altered. The environmental sector demands that the flood management sector minimizes the impacts to the environment or implement alternative measures. For example, the installation of a dam will prevent fish species from moving upstream or downstream. The environmental sector will demand the installation of fish ladders, or ensure that the passage of fish is adequately secured.
- The improvement of flood control measures results in a decrease in the frequency of flood events as well as its severity, which may have an impact on the environment. In the riparian environment, the occurrence of floods can be an essential means to maintain the native ecosystem. Reduction of floods for example, can cause environmental changes such as enhancing the invasion of tree species into river channels and compositional changes of riverbed material, which may affect the quality of habitats for aquatic species.

2.2.3 Practices that improve environmental services

In order to properly manage environmental sustainability, it is desirable that each sector carefully evaluates whether its practices are environmentally sustainable and whether or not they cause negative environmental impacts. In order to make sure your practices are environmentally sustainable, the relationship between your practices and such water characteristics as water quality and quantity and seasonal variability need to be considered. Practices that maintain or improve the effect of water characteristics at an ecologically acceptable level are considered to be desirable and are recommended. Some examples of such practices are shown below:

- Careful site selection during the planning stage of a construction project that is based on adequate environmental assessment to reduce unnecessary environmental effects and impacts.
- The installation of water treatment facilities for water quality management can improve downstream environmental quality.
- Installation of fish ladders at dams can resolve interference with species migration.
- Adaptation of environmental flow with respect to the water resource management scheme helps improve the quality of the aquatic environment.

2.2.4 The environmental sector in relation to IWRM and the advantages of IWRM

- IWRM cannot be achieved without the introduction of environmental perspectives, thus the implementation of IWRM is a definite advantage for the environmental sector. For efficient as well as adequate management of environmental sustainability, the environmental sector often needs to negotiate and coordinate with other sectors.
- The management of environmental sustainability contributes to meeting overall IWRM objectives in the river basin by preventing over-utilization of environmental resources and help maintain environmental quality in the basin, which also enhances the social and economic welfare of the river basin. Moreover, it improves the resilience and robustness of river basin ecosystems in the face of global changes.
- Environmental degradation caused by improper management of environmental sustainability will

have disadvantageous impacts on all sectors' activities and such negative impacts may continue for years, sometimes even several generations. Therefore, positioning the management of environmental sustainability as part of the IWRM objectives ensures that the efforts and costs to mitigate undesirable impacts are reduced.

2.3 WATER USER'S PERSPECTIVES

2.3.1 Agricultural Sector

- Primary concern is food production. Water is just an instrument.

Historically, the agricultural sector is one of the first water users with a long history of evolution as it adapted its practices to the environment in order to improve efficiency and productivity. Today, irrigated agriculture is widely implemented with both positive and negative impacts on the environment. At the same time, there are various applicable ways to improve and enhance environmental sustainability.

2.3.1.1. Interests of the agricultural sector

(Water for agricultural production)
Water, together with land, is only an instrument for agricultural production. The production outputs are food and ultimately revenues for the farmers. For farmers, water is a means of ensuring their livelihoods from their land. In arid/semi arid regions in most countries, the agricultural sector is by far the biggest water user and thus this sector has great potential for environmental improvement.

(Sense of historical entitlement as a precedence user)
The agricultural sector has a history of investing and acquiring water, often at a subsidized cost. Thus, there is a strong sense of entitlement to the exclusive use of the water for their own purposes. As a consequence, environmental conditions are generally preserved.

(From nearby water sources to distant water sources)
Irrigation infrastructure is a complex system of reservoirs, channels and drainage systems that has evolved over centuries in the search for water and, as a consequence, has modified a large part of the environment including groundwater and salinization.

In the monsoon regions of Asia, the amount of rainfall varies greatly during the wet season. Thus, people utilize groundwater, reservoirs or nearby rivers, and should they need more water, they build dams upstream of the river. In arid and semi-arid regions, there is always a need for additional water, but the search invariably begins with nearby water sources before seeking water further away as demand increases.

Thus, nearby water sources are utilized in most developing countries but as development proceeds in the basin, larger infrastructures such as wide-area water transfers become necessary in order to obtain adequate water for agricultural needs.

(Agriculture as the fundamental industry of the country)
The agricultural sector contributes to national security through food production. The agricultural managers of the country and the region consider the provision of a stable supply of food as the most important objective for the region. In developing countries, some consider that agriculture should be promoted in order to secure jobs and revenues in rural regions and prevent population concentration in urban cities. This cannot be realized without securing the water necessary for agriculture. The agricultural sector is also strongly influenced by national policies. Thus, it must be kept in mind that local coordination is sometimes inadequate.

The agricultural sector has adapted to climate variability including drought and increased agricultural production by building suitable infrastructures and groundwater reservoirs. As food security has increased, environmental protection has decreased.

2.3.1.2. How other sectors may affect the agricultural sector

(Impacts by other water users)

- There is the possibility that irrigation users may be unable to obtain sufficient water if other water users draw water upstream. If a structure, such as an intake weir, is to be constructed by another water user upstream, the upstream user will benefit from the advantageous position in drawing water, resulting in the opposition of the irrigation user downstream of such action.
- Hydropower generation uses water discharged from dams according to electricity demands. Thus, it may cause large fluctuations in river flow downstream of the dam that can alter the ecosystem. It can also impact on the stable intake or water quality of irrigation water. Also, water quality downstream may be degraded by water discharge; for example by water temperature changes as a result of cooler or warmer discharge water known as

'thermo-shock', by a lack of dissolved oxygen or by a contamination of organisms to toxic metals.

(Impacts by flood management)

- When there is a risk of flooding due to an increase in river discharge, drainage from agricultural land may be regulated, and prolonged inundation of the fields may cause damage to the crops. The scale of anticipated damage is dependent on the duration of inundation, landuse and the type of crops. The coordination of operational drainage measures that take into account such factors will be necessary.
- When floodwater is temporarily stored in a reservoir to lower the flood discharge level, the turbidity of water may persist even after the flood has subsided, depending on the nature of upstream sediment. If river water is used as irrigation water immediately after a flood event it may impact water use.

(Demands by the environmental sector)

- The environmental sector demands that the agricultural sector minimizes the impacts of agricultural production activity on the environment or requests alternative measures. For example, concrete channels for irrigation are conventionally designed in ways that are efficient from the economic standpoint. However, the environmental sector demands that channels use more natural materials such as soil, rocks and wood. Considering environmental conservation may increase costs or maintenance needs.

2.3.1.3. Agricultural sector in relation to the management of environmental sustainability

Irrigated agriculture induces various changes in a given environment, including water flow regime, through activities such as opening/clearing land, planting exotic species, use of chemicals (i.e. fertilizers, pesticide, herbicides). Therefore, irrigated agriculture has various environmental impacts such as reduction/loss of habitat, decrease of population in certain species, changes in biodiversity and so on.

- The activities carried out by the agricultural sector cause various environmental changes due to the alteration of land, water intake and discharge, the use of chemicals and fertilizers and the introduction of non-native species including crops themselves. Loss of habitat, the quality and quantity of river water and changes in species composition and population will reduce biodiversity, eventually leading to the degradation of environmental sustainability.
- Agricultural activities such as pesticide and herbicide use and the introduction of alien or non-native species to increase food production can affect biodiversity or cause compositional changes of species through the removal of native species. Use of genetically-modified species can have a long-lasting influence on the native ecosystem in terms of genetic diversity through cross-breeding with native species.
- Fertilizer use contaminates water discharge, which also affects water quality downstream and may eventually lead to eutrophication in rivers and lakes – a consequence of water pollution, often associated with a reduction of dissolved oxygen.

2.3.1.4. Harmonizing environmental sustainability for the agricultural sector through IWRM.

The agricultural sector is generally efficient in water use. An irrigation system, in particular, improves water use efficient and, as a result, contributes towards environmental sustainability.

However, the agricultural sector can improve environmental sustainability with the IWRM process through both structural and non-structural improvement measures as listed below:

- Structural measures: irrigation, rehabilitation of the natural environment, cleaning up canals, land levelling, aligning channels for less infiltration and so on.

- Non-structural measures: adaptation of water fees or charges, enforcement mechanism for water use efficiency and so on.

- If the agricultural sector wishes to continue with large infrastructure development, there is the possibility of significant cost reduction, as well as minimizing environmental changes if the venture is jointly implemented with other sectors. Furthermore, the agricultural sector may gain forms of compensation if it reaches compromise with other sectors with respect to securing water resources.

- By uniting specific organizations or individuals in the agriculture sector, the sector can represent a significant amount of water resources. It can, therefore, facilitate the consensus-building process for environmental improvements by implementing IWRM measures and thus enhance the benefits achieved by the entire agricultural sector.

2.3.2 Municipal and Domestic Water Supply Sector

- Water quality requirements in addition to water quantity

The municipal and domestic water supply sector has been the one of the most innovative sectors in introducing water conservation techniques to serve the ever-increasing demand. However, at the same time, this sector has associated environmental impacts, especially in large cities. For example, uncontrolled water abstraction can sometimes cause the subsidence of the groundwater level. Use of insufficiently treated water may lead to sanitary problems as well as water pollution in rivers and lakes in urban areas.

2.3.2.1. Interests of the municipal and domestic water supply sector

(Sanitation and domestic water supply)

The municipal and domestic water supply sector provides a steady supply of clean water to people and is highly public in its nature. The provision of safe drinking water may be the norm in developed countries or cities but it is still a fundamental requirement in sustaining the lives of people in developing counties and rural areas. One billion people still have no access to clean drinking water around the world. Furthermore, a stable water supply in these areas will lead to improvements in the social environment, such as less time fetching water and so on.

Modern water supply in cities was developed primarily to prevent water-related diseases. However, in most rural areas of the world, there are still many water quality problems related to domestic water supplies from village wells and rivers. Worms such as Guinea worms that cause water-borne diseases such as Dengue is one such example.

(No alternative for domestic water supply utility)

The current domestic water supply in cities does not provide an opportunity for users to choose their service. People have to use the available water supply in their vicinity. However, there is a great potential for improving environmental quality through demand management and by securing an alternative water supplier. The municipal and domestic water supply sector has been one of the most innovative sectors in serving ever-increasing demands.

(Privatization and water supply)

Water prices are calculated to collect initial investment and are based on operation and maintenance costs according to the area or utility. Thus, the water supply sector regards the water price differential as a normal condition. However, for most water users this issue is of primary concern.

The privatization of water utilities is often to enhance profits, cost recovery and improvements in services. There have been cases where privatization has not worked as effectively as expected.

(Water treatment technology and water source/ water quality)

Before water treatment technology was developed to its current level, an important consideration in the use of domestic water sources was not only 'quantity' but 'quality'. Thus, groundwater was often utilized as it was considered to be a safer supply of water. River water was used when groundwater alone could not meet the demand. Before treatment technology was developed to its current level, the sector sought better quality water upstream of rivers. This often led to conflicts with existing water users downstream, but for the municipal and domestic water supply sector it was important that good quality water was obtained in order to maintain a steady source of water.

In recent years, however, with advances in treatment technologies, water quality is no longer a major issue; recycling has been used more extensively and it is now possible to produce drinking water from treated wastewater.

[New technologies and domestic water supply]

With the advancement of water treatment technologies such as membranes, the cost of water treatment has decreased. With advanced and affordable technologies becoming newly available, water supply systems in developing countries today have the possibility of taking completely different approaches compared to developed countries where water resources have typically been secured through the construction, for example, of water storage reservoirs in upstream regions.

2.3.2.2. How other sectors may impact the municipal and domestic water supply sector

(Impacts by other water users)

- There is the possibility that a domestic water supplier may not be able to obtain sufficient water if other water users draw water upstream. If a structure, such as an intake weir, is to be constructed by another water user upstream, that user will benefit from the advantageous position in drawing

water, and thus the domestic water supplier will be opposed to such action. Rural water supply systems are especially susceptible to contamination.

(Impacts by flood management)
- When floodwater is temporarily stored in a reservoir to lower the flood discharge level, depending on the nature of upstream sediment, the turbidity of water may persist even after the flood has subsided. If river water is used for the domestic water supply immediately after a flood event it may impact on water quality making it unsuitable for domestic purpose. The groundwater and associated ecosystem will become contaminated for a long period of time following extreme flooding especially in a rural water supply.

(Impacts by the sewerage and drainage sector)
- A domestic water supplier will be affected if a drainage channel is connected or if effluent from a wastewater treatment plant is discharged close to the intake location.
- Discharged water is often contaminated, thus the domestic water supplier/sector would demand that any such discharge facility used for drainage or a wastewater treatment plant be situated downstream of the intake location.
- Treated wastewater could in some cases be recycled and utilized for the domestic water supply.

(Demands by the environmental sector)
- The environmental sector demands that the domestic water sector minimizes the impacts of the water-intake facilities and water-intake to the environment or requests alternative measures. For example, site selection in the installation of a new dam should be investigated with respect to advantages and disadvantages not only from an economic standpoint but also from an environmental standpoint. In addition, mitigation measures such as the installation of a fish ladder may be requested.
- Furthermore, the sufficient flow for maintaining the native ecosystem, or environmental flow, should be considered when deciding the amount of water intake. Reducing river flow – whether temporal or continuous – may impede or even halt river flow and cause habitat segmentation, interference with migration and the breeding activity of fauna.

2.3.2.3. Domestic water supply sector in relation to the management of environmental sustainability

- When demands for water supply increases due to the population growth of existing cities or a change in social situation, the domestic water supply sector will have to identify new water sources or reduce water demand and be faced with mitigating environmental impacts from landuse change such as the construction of new water purification plants. In addition, the domestic water supply sector should consider maintaining an adequate environmental flow to the native ecosystem when deciding the amount of water taken. Minimizing land changes and ensuring sufficient environmental flow is directly related to environmental sustainability in a basin.

2.3.2.4. Domestic water supply sector in relation to IWRM and the advantages of IWRM

- When introducing IWRM, conformity with plans by other municipalities or water use sectors can be ensured by accounting for upstream and downstream, right and left banks, and by coordinating among municipalities or water utilities. Furthermore, infrastructure such as dams, intake weirs and treatment plants can be jointly developed and a joint management framework can be established. These can present substantial advantages to the domestic water supply sector as well as environmental sustainability.
- If there is shortage of water due to population growth or rapid urbanization, water transfers from other uses, particularly the agriculture sector, can be an option, together with the development of new water resources infrastructure such as dams.

2.3.3 Sewerage (Sanitation)/Urban Drainage Sector

- How to collect wastewater efficiently and where to discharge it

Up until recently the urban environment – from the point of view of environmental sciences – was considered as a highly condensed anthropogenic system organized to provide efficient matter, energy and information flow so as to improve productivity and services and satisfy humankind's materialistic and spiritual aspirations and demands.

In the post-industrial era, as the level of education in society has increased, together with environmental consciousness, there is a growing demand to improve the quality of life within society. Consequently, in addition to basic services and the elimination of infectious disease, safe drinking water and pollution-free air is expected, as are access to aesthetic high value

city landscapes and recreation areas, which directly depend on the area and distribution of 'green areas' and freshwater ecosystems.

The proper management of wastewater by the sewerage (sanitation)/urban drainage sector is essential for environmental sustainability. One of the main environmental issues associated with wastewater is water quality. In many urban areas, wastewater is the primary cause of water pollution in urban rivers and lakes because it is often inadequately treated and thus low in quality. In the case of floods, the environmental impact of untreated wastewater may be even more acute because its impact extends not only downstream but also on the irrigation system.

2.3.3.1. Interests of the sewerage/drainage sector

(Maintaining a sanitary environment and risk management)
Providing access to sanitation is as important as a safe water supply when maintaining public hygiene and providing for a sanitary environment. For example, the sewerage system must account for stormwater otherwise urban areas can be flooded because of the shortage of stormwater discharge capacity, which can lead to the backflow of sewage or wastewater causing extremely unsanitary conditions and potentially causing the spread of water borne disease.

If wastewater is discharged upstream of a river – due to an underdeveloped sewerage system – the downstream river is rendered unsuitable as a water source for the domestic water supply. In many regions of the world, large cities are often situated downstream of large rivers. Wastewater disposal can bring about an ecological crisis situation in large cities if wastewater is not adequately treated.

(Recycling of wastewater)
Wastewater, if treated to an adequate level, can be effectively reused for water-use purposes. For example, primary treated wastewater can be used in the irrigation of public spaces and environmental flows. Secondary treated wastewater can be utilized for recharging groundwater, and tertiary treated wastewater can be substrates for industrial use. A sewerage system is thus very important in the recycling of wastewater and should be utilized as a water resource.

(Urban drainage)
Drainage facilities in urban cities are sometimes not developed fast enough and heavy rains can cause inundations in the lowlands of cities resulting in severe damage to underground spaces. Garbage disposed in drainage channels often prevents drainage and intensifies the economic and ecological damage caused by inundations.

(Public nature)
Sewerage and drainage systems are highly public in nature. The efficient collection of wastewater, treated to the level requested by society, then discharged downstream as quickly as possible are of paramount importance.

2.3.3.2. How other sectors may impact the sewerage/drainage sector

(Impacts by other water users)

- National and regional managers in the sewerage or drainage sector have to decide upon the discharge location by negotiating with other water-use sectors and the environmental sector. If the discharge location is set immediately upstream of the water intake location of a water-use sector, a conflict may arise. From the economic perspective, to be able to discharge at the closest location possible is ideal, but from the water users' perspectives it is necessary to discharge downstream or in another river. The bypassing of water using a wide-area sewerage network also raises questions.

(Demands by environmental sector)

- Water quality is also an important issue for consideration. It is technically possible to treat wastewater to an appropriately acceptable level. It is important to establish discharge criteria and permits, especially for low flow conditions, and regulate and enforce those permits. This also presents the advantage of reusing water for other purposes. On the other hand, it costs more as the treatment level is raised . The issue of who covers this cost is of great interest to this sector.

(Impacts by flood management)

- Rapid drainage of stormwater into rivers will cause an increase of river flow and will intensify flood risks downstream. Flood managers will thus demand that the implementation of drainage operations and river flood control be coordinated.

2.3.3.3. Sewerage and drainage sector in relation to the management of environmental sustainability

- Water quality relates not only to available water resources for human activities but also to living conditions, especially for aquatic ecosystems. Sew-

erage/drainage systems can regulate water quality by maintaining the sanitary environment and treating wastewater. Thus, it is beneficial to implement a sewerage/drainage system for both management of environmental sustainability and biological diversity.

- Activities of the sewerage and drainage sector reflect both the water quality and quantity of the river, which closely relates to the quality of the habitat of native fauna and flora. Furthermore, the development of the drainage/sewerage system may result in land modification, which is associated with environmental change. Such environmental changes, including those found in water flow, can have a significant influence on environmental sustainability.
- It can be ameliorated by providing separate sewerage and drainage systems, which contribute to increasing flood control capacity but at great expense.

2.3.3.4. Sewerage and drainage sector in relation to IWRM and the advantages of IWRM

- The drainage location and drainage water quality are important aspects that need coordination and consensus-building with other sectors. Furthermore, participating in IWRM from the position of securing water quantity will enhance interaction with stakeholders. By improving the quality of drainage water, it may be possible to set a closer location for drainage. This can lead to overall economic benefits such as ensuring adequate river flow and the recycling of wastewater.
- Uncontrolled discharge onto local wetlands and lakes has ecological consequences including human health impacts.

2.3.4 Industrial Sector

- Primary deciding factor is the cost of supply and discharge subject to environmental regulation.

Various types of industries exist in the industrial sector and each one presents a number of differences in terms of environmental impacts. Among those, water pollution resulting from inadequately treated wastewater from the industrial sector often becomes an important issue, especially when it concerns heavy metal contamination in industrial wastewater as it can cause serious environmental as well as health problems. For industries that consume large volumes of water such as the pulp and paper industry, the abstraction of water for industrial use can have a major environmental impact.

2.3.4.1. Interests of the industrial sector

(Low-cost water and industrial water)

The primary concern of the industrial sector is how to obtain and provide low-cost water and discharge wastewater in the least expensive way. This is especially true for high water-consumption industries such as the pulp and paper industry and power generation plants that require vast amounts of water for cooling. Cost is the primary deciding factor, subject to environmental regulation.

Compared to the domestic water supply sector, which does not provide alternative options for users, the industrial sector is considerably more attentive to the demand for cost-effectiveness. The industries themselves are greatly influenced by aspects other than water (logistics, employment, environment, and so on), thus it is difficult to develop long-term demand projections compared to the domestic water supply.
All water users in a system are assigned to various suppliers by a permit system. Competition for water becomes critical during drought periods while municipal and industrial water users generally have priority over other users.

(Groundwater utilization and industrial water)

Industrial water in the past was abstracted mostly from groundwater. This was because groundwater was a cheap and stable water source yet high in water quality. Drawing water from rivers requires water use rights, infrastructure development and water quality adjustment (treatment) thus the use of river water for industrial use was typically cost ineffective.

Excessive abstraction of groundwater in alluvial plains may induce ground subsidence or groundwater salination resulting in the deterioration of groundwater quality and the groundwater dependent ecosystem. Users of industrial water are mostly private entities such that these problems are likely to occur if there is no adequate environmental regulation. Conversely, in the mining industry, groundwater may be undesirable, or an impediment in their operations in some cases. Consequently, the over-abstraction of groundwater, in an effort to lower the groundwater level, may purposely take place to improve mining efficiency.

(Water quantity, water quality and industrial water)

Industries that use large amounts of water such as steel, oil, chemical or paper industries select locations within easy access to water. Industrial water, unlike domestic water, demands varying levels of water quantity or quality depending on the usage. For example, microchip companies requiring

super pure water have their own water purification systems and thus the industrial water supplier may only need to provide raw water. The disposal of untreated industrial water into the domestic sewerage system poses a serious pollution threat in the municipal water treatment system with associated environmental consequences.

Discharging used industrial water directly into the river may cause severe contamination downstream. Industrial water users understand this but generally only consider it necessary to meet the regulatory standards for industrial water discharge. Water contamination, especially of toxic substances such as heavy metals by the mining industry, is an important environmental impact issue such that the water used in the process of extracting target substances such as heavy metals requires adequate wastewater treatment which, for the sake of public health and the environment, is mandatory.

2.3.4.2. How other sectors may impact the industrial sector

(Impacts by other water users)

- There is the possibility that an industrial water user/supplier may not be able to obtain sufficient water if other water users draw water upstream. If a structure, such as an intake weir, is to be constructed by another water user upstream, that user will benefit from the advantageous position in drawing water, and thus the industrial water user/supplier will be opposed to such action as it will adversely affect the domestic water supply.

(Demands by the environmental sector)

- Environmental regulation requires environmental impact assessment, monitoring and reporting of water use and discharge before granting a license.
- The environmental sector demands that the industrial sector minimizes the impacts of water-intake facilities and water-intake to the environment or requests alternative measures. For example, site selection in the installation of a new dam should be investigated with respect to advantages and disadvantages not only from the economic standpoint but also from the environmental standpoint. In addition, mitigation measures such as the installation of a fish ladder may be requested.
- The environmental sector also demands the recycling of industrial water to reduce total water consumption and in order to maintain sufficient water flow in a river. A reduction of water consumption will be advantageous not only for the industrial sector, by providing economic incentives through lowering water cost, but also to the environmental sector, by reducing environmental impacts.
- Furthermore, the sufficient flow for maintaining the native ecosystem or environmental flow, needs to be considered when deciding on the amount of water intake. Reducing river flow – whether temporal or continuous – may impede or even halt river flow and can result in a loss of biodiversity segmentation, interference with migration and the breeding activity of fauna. A reduction in the groundwater flow, as well as subsidence of the groundwater level, can have various environmental impacts including salinization.
- The quality of discharged water is another important focus of the environmental sector. Contamination by toxic substances such as chemicals and heavy metals will invariably cause environmental hazards in the downstream region due to disproportional ecological impacts. The issue of toxic wastewater discharge is particularly important for the mining industry. In addition, temperature differentials between the discharged water and the river flow in a given location may cause direct environmental changes affecting both fauna and flora in the surrounding area.
- Enforcement and monitoring through appropriate regulatory regimes such as tariffs and fines are prerequisites in the attainment of IWRM goals.

2.3.4.3. Industrial sector in relation to the management of environmental sustainability

- The industrial sector imposes various impacts on environmental sustainability by abstraction and discharge of water. For example, the lack of adequate treatement in the discharge of wastewater will transform the native environment into one that is artificial, which may result in changes to the local biodiversity. Also, such facilities sometimes interfere with the migratory movements of some species resulting in habitat fragmentation. Furthermore, abstraction of water from rivers impacts the environment downstream of the intake location; for example, overuse of water will prevent the river downstream from receiving adequate quantities of water flow, which may affect water quality. The quality of discharged water will directly impact on both the water quality downstream and ecological sustainability.
- Therefore, improving efficiency in industrial water use will help reduce environmental impacts and maintain the environmental sustainability in the basin.

2.3.4.4. Industrial sector in relation to IWRM and the advantages of IWRM

- If the industrial sector wishes to conduct a large infrastructure development there could be a possibility of significant cost reduction if it is jointly implemented with other sectors.

2.3.5 Hydropower Sector

- How to generate the maximum revenue from energy in water

Even though hydropower generation is known to be relatively 'clean' on the environment scale when compared with other forms of power generation, it nonetheless has various environmental impacts caused by the construction of related facilities as well as the fluctuation of flow regime, such as flow volume and seasonal variability, of the river flow.

2.3.5.1. Interests of the hydropower sector

Electricity is indispensable for the development of the region and the country with both the private sector and governments promoting power generation projects. Power development is generally implemented over a wide area and provides high added value to the country though with many environmental costs. It contributes to industrial development and creates employment, and thus often forms a primary focus for developing countries as the foundation for regional industrial activities and local livelihoods.

(Characteristics of electricity)

- Electricity cannot be stored, thus facility capacity generally exceeds peak demand, which alters the natural hydrographs and associated ecosystem. Upstream environmental impacts include the transformation of stream to lake habitats.
- The same can be said for instant supply and demand, and the lack of flexibility in supply often leads to inefficient operation.
- There is often no alternative service for power supply and thus the price of power has a public utility cost.
- Infrastructure investment and cost collection plans are long-term.
- It can be distributed over a wider area, compared to water (and it is possible to transmit over long distances).
- Operational impacts include thermal shock, biological migratory paths and dissolved oxygen level.

In its early stages, hydropower generation was typically used to provide power for local consumption such as factories. Although typically instigated in the form of private projects, it soon expanded to general implementation in combination with other electricity sources to provide an economic and efficient electricity supply nationwide. In many countries, hydropower development began before the development of irrigation water.

Hydropower generation often has lower running costs than thermal power generation. Thus generating more electricity through hydropower and less through thermal power is an ideal solution to energy generation. Hydropower generation does not consume water as compared to other water-use sectors. Furthermore, hydropower generation upstream of a river harnesses the potential energy of water to its maximum extent. The hydropower sector plans to exploit this potential energy by utilizing as much water as possible by building multiple power-generation facilities. Its priority is efficient power generation; if that causes rivers to run dry, then this is considered an inevitable cost.

Hydropower generation uses dams to generate power based on demand, and thus the discharged water quantity fluctuates in a way that is unfavorable to other needs. This also influences water temperature such that other sectors and the environment would be affected, which should be taken into consideration. The hydropower sector may take measures to reduce its influence downstream by controlling discharges, but the sector is not proactive in this regard without public investment.

Thus, the hydropower sector considers investment and the efficiency of power generation among its priorities, and river flow and the environment are only considered when it is required to do so, i.e. because of environmental impact assessments.

2.3.5.2. How other sectors may impact the hydropower sector

(Impacts by other water users)

- If other water users increase their water intake upstream of a hydropower plant, the water available for hydropower generation will be reduced. This will also reduce the power generation capacity of the plant. Power generation is directly linked to the revenue of the hydropower sector, thus the sector will oppose any newly permitted forms of abstraction by new water users or otherwise may seek compensation.

(Demands by the environmental sector)

- The environmental sector demands that the hydropower sector minimize impacts to the environment by developing hydropower facilities such as dams, or requests alternative measures. For example, site selection in the installation of a new dam should be investigated with respect to efficiency not only from an economic standpoint but also from an environmental standpoint.
- In addition, mitigation measures such as the installation of a fish ladder may be desirable, although such ecological measures tend to be less efficient in the case of large-sided dams.
- Furthermore, the sufficient quantity and seasonality of flow for maintaining the native ecosystem or environmental flow needs to be considered when deciding on the quantity of water intake and discharge. Reducing river flow – whether temporal or continuous – will impede or even halt the river flow, which can have adverse effects on biodiversity.

2.3.5.3. Hydropower sector in relation to the management of environmental sustainability

- The hydropower sector imposes various impacts on environmental sustainability through its activities by altering the flow downstream of the dams in terms of seasonality and temperature. For example, the construction of hydropower plants will transform the native environment into one that is artificial, which may result in changes to the local biodiversity. Also, such facilities sometimes interfere with the migratory movements of some species resulting in habitat fragmentation. Furthermore, abstraction of water from rivers impacts the environment downstream of the intake location; for example, insufficient water flow volume at the section between the water intake and discharge facilities may affect water quality.
- Therefore, environmentally-sound actions by the hydropower sector will help reduce environmental impacts and maintain environmental sustainability in the basin.
- Environmentally friendly technologies include multiple level intakes, fish ladders, eco-friendly turbines and demand management.

2.3.5.4. Hydropower sector in relation to IWRM and the advantages of IWRM

There are many advantages to IWRM coordination such as the efficient development of facilities as well as energy efficiency, and in order to minimize unnecessary environmental impacts and improve environmental sustainability in activities related to the hydropower sector the following are considered:

- The construction of new hydroelectric facilities should be subject to environmental regulation.
- It is more difficult to plan new hydropower projects without overall coordination. However, in countries where public awareness of environmental conservation is high, and if the hydropower sector actively participates in IWRM and facilitates consensus-building with relevant stakeholders with a special focus on environmental conservation, this will facilitate project planning and implementation, and will become an advantage for the sector.
- Environmental regulations demand detailed environmental impact assessment, monitoring and reporting as part of project feasibility studies.
- Improving energy efficiency among various sectors in a river basin through IWRM coordination could help reduce the demand for electricity as well as the need for additional hydropower plants.

2.3.6 Inland Navigation/Recreational Boating/Tourism Sector

- How to maintain an efficient and safe service

The inland navigation/recreational boating/tourism sector share common characteristics in that they neither extract nor consume river water in the way other sectors do. This sector simply uses rivers as a channel for the movement of ships and boats. Nonetheless, negative environmental impacts are still associated with the common activities employed by this largely recreational sector.

2.3.6.1. Interests of the inland navigation/ recreational boating/tourism sector

(Secure route for efficient navigation)

The inland navigation sector often uses relatively large vessels with a cargo capacity. The efficient navigation of such vessels requires that the ship lanes have an adequate depth and width to accomodate its size. As river channels are constantly altered by the natural processes of occasional floods and turbulences, dredging ship lanes have relatively high costs in rivers with a high occurrence of floods.

(Secure public safety)

In the recreational boating/tourism sector, securing public safety from both accidents and natural disasters is an important issue. The sector is very attentive to such potential 'risks' as weather, dangerous animals,

disease and floods and therefore keeps well-informed of the evolving situation.

2.3.6.2. How other sectors may impact the inland navigation/recreational boating/ tourism sector

(Impact by water users)

- The reduction of river flow volume may directly affect navigation at river channels. If the depth and width of a river channel used as a ship lane is significantly reduced by water users, the inland navigation sector would need to dredge river channels or prepare canals in order to support the displacement of vessels.
- Facility installation such as the construction of dams may interfere with the navigation of ships and boats from upstream to downstream or vice versa.

(Impact by flood management)

- The reduction of flood events as a result of effective flood management may sometimes cause sediment accumulation on river channels and an invasion of vegetation in riparian areas. Such changes may interfere with the vessel's navigation and require additional maintenance of shipping lanes.

(Demands by the environmental sector)

- The environmental sector demands that inland navigation/recreational boating/tourism sectors minimize the impacts of their activities. For example, the construction of a harbour and other facilities as well as dredging for maintaining shipping lanes should be carefully implemented and based on observations by environmental assessment.
- The frequency and volume of the activities in a river may be limited in a environmentally important area such as the habitat of endangered species. In order to reduce human impacts, it is desirable to minimize the presence of human activities such as boating.

2.3.6.3. Inland navigation/recreational boating/ tourism sector in relation to the management of environmental sustainability

- In the case of facility installation such as the construction of a harbour and/or dredging a shipping lane, it is important to minimize the environmental impact. Environmental impact assessments can provide useful measurements that prevent or reduce negative impacts in these cases.
- The presence of recreational ships and boats on a river may not have a significant environmental impact when their presence is not highly intensive. However, environmental impacts may become apparent as the intensity of activities increases. Thus, it is a good idea to conduct regulatory environmental monitoring to ensure and maintain environmental sustainability.

2.3.6.4. Inland navigation/recreational boating/ tourism sector in relation to IWRM and the advantages of IWRM

- As the navigational use of river channels by the inland navigation/recreational boating/tourism sector may interfere with those of other sectors, IWRM coordination may be helpful in harmonizing the various needs and requirements.
- If the inland navigation/recreational boating/tourism wishes to conduct a large infrastructure development or river works such as dredging, it could potentially enjoy a significant cost reduction if it is jointly implemented with other sectors.

2.3.7 Commercial/Subsistence Fishing Sector

- Maximize fishing efficiency while avoiding the reduction of fish abundance

Both commercial and subsistence fishing sectors set their primary focus on catching fish while reducing their costs associated with fishing activities, even though intensity of fishing varies between them. Because of the nature of fishing, which depends on a favorable natural environment, the sense of environmental sustainability is often naturally established among commercial/subsistence fishers. However, some typical practices may still have environmental impacts.

2.3.7.1. Interests of the commercial/ subsistence fishing sector

(Harvest of nature)

The primary objective of commercial/subsistence fishing sector is to catch fish and other valuable aquatic species, such as crabs. In most cases, their fishing activities depend on harvesting fish from rivers and lakes. The volume as well as types of fish harvested reflects the aquatic biodiversity of the local river or lake.

(Maximize economic benefit in commercial fishing)

Unlike subsistence fishing, the commercial fishing sector relies on catching as much fish as possible to increase its revenues. As a result, more profitable fish species, with higher market values, tend to be extracted more than commercially less valuable fish. For the same reason, non-native species, which have a

considerable impact on aquatic biodiversity, are occasionally introduced.

(Sense of environmental conservation for maintaining sufficient catch)
The fish catch directly reflects the condition of the natural river habitat. If the ecological quality of the natural habitat becomes degraded, the population of a certain species may consequently decrease to a level that affects fishing productivity. Therefore, the commercial/subsistence fishing sector is receptive to conserving the environmental conditions at an ecological sustainable level.
Considering fisheries and biodiversity from a basin perspective, it is worth identify, 'hot spots' for fish biodiversity and reproduction, keeping in mind that fish are to a great extent migratory.

2.3.7.2. How other sectors may impact the commercial/subsistence fishing sector

(Impact by water users)

- Environmental changes associated with aquatic habitats such as a reduction of river flow, degradation of water quality, a change in seasonal variability of the river flow and a reduction in flood events, may affect the habitats of fish and other valuable species.
- Facility installations such as the construction of dams also has various impacts. It may disturb natural habitats as well as lower the quality of the habitat making it unsuitable for fish. Also, the migratory movement of fish and other aquatic species may be interrupted.

(Impact by flood management)

- Alteration of the river flow regime or the seasonal variability of river flow may affect habitat quality downstream. However, occasional disturbance of rivers is a natural process that helps maintain the aquatic habitat through the process of ecological succession by refreshing river bed material and removing vegetation. Furthermore, some species have adaptated their migratory and breeding activity to seasonal flow variability.

(Demands by the environmental sector)

- The environmental sector demands that the commercial/subsistence fishing sector minimize the impacts of fishing activity by requesting a suitable control over the amount of fish caught as over-extraction may lead to local extinction of the fish population.
- In addition, the environmental sector may request that the commercial/subsistence fishing sector implement some environmental measures such as promoting the release of premature fish in order to sustain fish reproduction and fish farming for future stocks.

2.3.7.3. Commercial/subsistence fishing sector in relation to the management of environmental sustainability

- Despite the fact that the commercial/subsistence fishing sector is typically attentive to environmental conservation, the activities carried out by the sector does impact on the environment, for example in the case of over-extraction or fish harvesting. The introduction of non-native species for commercial fishing purposes also has a considerable impact on aquatic biodiversity.

2.3.7.4. Commercial/subsistence fishing sector in relation to IWRM and the advantages of IWRM

- Management of environmental sustainability by IWRM coordination is helpful to the commercial/subsistence fishing sector because the quality of the aquatic habitat is directly affected by fishing productivity. Reducing environmental impacts by other sectors in a river basin brings the promise of improved aquatic environments.

2.4 FLOOD MANAGEMENT SECTOR'S PERSPECTIVES

- Protecting the lives and properties of residents living in the river basin

The main objective of flood management is to minimize the damage to human lives and properties by floods. This objective is achieved mainly through reducing both the intensity and frequency of floods. Nevertheless, a flood is an important phenomenon or 'event' within a natural process and aquatic and riparian ecosystems, including those established within floodplains, have evolved by adapting to floods. For instance, occasional disturbances induced by floods help to refresh the habitats of aquatic species by removing litter and helping to relocate river bed materials. Environmental change as a result of floods, such as the removal of vegetation including trees and a modification of river morphology, have been integrated into ecological successions in a given area and helps keep ecological balances within the ecosystem.

2.4.1 Interests of the flood management sector

(Minimizing flood damage)

The primary dual concern for flood managers is to protect people and their properties in the river basin from floods and to minimize damage in a basin-wide manner. Promptly realizing the benefits of flood control measures is the priority of flood managers. In this regard, flood managers consider it necessary to collaborate closely with managers responsible for IWRM in order to ensure complete coordination such as warnings, evacuations and so on during flood events, with other sectors and stakeholders in a way that is as efficient as possible.

2.4.2 How other sectors may impact the flood management sector

(Impacts by water use sectors)

- In abstracting water from rivers, water-use sectors expect that their water-intake facilities and locations allow for efficient water diversion.
  - → Water intake structures may impede floodwater flow so fewer and smaller structures are desired.

- When developing multi-purpose water storage facilities such as dams, water-use sectors want to secure as much capacity as possible for water utilization.
  - → Due to the limitations of dam capacity, this may interfere with flood-control capacity and therefore efficient flood control operations.

- During flood events, the agricultural sector tries to drain stormwater from their agricultural land as quickly as possible in order to avoid prolonged flooding of crops and the resultant negative impacts to agricultural production.
  - → The timing and quantity of drainage needs to be controlled so that it takes into account river water levels.

- When a structure crossing a river channel (such as a distribution line for domestic, industrial or agricultural water) is being planned or designed by a water-use sector, they would try, as a rule, to find a location, direction or structural design for their structure (bridge, siphon or tunnel) that can distribute water in the most economical way, and which does not diminish the hydraulic capacity of the river to pass flood flows.
  - → In order to prevent such structures from restricting flood flow or negatively impacting flood control facilities such as levees, the water-use sector's plan – regarding the location/direction of the structure – would need to be changed to account for levels of impacts such as flood flow interference or impacts on flood control facilities and so on. It should also account for river improvement/construction plans such as for levees, facilities and watercourses.

(Impacts by the drainage and sewerage sector)

- Drainage and sewerage sectors want their drainage facilities and locations to enable fast and efficient stormwater drainage into rivers via urban or sewer drainage systems in order to prevent inland flooding.
  - → In areas where drainage facilities for inland flood control are extensively developed, but the river channel does not have adequate flood control measures implemented, drainage activities or the construction of further drainage facilities could cause the flood discharge capacity of the river to be exceeded. Prohibiting or restricting drainage operations/activities during flood events should be discussed with flood managers. It is essential that drainage locations are set in a manner that minimizes flood risk to the basin by accounting for areas that need to be protected or are vulnerable to flooding.

(Impacts by inland navigation/recreational boating/tourism)

- Navigation sectors or those who transport goods and people using boats may try to construct docks or mooring facilities in a convenient location in order to ensure efficient transport. They may also dredge channels in order to ensure adequate navigable space when identifying the preferred route for navigation.
  - → Such activities may interfere with flood flow. The facility locations and their size have to be accounted for and there must be coordination with their representative in order to prevent such impacts. Dredging may increase the discharge capacity of the channel but over-dredging or dredging close to structures could cause river flow to scour river facilities and cause negative impacts.

(Impacts by commercial/recreational fishing)

- Fisheries are dependent on the improved quality of rivers. Also, the connectivity of aquatic habitats for migratory species is vital in order to maintain the

fish population. The commercial, recreational and fishing sector require minimum infrastructure.

(Demands by the environmental sector)

- The environmental sector is concerned about the environmental impacts of constructing or improving flood control infrastructure.

- The environmental sector considers it desirable that habitats for fauna and flora be maintained in their natural condition to the furthest extent possible. They consider that native vegetation species, including trees in river channels, should be conserved.

- The environmental sector also considers that occasional flood's or hydrological variability is necessary to maintain existing habitats for fauna and flora. They consider that the riparian ecosystem is established on the balance controlled by natural events such as floods.
  - → Flood control will change the natural flow of rivers resulting in a reduction of both flood frequency and discharge downstream. In the natural riparian environment, occasional floods are considered to be the key phenomena or factor for controlling ecological succession and maintaining a certain balance in the ecosystem.

(Impacts by municipalities and developers)

- Urban development generally infringes on natural flood plains. Such developments can increase flood risks and will interfere with ecosystems.

- Increased urban development will reduce infiltration and water retention capacities of the basin areas resulting in higher peak discharges and a higher risk of flooding.

- Local municipalities and developers may wish to utilize the waterfront area of rivers and lakes, and promote the use of facilities situated in such areas for recreational purposes such as sports facilities, parks and promenades. They may wish to promote greater use of the river and water recreational spaces.
  - → More use of waterfront areas of rivers and lakes during flood events increases flood risks in the area. Locating facilities along the waterfront will also increase flood risk and affect riparian habitats.

(Relevance to society as a whole)

- Public awareness on the beneficial use of natural flood plains needs to be promoted and all means to maintain flood plains in their natural state need to be undertaken.

(Impacts by other sectors)

- When a structure crossing a river channel (such as roads, railways and lifeline infrastructure) is being planned or designed by other sectors, they would, as a rule, try to find a location, direction or structural design for their structure that is the most efficient and economical, and which does not diminish the hydraulic capacity of the river to pass flood flows.
  - → In order to prevent such structures from impeding flood flow or negatively impacting flood control facilities such as levees, coordination is necessary with other sectors regarding the location/direction of the structure and levels of impacts such as flood-flow interference or impacts on flood control facilities and so on. It should also account for river improvement/construction plans such as for levees, facilities and watercourses.

- People living in poverty may be living or cultivating on the flood plain of a river.
  - → This increases flood risks and risks to public safety. Coordination with other policy measures needs to be considered in order to prevent the proliferation of new settlements in areas of flood risk, and to facilitate the smooth relocation of existing inhabitants.

2.4.3 Flood management sector in relation to the management of environmental sustainability

- The focus of the flood management sector is to effectively reduce the peak water discharge during severe precipitation conditions. However, reducing flood discharge as well as frequency may affect the ecological balance in the riparian environment downstream because natural disturbances, as a result of occasional flooding, are important phenomena that help in protecting ecological succession in riparian environments. For example, floods help riparian vegetation to stabilize by regulating the invasion of tree species in river channels. Temporal turbidity of river flow refreshes riverbed materials and maintains algae as well as fish and benthos habitats.
- Flood management sectors install various types of flood-controlling infrastructure such as dams, levees, groins and dredging, depending on the specific purpose and site characteristics. Installation

of such infrastructure may bring environmental changes even though the induced changes differ with respect to the affected area, duration and forms of impacts and so on. Therefore, efficient infrastructure developments, through coordination with other sectors, can be beneficial in managing environmental sustainability. In addition, environmental conservation measures such as nature-oriented river works[3] demonstrate significant benefits for environmental sustainability.

- Integrated floodplain management requires a regulatory licensing process to coordinate floodplain activities, and enforced regulations emphasize non-structured flood plain management mechanisms among which include relocation from flood plain, restoration of the ecological habitat, improvement of riparian areas and so on.

2.4.4 Flood management sector in relation to IWRM and the advantages of IWRM in improving environmental sustainability.

Flood managements mainly focus on social and economic benefits in a river basin by protecting human lives and properties. However, it is important to recognize that flood management actually modifies the natural processes in a river basin and can have a negative impact on the environment. Therefore, adequately balanced, flood management schemes, in terms of social, economic and environmental benefits, are desirable for environmental sustainability. IWRM coordination among various relevant sectors, including the flood management sector and the environmental sector, will be helpful to achieve such balanced flood management.

- The management of flood risks needs to be planned through the involvement of various basin stakeholders, including development sectors, municipalities as well as residents.
- Flood managers are generally found on the coordination end of IWRM, with the relevant stakeholders and managers responsible for overall IWRM coordination.
- Flood risk management contributes to meeting overall IWRM objectives in the basin by preventing disastrous damage caused by floods, and hence enhancing the social and economic welfare of the basin. Its existing framework for negotiating with basin stakeholders can also be utilized for overall IWRM coordination, allowing for efficient stakeholder participation and coordination.
- Flood control not only mitigates flood disasters but also provides benefits for water-use sectors. Temporarily stored floodwater in facilities/reservoirs can be allocated for later water use. This can lead to cost effective multi-sector collaboration, where flood managers as well as water-use sectors can all benefit from working together.
- The roles of flood managers include the following:
  - prepare flood forecasting and warning systems.
  - firmly positioning flood risk management as part of IWRM objectives ensures that the prevention and preparedness capacities of the basin against future flood risks is enhanced.
  - consider that floods are known to be essential for maintaining ecological functions and services at riparian areas and flood plains, such as providing soil moisture, recharging groundwater, transporting fertile soils and so on. In some rural areas, such as the communities in the lower Mekong river basin, local communities have adapted their daily activities, including agriculture and fishery, to occasional flooding.
- In terms of environmental sustainability, occasional low intensity floods that adequately avoid severe social and economic impacts may even be recommended. In the decision-making process of flood management planning, it is important to maintain a proper balance between social and economic benefits and environmental costs. Coordination of IWRM will be significantly effective in this respect.

2.5 URBAN LANDUSE AND WATERSHED DEVELOPMENT PERSPECTIVES

- How to use available lands and water resource for sustainable development

Developments are typically associated with major alterations in landuse in a given area. In many cases, such landuse change results in environmental degradation through the transformation of natural lands to man-made lands.

2.5.1 Interests of the municipalities and developers

(Maximizing public conveniences and industry)
Local governments generally control development in

3 'Nature-oriented river works' refers to the implementation of a river project that gives due consideration to good habitats provided by a natural river and conserves or creates a scenic natural environment. Natural materials such as boulders and logs are often used in improvement works in substitution for artificial materials.

their jurisdiction. Local governments may consider developing housing and industries in the basin with public amenities and industry as their priorities. Such developments could increase the risk of flooding and could interfere with river improvement projects; they also may compete with environmental conservation efforts.

(Effective use of available land)
They may seek to make effective use of available land by promoting the development of natural and unused land. This will reduce the infiltration and water retention capacities of the basin areas resulting in higher basin runoff and a higher risk of flooding.

(Increase usage of waterfront areas)
Local municipalities and developers may wish to utilize and develop land in the basin to optimize the use of land resources. Increased usage of waterfront areas will increase the ecological degradation of riparian environments.

→ Local municipalities and developers may wish to utilize the waterfront area of rivers and lakes and promote the use of facilities situated in areas for recreational purposes such as sports facilities, parks and promenades. They may wish to promote greater uses of the river and water recreational spaces.

2.5.2 How other sectors may impact the municipalities and developers

(Needs of the environmental sector)

- The environmental sector requires that the municipalities and developers minimize the impacts of developing available lands or requests alternative measures. Watershed developments will increase the risk of contamination of the aquatic environment and would therefore need to be considered as part of IWRM.

- The quality of discharged water is another important focus of the environmental sector. Contamination of toxic compounds such as chemicals and heavy metals is always a source of environmental hazard in the downstream region. Therefore, during the construction phase, the environmental sector may request relevant measurements of the water quality discharged as well as monitoring, which ensures the effectiveness of such measurements.

(Impacts by water-use sectors)

- Cumulative effects of other watershed activities on streams and aquatic environments include, for example, resource extraction activities such as forestry, while sub-urbanization adds to the ecological degradation of the aquatic environment.

- Over-abstraction of groundwater by water-use sectors will lead to ground subsidence, which may result in unstable housing. Lowered ground levels will increase flooding risks and thus it is necessary to strengthen those facilities, i.e. with levees.

(Impacts by the flood management sector)

- Flood management sectors may consider requesting that development planners pay due attention to the risks of flooding so as to minimize flood damage. Developing housing and industries in the basin with public amenities and industry may increase flood risks and could interfere with river improvement projects.

- Coordination with the flood management sector may be required in developing waterfront areas because it could increase the risk of flooding. It may also interfere with river channel improvement. Development in the basin reduces stormwater permeability and the storage capacities of the basin as flood runoff increases and heightens flood risks in the area.

2.5.3 Municipalities and developers in relation to the management of environmental sustainability

- Available lands for new developments by municipalities and developers are often areas that are maintained in a natural condition or relatively undisturbed. In other words, available lands for the public and industrial sectors are, in reality, already used and occupied by native species and the ecosystem.
- Flood plains, including riparian areas, and unused land near developed areas tend to be vulnerable to development. Even though these flood plain environments have unique ecological functions and support the existence of diverse wildlife resulting in the establishment of local biodiversity, cost-performance is often considered more important than the conservation of biodiversity.
- Landuse management that controls non–point source pollution is a necessary component of IWRM and should thus be considered in future planning.
- There is a need to ensure that runoff from the developed landscape does not harm the ecological function of the receiving water bodies.

2.5.4 Municipalities and developers in relation to IWRM and the advantages of IWRM

- Developments implemented by municipalities and developers may have significant impacts on ecosystem conservation and environmental sustainability. Such impacts may be reduced by adequate landuse planning and by carrying out conservation measures through IWRM coordination involving relevant sectors, including the environmental sector.

2.6 OVERALL COORDINATION PERSPECTIVES

- Are stakeholders engaged? Is the action socially justifiable and environmentally sustainable?

Together with managers responsible for overall IWRM coordination, the environmental sector generally coordinates with the relevant stakeholders. The principle of IWRM coordination requires maximum participation of stakeholders – a process that can take a long time. Close collaboration and a good understanding of the need for better management of environmental sustainability by IWRM coordinators is necessary to ensure that adequate priority is given to managing environmental sustainability within the overall water resources management objectives, and that the benefits of environmental sustainability can be achieved in a timely manner.

The last part of this chapter describes how managers in charge of coordinating IWRM in the basin (such as in a river basin organization) think and act with respect to environmental aspects.

IWRM is a process that (1) promotes the coordinated management of water resources among all stakeholders, (2) integrates management of water and land resources, and (3) facilitates information-sharing and participation among the people involved.

Managers coordinating the IWRM effort understand the necessity for IWRM and seek to make progress. However, this requires a firm understanding of the interests and concerns of other water-user sectors, particularly needs for management of environmental sustainability.

The water resources manager leading the coordination may not be aware of the history of water use or flood control efforts in the basin, or may set unrealistic goals from the beginning, or rush to reach a consensus without sufficient assessment or consultations. It is important that the views of each sector are well understood by those leading the coordination process in order to ensure that it proceeds smoothly and efficiently.

Water resource managers need to identify all opportunities for environmental improvements within every water use sector considered under IWRM.

Coordinators can sometimes be influenced by the supporting organization or opinions of political decision-makers, but unjust coordination will cause problems later on. For example, if a stakeholder thinks that he/she has been disadvantaged during coordination when developing an infrastructure, it will become extremely difficult to obtain his/her approval when seeking consensus as the infrastructure ages and needs to be rehabilitated or improved.

It is also important that the coordinator is socially trusted, and that the content of the IWRM coordination is justifiable to all relevant stakeholders and society. Thus, ensuring transparency through proactive information dissemination is one of the coordinator's most important responsibilities.

Moreover, collaboration with sectors other than those related to water could enhance IWRM coordination. Landuse management is a good example. For example, land and water resources can be utilized more efficiently by ensuring consistency in river improvement through urban or agricultural landuse planning, and developing roads or agricultural infrastructure simultaneously. By establishing the possibility of coordination with sectors other than water sectors, the coordinator will be able to gain the trust of other water users.

Effective collaboration with IWRM coordinators can lead to smoother implementation of IWRM management of environmental sustainability and can also contribute to other water-related sectors leading to cost effective multi-sector collaboration.

3. Key for Success to Manage Environmental Sustainability in IWRM

A 'Key for Success' (KFS) in terms of managing environmental sustainability is an idea/information that can be used in practice to help make IWRM succeed. They are keys for establishing breakthroughs in challenging situations, or to opens door to better IWRM. They provide tips and clues for making progress in the IWRM process (see Fig. 3.1).

Many of the keys for success have been proven in practice and are linked to Practical Examples in Chapter 5. Some are generic, in other words, apply to every successful example of IWRM; others may apply only to specific situations, and some may not be in place as yet. You do not have to apply them all. Work with them to see how they can assist you to move ahead with IWRM implementation in your basin.

Each 'Key for Success' is explained using the following format:

- Key: The essence of the 'Key for Success' is indicated in bold in the box.
- Why: The reason why the 'Key for Success' is important or useful is indicated in the box.
- How: The ways of implementing the 'Key for Success' are indicated outside the box.

You will also find links to **Useful Tools** and **Practical Examples** for easy reference.

To achieve success in managing environmental sustainability, it is critically important to pay attention to the relevant data in order to recognize the environmental condition. Thus, it is important to identify available data as well as additional required data, which will be explained in more detail in section 3.2.1.3.

Also, IWRM can be smoothly implemented by applying the idea of 'Ecohydrology' which focuses on ecological processes occurring within the hydrological cycle and strives to utilize such processes for enhancing environmental sustainability.
Ecohydrological approach can expand the understanding of ecological and hydrological process in a basin and their interactions and vice versa. Ecohydrological approach is also related to human activities in its way of managing environmental sustainability such as regulating flood control and improving water quality as well as enhancing ecological carrying capacity (e.g. biodiversity, ecosystem services).
Thus, Ecohydrology can become a component of IWRM, and the idea of the ecohydrological approach is important in order to implement the majority of KFSs explained in the following paragraphs.
For further information on the ecohydrological approach, please refer to Chapter 6.1, 'Ecohydrological approach'.

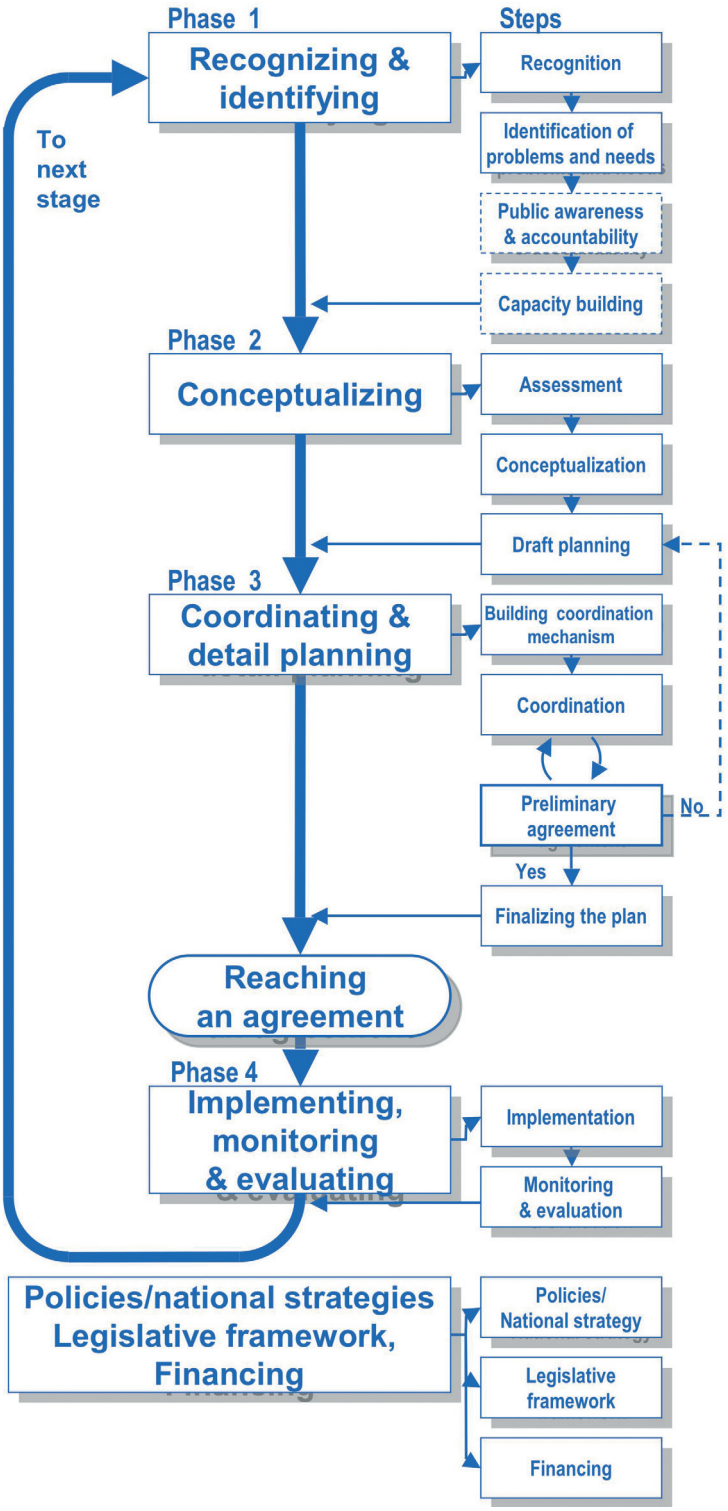


Fig. 3.1 IWRM Process

3.1 RECOGNIZING AND IDENTIFYING

The important part of this phase is to 'recognize' the need for IWRM and to grasp the overall picture of existing issues in the basin. Things to note in this phase are:

- Do you understand the needs and problems? Are you in need of IWRM?
- Are you aware of past evaluation results and the current situation?
- Are you thinking into the future?

Recognizing the need for IWRM through the identification of needs and problems in the basin becomes the catalyst for improving water resources management in the basin. It is important to proactively 'recognize' the needs, and your understanding of the situation can be measured by how well you can make others understand. You can identify existing basin-wide issues by exploring the needs for improving existing approaches or schemes based on existing or past evaluation results, and by being alert to newly-arisen problems or issues as a result of socio-economic and environmental changes.

3.1.1 Recognition

3.1.1.1 Status recognition

Recognize the environmental status of the river basin, including environmental problems that need to be solved.

- In order to recognize problems to the environment and countermeasures to them, make use of available information and existing data to discover the current environmental status of the entire river basin.

- The first step towards achieving environmental sustainability through IWRM is to understand the current environmental conditions in the river basin and to identify problems associated with environmental sustainability.

- It is important to identify and prioritize the information necessary for evaluation or decision-making. To implement this, it is advised to collect/organize the following information.
  - Gather information regarding locations and areas of ecological importance (e.g. habitats of endangered species, or the main corridor of the ecological network).
  - Establish which information is significant: be aware of the sites, observe the basin and listen to people's opinion.
  - Verify the objectivity of the gathered information.

- According to the level of information gathered, attention should be paid to the following points:
  - Use information published by official organizations such as United Nations, World Bank and governmental organizations.
  - Acquire latest information so as to precisely recognize the current environmental status of the river basin.

- It is important to disseminate and share the collected information and assessment results with stakeholders and residents of the basin.

Useful Tools

>> Motion charts for visualizing long-term water quality, p. 119

3.1.1.2 Effort recognition

Recognize efforts to conserve the environment in the river basin.

- It is important to recognize the efforts of environmental conservation in the river basin as much as possible. The public sector as well as the private sector and NGOs may play important roles in environmental conservation.
- Find practitioners' as well as organizations' specific environmental interests and concerns. Communicate with stakeholders.

- Managing environmental sustainability has a close relationship with environmental/ecological conservation. The key idea of environmental sustainability is to maintain the environment's physical and biological features in such a way that ecological functions and services will be provided in a sustainable manner. In other words, keeping environmental or ecological change at the level at which environmental degradation will not ensue.

- Due to the increase in awareness of environmental/ecological conservation in recent years, activities or efforts towards environmental conservation have taken place in many regions. Furthermore, in some areas, the effort of environmental restoration to its original natural condition is implemented.

- Consideration of these those efforts and activities should be taken into account when implementing the management of environmental sustainability in IWRM.

- The following information should provide useful ideas in achieving appropriately adequate management of environmental sustainability in the river basin:
  - Search environmental/ecological conservation practitioners or organizations. Understand their objectives and content of activities. Also, see if their efforts are successful and demonstrate tangible benefits. Furthermore, it is useful to know about the problems they face and their approaches in resolving those problems.
  - Even if efforts towards environmental conservation are not found, there is a possibility that daily acts by local residents may contribute towards environmental sustainability. Knowing such acts may give a clue to managing environmental sustainability in the river basin.

- Environmental sustainability as well as environmental conservation and restoration require continuous efforts for a long period of time. Thus, it is a good idea to understand the existing efforts to be able to incorporate them into the management of environmental sustainability schemes in the river basin. Experiences and knowledge obtained from such efforts are always useful in planning any future action.

3.1.2 Identification of problems and needs

3.1.2.1 Identification of actual and future priority area

Identify actual and future priority areas (critical locations and key issues) as well as objectives for sound management of environmental sustainability within the context of IWRM in a river basin.

- Important locations or key issues need to be addressed first in order to achieve effective implementation of IWRM leading to the management of environmental sustainability.
- Such priority areas can be identified through an assessment of the current status of water resources as well as water use in the basin. Pressing issues including water pollution, environmental degradation and natural disasters are such examples.

- Explore and identify issues and problems currently occurring in the basin as well as potential future issues.

- It is important in the first instance to roughly estimate the available amount of water in the river basin and the extent of water use. If the basin's water resources are used extensively, it is desirable to study in detail the natural and original capacity of the basin. Determining the water budget in the basin will be useful in understanding the current status of the basin's water resources.

- It is desirable to identify priority areas (critical locations and key issues) before coordinating the interests of sectors. An example of a critical location can be where there exists an overlap of interests due to a rapid increase in water demands or severe pollution loads, or areas of ecological significance such as a place where protection of endangered species is a critical concern.

- Potential priority areas for managing environmental sustainability include:
  - Habitats for endangered species.
  - Habitats that support 'keystone' species and/or high biodiversity.
  - Habitats that are relatively rare in the river basin.

- It is helpful to have an understanding of the historical background of water usage as well as environmental aspects in the basin, and how they have changed compared to the past. Look through documents and historical records or communicate directly with local elders. Hearing form local people helps understand their viewpoints, and the information obtained becomes a persuasive tool for later coordination and negotiation.
    - Effort must also be made to address not only the current issues but also prospective needs and challenges in the future, for example, looking for opportunities to restore the degraded habitat and flood plains.

Practical Examples

>> Extracted Key for Success from Citarum river (Indonesia) (3), 'Area pollution sources management', p. 76
>> Extracted Key for Success from Arakawa river (Japan) (2), 'Formation of Consensus through Participation of stakeholders', p. 108

Useful Tools

>> Environmental status mapping tools, p. 118
>> Motion charts for visualizing long-term water quality, p. 119

3.1.2.2 Assessing the long-term environmental changes in the river basin

Identify the effects on the river, lake and estuary ecology associated with various changes in the river basin.

Changes in the basin, such as urbanization, agriculture and industry, the natural hydrological cycle, water quality, erosion and sedimentation, may affect the environment of the river basin throughout the water cycle. Therefore, it is necessary to research the effects of change in the river basin and assess the long-term environmental changes.

- Early detection of environmental change and the implementation of necessary measurements are important for the efficient management of environmental sustainability. If adequate treatment is delayed, the cost for such treatment might increase, while the possibility of recovering the original condition is reduced.
- However, since the environment involves a wide range of aspects, and many environmental changes are not sudden but very gradual and continuous, such changes might be undetected if they are not carefully and properly monitored.
- Environmental change somewhere in the river basin often shows up in changes or effects in river and lakes. Such changes tend to be apparent in estuary ecology in the riparian environment. Therefore, monitoring and assessing long-term environmental change in the riparian environment can be effective in the early detection of environmental change affecting environmental sustainability in the river basin.

Practical Examples

>> Extracted Key for Success from Citarum river (Indonesia) (4), 'Rehabilitation of Degraded Watersheds', p. 77

Useful Tools

>> Ecohydrological approach, p. 117
>> Motion charts for visualizing long-term water quality, p. 119

3.1.2.3 Hydrological variability in terms of water quality and quantity

Identify the causes and effects of current water management practice on water quality, quantity and variability in the basin on ecosystem functions and services.
Identify options for improving water quality, quantity and variability on ecosystem services for both water and land management.

- Hydrological variability (water quality, water quantity) affect the ecosystems and human life.
- The extent affected will depend on the nature of each river basin. Therefore, it is necessary to determine the effect of water quality in the river basin.

- It is important to recognize that maintaining hydrological variability in river flows and lakes is crucial to the effective management of environmental sustainability in the river basin because water is one of the fundamental constituents of habitats and ecosystems.

- From the environmental standpoint, three basic characteristics of water are considered: water quality, quantity and variability.
  - Water quality includes pH, temperature, COD and BOD, DO, SS, as well as toxic chemicals and heavy metals. All species have a tolerance level or a range within which they need to survive.
  - Water quantity is often important in terms of river flow. If the amount of river flow is severely reduced, some species, for example fish and hygrophytes with low tolerance levels, may eventually disappear resulting in the degradation of both the aquatic and riparian ecosystem. Therefore, the minimum amount of river flow that can satisfy environmental needs is called the 'environmental flow', and great attention should be focused on this measurement in order to maintain an adequate environmental flow for environmental sustainability.
  - The variability of water, or river flow, is another important aspect of environmental sustainability. The natural environment in a riparian area is based upon the balance between stability and disturbance induced by various factors, including natural events. Under natural conditions, the river flow is one of the main factors causing disturbance. Seasonal changes in river flow and occasional floods are known to change instream morphology and affect ecological succession.

- Environmental responses caused by hydrological variability differ among river basins. It is important to identify how the environment and ecosystem in your river basin will be affected and transformed by such changes in river flow. One possible approach is to investigate environmental changes in relation to reconstructed river flow in the past.

Practical Examples

>> Extracted Key for Success from Arakawa river (Japan) (1), 'Preservation of Ecosystem', p. 106

Useful Tools

>> Ecohydrological approach, p. 117
>> Environmental status mapping tools, p. 118
>> Motion charts for visualizing long-term water quality, p. 119

3.1.2.4 Instream morphology and floodplain connectivity

Identify the importance of instream morphology and flood plain connectivity on ecosystem function. Research the effects of physical hydraulic alterations and its effect on environment and ecosystem functions

- Physical effects of river flow may affect ecosystems and may cause water quality degradation, therefore it is necessary to maintain appropriate water quantity levels.
- Sediment processes are important features for maintaining and restoring flood plain ecosystem structure and functions.
- Aquatic habitat connectivity is the cornerstone of successful management of environmental sustainability.

- Physical hydraulic alternation is one of the main factors controlling the riparian environment. A change in the amount of river flow induces both a qualitative and quantitative alteration of habitats, which eventually leads to changes in population size and the composition of existing species. As a result, ecosystem functions and services in a particular location in a river basin may be reduced. It is important to recognize that drastic changes of water quantity can cause severe environmental damage.

- The 'water quantity necessary for the ecosystem' is known to be the 'environmental flow'. There are numerous documents or guidelines in this respect. Defining adequate environmental flow in a river is a complex process due to the fact that there are many contributing factors to be included in decision-making. However, maintaining environmental flow in a river is required in order to achieve environmental sustainability.

- Sediment process and flood plain ecosystems are highly interrelated and therefore it is important to identify how the sediment process has occurred and managed in the river basin.

- Aquatic habitat connectivity from rivers to riparian forests is crucial especially for some species that need both environments for their lifecycle. Also the connection of aquatic habitats provides variable environments such as spawning sites for fishes. Thus, the flood plain connectivity should be considered in terms of managing biological diversity by conserving or restoring in the process of environmental management and planning.

Useful Tools

>> Ecohydrological approach, p. 117
>> Environmental status mapping tools, p. 118

3.1.3 Public awareness and accountability

3.1.3.1 Public awareness, transparency and accountability

Share information on the status of the environment in the river basin with other sectors and stakeholders.

- Stakeholder participation is a crucial element in IWRM implementation. Public awareness, transparency and accountability are indispensable for facilitating coordination and negotiation among stakeholders in order to reach agreement on a plan.

- Public awareness, transparency and accountability are fundamental activities in IWRM because stakeholder participation is a crucial element in IWRM in the smooth coordination and negotiation among stakeholders in order to reach agreement on a plan. In addition, the environmental condition in a river basin always transforms one state to another in a complex manner under the influence of interactions between physical, biological and social elements in a river basin. Therefore, for a common understanding of the current environmental situation, shared information needs to be 'alive' or up-to-date.

- It is also important that information-sharing be achieved so that it contributes towards coordination and negotiation among stakeholders by providing transparency and accountability. The selection of information to be shared is necessary because environmentally-related data can often be too large to be delivered. However, it is important that shared information, which may have significant consequences affecting decision-making and public awareness, be included. Disclosure of information including inconvenient data for you or specific groups, such as negative information on the action or plan implemented, is important if you wish to avoid misunderstanding as well as deter future problems and conflict.

- Information related to the current environmental conditions is collected in various sectors operating in a river basin. Therefore, every sector and stakeholder should recognize that they can make a significant contribution to the process of public awareness, transparency and accountability. Information gathered from different stakeholders enhances understanding not only from the viewpoint of environmental status but also on the environmental problems and issues in the river basin. This understanding should help promote public awareness in environmental sustainability.

Practical Examples

>> Extracted Key for Success from Bermejo river (Argentina) (2),'Identify key needs in potential priority areas (critical locations and key issues) for IWRM implementation in the basin. Identify the ecosystem management objectives', p. 84
>> Extracted Key for Success from Bermejo river (Argentina) (3),'Develop alternative environment management plans', p. 85

Useful Tools

>> Motion charts for visualizing long-term water quality, p. 119
>> Decision support system, p. 119

3.1.3.2 Environmental education

Promote educational activities on environmental sustainability in the river basin.

- A river basin is an appropriate unit for learning about the importance, complexity as well as the difficulty of sustainable developments. All activities or events taking place within a basin, including agriculture, industry and water-related disasters, have consequences on environmental sustainability.
- Therefore, environmental education relative to the river basin, together with other features (e.g. water utilization and water-related disasters) is recommended. Target groups should include both policy- and decision-makers. It is also recommended to have an opportunity to learn about environmental sustainability through formal and non-formal education.

- Awareness among the general public including children and women is important in terms of environmental sustainability. Environmental education can be included in the school curriculum, or workshops on environmental sustainability can be organized targeting the general public. The awareness built through such programmes can then extend to their families and, through everyday activities, can spread throughout communities. Examples of awareness-raising activities include:
  - Incorporating environmental education, especially on the sustainable use of the environment, into school curricula in areas where there are schools.
  - Holding contests related to environmental conservation activities in the local basin as part of school education.
  - Holding workshops or field excursions to promote understanding of the local environment and ecology.
- Local activities are an essential part of environmental sustainability because maintaining the environment in a sustainable manner requires continuous activity on a daily basis. Such activities are hardly possible if the importance of environmental sustainability is not understood.
- Non-formal education, for example provided by environmental NGOs, also plays an important role in environmental education as formal education is often limited with neither the spare time nor enough trained staff to teach environmental sustainability to every stakeholder involved in IWRM. In addition, non-formal education activities by local public entities and NGOs often fully reflect the local situation and are therefore highly effective in cooperative efforts.

Practical Examples

>> Extracted Key for Success from Bermejo river (Argentina) (7), 'Promote education of river basin environment', p. 89

3.1.4 Capacity-building

3.1.4.1 Promotion and development of necessary knowledge and capability

Promote capacity-building by developing the capacity of leaders and managers who can recognize problems, find necessary solutions and implement them.

- Coordination with the many stakeholders requires leadership. Leading a coordination effort requires a good understanding of the positions and opinions of individual stakeholder groups, while keeping sight of the overall picture. An important ability of such a leader is the skill to recognize problems and find solutions to implement IWRM and management of environmental sustainability.
- An appropriate understanding of the problems and an extensive knowledge and understanding of the basin is required in order to develop knowledge among indigenous people, which can be achieved by using capacity-building as one of the tools.

- To promote capacity in terms of environmental sustainability, it is crucial to develop capacity-building for institutions. It is important to support water managers who are able to understand the relationships between such water issues as the water environment, water use and water-related disasters.
- Conduct regular seminars for water managers to promote recognition and the implementation necessary to achieve adequate management of environmental sustainability.
- Not only the capacities of the person leading the coordination, but also the capacities of the representatives of individual sectors need to be developed.
- IWRM coordination requires an appropriate understanding of the problems faced by each sector, and an extensive knowledge and understanding of the basin as well as ample experience, the ability to understand diverse perspectives, and the willingness to learn and gain wisdom backed by knowledge and experience.

Practical Examples

>> Extracted Key for Success from Bermejo river (Argentina) (5), 'Recognize status of environment of the river basin. What needs fixing?' p. 87

3.1.4.2 Technology transfer and development

Transfer and adaption of best management of environmental sustainability practice that reflect local conditions.

- Adapting technology from other basins or countries that has demonstrated proof of effective technological development or effective application of the technology.
- Technologies concerning conservation and restoration of the river environment may be developed for unique circumstances.

- In order to tackle the local situation, it is necessary to undertake technological development/application proven to be effective, and building upon regional experience.
- In areas where funding for environmental conservation measures is insufficient, it is particularly important to adopt comparable technologies utilizing affordable and locally accessible materials. In many cases, less costly technologies or low cost measurements can effectively solve problems.
  - o Research traditional local techniques applied in order to improve natural environments and habitats.
  - o Establish/revise technological standards, and so on.
  - o Develop technologies for the efficient collection/distribution of information from various sources.
- Many local resources are usually developed under local circumstances and thus can be applied to produce adequate results.

Practical Examples

>> Extracted Key for Success from Werra river (Germany) (3), 'Cost-benefit analysis', p. 67
>> Extracted Key for Success from Bermejo river (Argentina) (5), 'Recognize status of environment of the river basin. What needs fixing?', p. 87
>> Extracted Key for Success from Murray-Darling (Australia) (2), 'Innovative methods of application of environmental flows', p. 96

3.2 CONCEPTUALIZING

The point of this phase is to understand the overall structure of the problem and conceptualize future actions. Things to note in this phase are:

- Is it in line with social demands?
- Is it well balanced?
- Do you understand the constraints, and are you exploring 'what you can do?'

By viewing the structure of the problem from a broader perspective, you will be able to find clues, or a place to start to find a solution. Furthermore, you will have to consider the course of action and the relevant stakeholders and their relationships in order to tackle the problem. You can conceptualize possible solutions by laying out various alternatives that meet the basin-wide balance between economic, social and environmental needs, as well as the balance between supply and demand, and the balance among stakeholders, then narrow down the list on the basis of the given constraints. You will have to reject certain aspects of your ideal plan in order to make implementation a reality.

3.2.1 Assessment

3.2.1.1 Defining Goals

Conceptualize the environmental requirement within IWRM, and set the goals for managing of environmental sustainability.

- To conceptualize future actions needed to solve identified environmental problems, it is important that the goal you want to achieve through IWRM is set within an appropriate time schedule.
- To reach consensus of IWRM for the river environment, the goals set should be feasible.

- As the leader of managing environmental sustainability in IWRM, the environmental sector is responsible for conceptualizing the environmental requirements and options (or methodologies) to achieve its goals. Make sure that the goals are not only environmentally sound but are also acceptable to other sectors. Highly conservative goals focusing on thorough environmental conservation or preservation may be unacceptable by other sectors and so reaching public agreement may not be achievable. Hence the importance of setting realistic targets.

- At the same time, it is advised that the environmental sector makes its position clear from the outset when starting the coordination process. However, the position needs to be fair and feasible with respect to environmental, social and economical standpoints.

- You should observe carefully whether or not the coordination mechanism is favourable to the environmental sector's interests while remaining satisfying to the sector when coordination is left to other persons/organizations.

3.2.1.2 Defining Stakeholders

Identify key stakeholder groups, including those who are impacted or socially vulnerable, and identify key persons within them.

- Knowing key stakeholder groups or individuals and getting them involved at an early stage will facilitate coordination when managing environmental sustainability. The involvement of key persons who have influence over decisions within their sectors/stakeholder groups is important for later consensus-building.

- Identify at an early stage the key stakeholder groups and key persons or individuals within them who can provide useful input and/or facilitate coordination when managing environmental sustainability.
  - Begin by first visiting each individual group. Ask and obtain information about their circumstances and opinions as regards the management of environmental sustainability through informal interviews and meetings. Bear in mind that planning has already begun.
  - When the appropriate representative of a sector is not clearly obvious, it may be useful

to begin by talking with elders or those who are familiar with the area's species and its natural history as well as fishery and forestry.

- Approaching impacted stakeholders can be particularly difficult. However, disregarding their involvement can often lead to major impediments later on. It may be difficult to approach them at the very beginning, but it is necessary to identify key people early on and work towards an appropriate timing to encourage their participation.

3.2.1.3 Identifying available information and additional required data

Identify available information and make good use of existing information.

- It is important to maintain a broad view and be aware of the history, trends and issues in the basin. Information such as the opinions of the local elders, general public interest and political discussions in local and national governments may provide good ideas. If the IWRM process is well underway, the utilization of monitoring and evaluation results is effective in identifying areas for improvements.
- When prioritizing data collection, it is necessary to consider the time, efforts and costs required. Do not collect data in an exhaustive way. First collect and examine existing or readily available data.

- When introducing an IWRM approach for the first time, monitoring or evaluation results from the past may not be adequate or entirely available. However, it is not necessary to conduct a new extensive and exhaustive survey to obtain new information as this may delay the entire process. What is important in this phase is to utilize the existing information, understand the changes occurring in the natural and socio-economic environment, and recognize the necessity for an IWRM approach.

- In cases where monitoring and evaluation of past IWRM activities exist, it is possible to re-evaluate past efforts based on the monitoring and evaluation results and identify existing challenges.

- When the necessary data is unavailable, it may be possible to deduce the required information from other data. For example, river flow can be estimated from rainfall data. The possibility of utilizing the data to extrapolate other necessary data should be thoroughly evaluated.

>> Extracted Key for Success from Citarum river (Indonesia) (3), 'Area pollution sources management', p. 76

3.2.2 Conceptualizing

3.2.2.1 Identifying options

Identify a range of options available to achieve goals for managing environmental sustainability.

- Since there is always uncertainty in the effect of options on environmental response, an option may not necessarily achieve the expected result. It is advisable to have multiple options from the outset.

- When preparing options, it is necessary to have 'variety' among them. If two options show many similarities, they should not be considered as multiple options. Multiple options need to present differences in approach, effectiveness, costs and benefits, and so on. Therefore, it is important to prepare options having dissimilarities in their advantages and disadvantages.

- In addition, it is also recommended to evaluate the level of uncertainty in each option. As regards environmental measurements, the uncertainty can be the main factor for consideration in the decision-making process.
- If the uncertainty is large and key to making a decision, it is important to institute a monitoring programme and re-evaluate with the acquired data from monitoring.

3.2.2.2 Harmonizing the related plan

Harmonize related plans including those from outside the water sector.

- Harmonizing related plans can help prevent conflicts at a later stage. Other sectors would include landuse, regional development, disaster prevention, environmental conservation, forestry, agricultural development, and so on.

- In addition to water-related sectors such as water supply for domestic or agricultural uses, protection of water quality and the aquatic environment, and flood management, other sectors not directly involved – but often related – include health/sanitation, urban planning or private sector development. It is important to be aware of plans made by all related sectors and share those plans among them. This helps to avoid duplication, and also leads to planning among sectors for win-win situations.

- To understand other related plans, it is important to be aware of the relevant background and intentions. This information can be obtained directly from the person involved in planning. Refer to '2. Sectoral Perspectives in IWRM' in this document for information on sectoral perspectives in IWRM. Understanding the intentions of the individuals in charge of their respective sectors can help facilitate coordination when managing environmental sustainability.

- Depending on the maturity of the plan and the stage of the planning process, options for developing multi-purpose infrastructure and ways of managing environmental sustainability should be considered

- The appropriate balance at one time may become inappropriate later as social changes or economic developments progress. Be ready to revise the plan when necessary. It will be necessary to evaluate the plan even if it is already at the implementation stage.

Practical Examples

>> Extracted Key for Success from Werra river (Germany) (2), 'Balance of material', p. 66

Useful Tools

>> Ecohydrological approach, p. 117

3.2.2.3 Harmonize multiple objectives for water management

Harmonize multiple objectives taking into account the appropriate balance among water-related sectors in the whole basin.

- Water resources management plans should take into account the balance within the whole basin, including long-term changes such as socio-economic changes. It is difficult to achieve consensus on a biased plan and such plans can lead to future conflict.

- Harmonizing multiple objectives among water-related sectors means assigning benefits through water among areas or sectors for maintaining social fairness within the basin.

- In this case, 'harmonized' does not imply that everything is fair and equal. An appropriate balance among water-using sectors and the environment, and among upstream and downstream, must be based on appropriate development standards (capacities against floods and droughts, and so on) for the entire basin area, accounting for social, economic, and environmental needs, and the demands and requests of various sectors and future forecasts.

- There is no prescribed method for determining the appropriate harmonization. Consider where you stand in the IWRM spiral and identify priority issues and possibilities for trade-offs. Refer to other cases and see how they have determined their appropriateness.
- 'Harmonizing' may provide you with some insights. Refer to Chapter 4 for a further description of the IWRM spiral.

- Prepare future scenarios by combining various options based on the expected future sector's needs, costs and timings of implementation. Simulating such future scenarios could facilitate the harmonized management of environmental sustainability.

- Plans prepared by individual sectors must be consistent in order to realize a 'harmonized' plan. Check for inconsistencies, discrepancies, or overlaps. It is a good idea to make information 'visible' by displaying it through figures or graphs with quantitative indicators. Doing so makes it possible for stakeholders to share a common understanding of the present situation and thus facilitate consensus-building.

- When conducting simulations with combinations of various options and planning based on their results, it is important to verify the gap between the simulated results and actual situations in the field. Being consistently aware of the actual field situation will help identify such gaps.

- Moreover, it is desirable to regulate water use, not only under normal circumstances but at times of water shortages such as drought in order to secure a sufficient quantity of water in the river flow.

- In the case of water shortage – depending on how severe the situation is – the importance of securing a sufficient quantity of water in the river flow should be considered.

Practical Examples
>> Extracted Key for Success from Werra river (Germany) (3), 'Cost-benefit analysis', p. 67

Useful Tools
>> Ecohydrological approach, p. 117
>> Decision support system, p. 119

3.2.3 Draft planning

3.2.3.1 Alternative plans

Develop alternative environmental management plans that balances with water resources management objectives and environmental objectives.
- An improvement plan related to the river environment and implemented by respective stakeholders, as well as setting targets in the public water area are useful since effective results are usually derived from having a complete perspective of the issues in a basin.
- It is essential to consider a water management plan since alternative environmental management plans cannot be independent from it.

- The purpose of preparing multiple plans in environmental management is to accommodate the strengths and weaknesses of each element of the plan so as to improve the chances of reaching agreement among the relevant sectors, and which allow for flexibility in cases of uncertainty. Therefore, it is deemed necessary to arrange a set of alternative plans so as to have clear differences in the nature of each plan. To be more precise, each plan should be unique in terms of expected costs and benefits.

- It is also recommended that a set of alternative plans include a difference in the level of environmental consideration – from high to low. For example, one of the plans should set its target at the maximum level of environmental conservation while one plan should place more emphasis on economic or social consequences with the minimum level of environmental conservation but still sufficient to maintain environmental sustainability.

- Because the impact of the environmental management plan covers the various activities of the many sectors in a river basin, commensurate coordination and negotiation is imperative for successful planning.

- Water has many stakeholders, and individual sectors can be implementing measures in accordance solely with their own relevant plans, which puts the sustainability of water management in the basin at risk. Thus managing water and implementing water-related projects requires sector cooperation and coordination.

Practical Examples
>> Extracted Key for Success from Werra river (Germany) (3), 'Cost-benefit analysis', p. 67

Useful Tools
>> Ecohydrological approach, p. 117

3.2.3.2 Environmental Assessment

Conduct environmental impact analysis for assessing environmental impact on the draft plans and environmental benefit analysis to evaluate social and economic impacts.

- In the process of formulating a plan, it is recommended to prepare data or facts that support the credibility of the plan based on investigation using knowledge, experience and available techniques. For example, environmental impact analysis including modeling, forecasting and evaluation based on applied scientific and engineering techniques will provide some clues on the plan's suitability with respect to ecological and environmental aspects.
- Also, environmental benefit analysis that evaluates the benefits and costs of the plan based on social impacts will help measure the validity of the plan within the social and economic context.

- Environmental assessment covers a wide range of topics from environmental (ecological) to social (economical). Therefore, the process of such an analysis can be fairly costly and complex requiring a long lead-time, depending on the type of analysis to be conducted. In order to implement environmental impact analysis, the following considerations should be noted:
  - Choose the topics or elements included in the analysis. Understand the nature and characteristics of the target plan and outline the subjects for such analysis. If there are available examples similar to the target plan, utilize the information and experience of such examples. Also, try to incorporate stakeholders' opinion in the process of outlining the environmental assessment for better coordination and negotiation among the relevant sectors.
  - Incorporate reliable experts in the process of analysis. The analysis often becomes highly specialized and thus it is advisable to use the knowledge and experience of the experts for satisfactory results in terms of reliability.
  - Maintain the transparency and accountability of analysis by disclosing the positive and negative results as well as clarifying uncertainty in the resultant analysis. The result of environmental assessment becomes the basis of decision-making in the coordination and negotiation process.
- A wide variety of technologies and methodologies are available for environmental impact analysis such as GIS, statistical modeling and various investigation techniques developed by the scientific field of environmental accounting. Experts should be at hand to provide such techniques.

Practical Examples

>> Extracted Key for Success from Oigawa river (Japan) (1), 'Formation of Consensus through Participation of Stakeholders', p. 114

>> Extracted Key for Success from Citarum river (Indonesia) (2), 'Basin-wide Water Quality Management', p. 75

Useful Tools

>> Environmental status mapping tools, p. 118

3.2.3.3 Feasibility Study

Consider the feasibility of the draft plans with social and industrial aspects.

- Goals for managing environmental sustainability in the draft plans may compete with other plans such as the industrial development of the area thereby occasionsally making it difficult to realize a project.
- A feasibility study can provide insights as to whether a plan can be realized in terms of other sectors' perspectives.

- It is important to clarify the feasibility of the draft plans. In many cases, goals for managing environmental sustainability tend to set limitations on development and landuse, which may suggest an inconvenient or negative force working against development and landuse. Thus, by investigating the feasibility of goals with social and industrial sectors, agreements from other sectors is likely to be more effectively obtainable.

- Lay out the technical, economic, ecological and institutional feasibility of each environmental solution. The feasibility of realizing such a framework can be enhanced through the following schemes:
  - o Ensure that stable and continuous investment is agreed at the national level, and achieve national consensus.
  - o Clarify costs and benefits, and monitor the effectiveness of the investment.
  - o Coordinate with other water users, such as water supply or irrigation sectors, and explore cost-reduction strategies by making projects multi-purpose.

- When introducing new technologies to replace a conventional method currently used, it is necessary to examine the benefit and cost of applying such technologies including their future feasibility.

3.3 COORDINATION AND DETAILED PLANNING AND CONSENSUS BUILDING

This phase finalizes the concepts formulated in Phase 2 into a detailed plan, and coordinates with stakeholders toward reaching an agreement.

- Is transparency secured (does it satisfy reason)?
- Are stakeholders convinced?
- Is it socially fair (does it satisfy the law)?

The coordination involved in reaching agreement on a draft plan means revising the plan based on the opinions of the relevant stakeholders. A transparent process and public awareness are both prerequisites for ensuring effective stakeholder participation. They also ensure social fairness of the process. Striving to improve the situation of all stakeholders will help reach an agreement.

3.3.1 Plan selection

3.3.1.1 Roles and responsibilities

Identify the roles and responsibilities of each relevant sector and stakeholders in each proposed plan, and obtain agreements from the sectors.

- For effective and coordinated implementation with the various sectors, it is advised that the roles and responsibilities of each sector are clearly stated from the outset thereby preventing any misunderstandings.
- Establishing agreements from each relevant sector is also necessary to make sure the performances by each sector are as expected.

- When assigning roles and responsibilities, it is important to secure equity or balance among the related sectors. If the assignment is poorly balanced, there is a possibility that the collaborative work achieved thus far among the various sectors may fail such that the mutual monitoring functions are lost resulting in inappropriate execution of the plan. For example, a particular sector might push forward a plan that is greatly advantageous to the sector.

- Be careful not to force roles and responsibilities on participating sectors but try to accept them voluntarily through coordination. It is likely that a role and/or responsibility made compulsory may not be properly executed if a law, regulation or penalty does not exist to compel action.

Practical Examples

>> Extracted Key for Success from Werra river (Germany) (2), 'Balance of material', p. 66
>> Extracted Key for Success from Arakawa river (Japan) (2), 'Formation of Consensus through Participation of Stakeholders', p. 108

3.3.1.2 Public evaluation of plans

Evaluate different planned options through public consultation, and refine/revise alternative plans.

- Each option presents advantages and disadvantages in terms of environmental, social and economic aspects and thus the consequences of implementing each option may vary among sectors. Therefore, when planning, it is important to include public consultation in the evaluation process of the options that reflect valid opinions.

- Public involvement in the planning stage is crucial for the successful management of environmental sustainability because a long-lasting effort at the local level is a requisite.

- Consider adequate methodology of public consultation such as timings, locations and content for consultation, especially social equity and accountability, which are important in public consultation. Also, important data and facts should be disclosed in a proper manner and should include all information, even if it is negative or inconvenient.

3.3.1.3 Social equity and transparency

Secure social equity and transparency.

- A lack of social equity and transparency in a plan or in a planning process will raise dissatisfaction among stakeholders even after having established the agreement, and will prevent the fulfillment of public accountability.

- Securing social equity requires not only an agreement among stakeholders but also that the result of coordination during the planning or implementation phase is acceptable to the public and society as a whole.
- Ensuring transparency and accountability is indispensable for avoiding scepticism regarding the plans or decision-making process and for the smooth implementation of the agreed plan.

Useful Tools

>> Decision support system, p. 119

3.3.1.4 Future prospects

Take into account future prospects for social and environmental change when spatial planning is applied in the basin.

- The condition of the environment is continuously interacting with each component, of which it comprises, and therefore the existing environmental condition is formed based on a temporarily established balance. This is particularly the case with global climate change as it is the principal factor driving continuous environmental change. It is important to examine the suitability of a given plan based on the present circumstances as well as expected future change.
- A balance between development and environmental conservation in terms of environmental sustainability should be considered. Appropriate utilization of environmental resources that accommodate both social and environmental needs is always an objective in spatial planning.

- In the planning stage, it is recommended that possible changes in the basic or prerequisite conditions of the plan, such as population increases and climate change, be considered. If such changes are not reflected in the plan, some adjustments to the plan may need to be made.

- Apply the best knowledge and experience to estimate future change so as to ensure the suitability of the plan. Consultation with experts and relevant sectors should provide useful information on projecting future change.

- For successful spatial planning, the planning process should be implemented in an adaptive manner. As soon as unexpected changes are detected, collect relevant information and estimate successive changes. If the successive changes are significant, modify the spatial plan accordingly.

Useful Tools

>> Ecohydrological approach, p. 117

3.3.2 Building coordination mechanism

3.3.2.1 Stakeholder participation

Prepare a framework for stakeholder participation to build consensus among stakeholders.

- A framework for stakeholder participation is necessary in order to facilitate smooth coordination and consensus-building. Considerable time and resources may be required if such a framework does not exist.

- An organizational structure for coordination can take many forms such as informal meetings for information-sharing with committees – provided with a level of authority – or specialized institutions, even though a formal structure is preferable.

- It is important to consider existing coordination processes or changing needs within the basin, and build step-by-step an appropriate process or organization to realize the overall objectives.

Practical Examples

>> Extracted Key for Success from Citarum river (Indonesia) (2), 'Basin-wide Water Quality management', p. 75
>> Extracted Key for Success from Bermejo river (Argentina) (2), 'Identify key needs in potential priority areas (critical locations and key issues) for IWRM implementation in the basin. Identify the ecosystem management objectives', p. 84
>> Extracted Key for Success from Bermejo river (Argentina) (3), 'Develop alternative environment management plans', p. 85
>> Extracted Key for Success from Murray-Darling (Australia) (3), 'Managers involvement in deciding environmental flow releases', p. 97
>> Extracted Key for Success from Oigawa river (Japan) (1), 'Formation of Consensus through Participation of Stakeholders', p. 114

3.3.2.2 Incentives

Introduce water conservation incentives appropriate for local conditions.

- The introduction of incentives such as water charges, and so on can promote water-use efficiency and enhance sustainability and flexibility of water use.
- Incentive is different from regulation because the former intends to promote desirable activities while the latter prohibits undesirable activities. Both incentive and regulation measures may have a common goal; incentives may be easier to introduce and be accepted by the public.

- The purpose of incentives is to make benefits more visible and easily felt. Ideally, incentives are simple and understandable. This is especially true in areas where the public understanding of environmental sustainability has yet to be promoted. When applying incentives to promote positive activities for environmental sustainability, try to introduce incentives in daily activities, for example managing water use and consumption.

- When introducing an incentive system for the first time, it may not be effective to introduce the same systems employed by other regions. Analyse the regional characteristics and apply the incentives that local people would willingly accept.

- Incentive is different from regulation. The purpose of regulation is to prohibit human activities that may cause undesirable environmental conditions. For more information, refer to 3.5.2.1.

3.3.2.3 Formal coordinating body

Prepare a formal coordinating body and clearly indicate roles and responsibilities in the river basin (e.g. a river basin committee)

- It is recommended to establish a formal coordinating body (e.g. a river basin committee) where municipalities, citizens and experts work together as a decision-making body on important matters affecting a basin, and to formulate policies/regulations and action programmes for water management.

- Organizational structure for coordination can take many forms, such as informal meetings for information-sharing with committees – provided with a level of authority – or specialized institutions, even though a formal structure is preferable.

- It is important to consider existing coordination processes or changing needs within the basin, and build step-by-step an appropriate process or organization to realize the overall objectives.

Practical Examples

>> Extracted Key for Success from Werra river (Germany) (1),'The European Water Framework Directive (EU-WFD)', p. 65

>> Extracted Key for Success from Citarum river (Indonesia) (2),'Basin-wide Water Quality management', p. 75

>> Extracted Key for Success from Bermejo river (Argentina) (1),'Establish formal coordinating body in the river basin (e.g. river basin committee)', p. 83

>> Extracted Key for Success from Bermejo river (Argentina) (6),'Identify the effects of changes in the basin as the effects of river, lake and estuary ecology', p. 88

3.3.2.4 Representative

Acting as the representative for the environmental sector and/or organizing an environmental technical working group.

- According to the definition of IWRM, the sustainability of the vital ecosystem must not be impaired. It is important to recognize the environment as a stakeholder. If there is no definitive sector representing environmental conservation, it is necessary for the coordinating organization to act as a spokesperson for environmental conservation activities during the coordination process.

- When developing infrastructure, the coordination process must pay due consideration to impacts on the natural environment and ecosystem.
  - o Organizations and sectors in the basin that can speak on behalf of the environment must participate in the planning process. If such organizations or sectors do not exist, then the coordinator should take into account environmental conservation when coordinating with other sectors. Also, it is desirable to establish the environmental technical group in a river basin and involve it in coordination as a member of the technical group. Be sure that there is merit when involving such working groups in trying to improve the environmental performance of your sector. Take ideas and experiences from other sectors obtained through communication within the group. It should be possible to develop new options and make better decisions for environmental sustainability in the implementation of your projects.
  - o A coordinator must have good knowledge of the basin environment in order to be a spokesperson for environmental conservation.

- Data collection for addressing problems in the basin should also include available data and information on the basin ecosystem. It is recommended that environmental concerns or problems facing your sector – with hopes for resolution – be provided. The environment related information collected by your sector will be valuable in better managing the environment.

- Environmental sustainability in a river basin affects any activities and processes having a relationship or interaction with the environment. Thus, environmental degradation and the subsequent effect of reducing sustainability will interfere with your sector's performance in some point in the future. Think of yourself as the representative of the environmental sector and act in a way such that environmental sustainability is one of your primary objectives.

3.4 IMPLEMENTING, MONITORING AND EVALUATING

The aim of this phase is to implement, develop, manage and operate the agreed scheme or framework (including infrastructure development or the establishment of legislation or institutional framework). Things to note in this phase are:

- Is the implementation programme executed promptly?
- Is the system adapted and functioning?
- Are there any new problems with the new approach/scheme?

Prompt execution of the implementation programme and early realization of its impacts and effectiveness is important for the IWRM process. However, things do not always turn out as planned. There are times when the established approach or scheme does not function in the way expected. Thus, monitoring is an important aspect of an IWRM process. Furthermore, it is necessary to retain a broad view and be attentive to new problems such as those caused by social changes.

It is also important to evaluate the impacts of issues not addressed in the current plan and see if such issues need further attention in the future. This leads to the 'recognizing and identifying' phase in the next stage of the IWRM spiral.

3.4.1 Implementation

3.4.1.1 Coordination scheme

Confirm the coordination scheme established for planning, and share information among stakeholders.

- Even if a plan is agreed upon by stakeholders additional challenges may occur at the implementation phase. Maintain the participatory scheme established during the planning stage. Continuous information-sharing allows additional issues to be addressed in an appropriate and participatory manner.

- The coordination scheme established for planning can be used later on as a mechanism for coordination, during droughts for example.
  - A permanent framework for information-sharing will facilitate understanding among stakeholders on the status of water resources and its uses, and will facilitate coordination among stakeholders. Organized regular annual meetings and similar gatherings are effective.
  - Such schemes can also serve the function of mutually monitoring stakeholders to ensure compliance with the agreement.

Practical Examples

>> Extracted Key for Success from Bermejo river (Argentina) (4), 'Implement basin management plans in an integrated manner', p. 86

3.4.1.2 Overall guidelines of implementing agreed plan

Implement all elements of the agreed plan to achieve designated goals.

- Once planning and coordination have been completed, make sure that all elements included in the agreed plan will be implemented by responsible sectors as planned.
- When problems associated with the planned actions occur in an unexpected situation, the responsible sector needs to inform and consult about the situation to all the relevant sectors. Depending on the nature of the problem identified, it may be requested that a procedure is followed.

- In the implementation stage, it is important to execute all actions in the manner planned. Each responsible sector should always keep its role and responsibility firmly on its mind, and efforts to obtain designated objectives, as noted in the implemented plan, are expected.
- On many occasions, a situation may arise whereby the actions originally planned cannot be executed. In such a situation, the responsible sector should immediately consult relevant experts and other sectors in order to decide on subsequent actions.

3.4.2 Monitoring and evaluation

3.4.2.1 Monitoring/evaluating programme

Develop monitoring and evaluation programmes in consultation with technical groups and plan for elements that have uncertain outputs.

- Proper implementation of the agreed plan can be achieved based on continuous monitoring and evaluation. Monitoring helps to collect necessary information while evaluation gives an idea as to whether the proposed plan needs to be revised or not.
- Because environmental monitoring can be highly specialized in terms of contexts, it is often advised that a course of monitoring and evaluation programmes be prepared in advance, in cooperation with appropriate specialized technical groups, to plan for elements that have uncertain outputs.

- The preparation of a monitoring and evaluation programme in planning, or a coordination stage prior to implementation of the plan, is desirable for the following reasons:
  - In the process of environmental impact assessment, environmental changes or negative impacts are sometimes projected. Also, when uncertainty of the future environmental change is identified, it can be the subject of environmental monitoring in the implementation stage. Therefore, it is often possible to specify the object of monitoring in advance.
  - Environmental monitoring requires time and money and thus selecting the element or objective of monitoring in advance will help improve efficiency and reduce the total costs associated with monitoring.
- When preparing the monitoring and evaluation programme, it is advisable to make assumptions or possible scenarios of environmental responses. Such assumptions should include several scenarios that are like to occur. Also, it is necessary to set the evaluation algorithms and standards in advance so as to increase the efficiency of the whole monitoring and evaluation process.
- Continuously monitor at regular intervals. Consecutive and integrated monitoring requires basic environmental information of the river basin, including those for environmental sustainability in the future especially of the public water area.
- It needs to be stressed that recording and storing data over the long-term requires financial and human resources to be instituted in a continuous manner. Policy-makers need to recognize the importance of continuous data collection. Furthermore, managers responsible for data management need to thoroughly consider the necessity and sus-

tainability of continuous data collection, select the type of data to be stored and utilized, and decide on the data management strategy.

- A database is useful but not versatile. Developing a database requires thorough consideration of how the system to be developed will be utilized, maintained and updated in a sustainable manner in the future.

Useful Tools
>> Ecohydrological approach, p. 117

3.5 POLICIES/NATIONAL STRATEGIES, INSTITUTIONAL AND LEGISLATIVE FRAMEWORKS AND FINANCING

The section includes 'keys for success', which are useful for readers concerned with policies/national strategies, legislative frameworks and financing, but are also important throughout the entire IWRM process. Things to note in this phase are:

- Can you move ahead with just the consensus built among stakeholders or do you need a formal framework?
- Are you working bottom-up to influence the national or higher level organizations?
- Do you have the financial resources to achieve your environmental objectives?

3.5.1 Policies and national strategies

3.5.1.1 National principles for environmental sustainability

Contribute to the development and revision of national principles, policies and strategies for managing environmental sustainability.

- Sustainable development requires a well-balanced approach between development and environmental conservation/protection. The establishment of national principles for environmental sustainability always helps achieve balanced developments by both advocating the importance of environmental sustainability at the basin level and promoting coordination among all sectors.

- It is advisable to first position environmental sustainability within a national development strategy.
- It is advisable to include in the strategy short, medium and long-term goals and achievements expected in each phase, as well as the required financial resources so that the strategy can be further reviewed and strengthened.
- As management of environmental sustainability of the public water area by legislation and regulation is the effective approach, try to establish means of enforcing adequate management of water quality and quantity by legislative frameworks if such frameworks do not exist.

Practical Examples
>> Extracted Key for Success from Werra river (Germany) (1), 'The European Water Framework Directive (EU-WFD)', p. 65
>> Extracted Key for Success from Citarum river (Indonesia) (3), 'Area pollution sources management', p. 76
>> Extracted Key for Success from Murray-Darling (Australia) (1), 'Targeted Government Action with Limited Water and Funding', p. 95
>> Extracted Key for Success from Arakawa river (Japan) (1), 'Preservation of the Ecosystem', p. 106
>> Extracted Key for Success from Oigawa river (Japan) (2), 'Securing River Maintenance Flow', p. 116

Useful Tools
>> Guidelines on Water Release from Hydraulic Power Plant to Secure Environmental Flow, p. 120

3.5.2 Institutional and legislative framework

3.5.2.1 Revising institutional frameworks

Revise the corresponding institutional guidelines and design procedures, which are consistent with national policies and strategies for sustainable development.

- Some of the existing institutional frameworks such as guidelines and design procedures may have a relationship with environmental sustainability. Revising those guidelines by incorporating the principles that emphasize environmental sustainability will improve the overall performance of environmental sustainability.

- Identify the institutional guidelines and design procedures, which relate to environmental sustainability. Typical examples are guildelines associated with water use and discharge, landuse and modification such as infrastructure developments. As many institutional frameworks regulate human activities, there should be numerous opportunities for management of environmental sustainability principles and schemes to be incorporated within the frameworks.

- There are also international treaties concerning management of environmental sustainability. Many nations develop legislative management schemes on the utilization of public water area such as the 'Convention on the Protection of the Rhine' and 'The Great Lakes Water Quality Agreement of 1978'. Such legislation and regulation typically enforces water quality standards as well as water quantity in terms of use and discharge.

- It is recommended that by incorporating the concepts in the institutional frameworks, management of environmental sustainability in a river basin will be improved and meet with international standards.

Practical Examples

>> Extracted Key for Success from Citarum river (Indonesia) (1), 'Remediation Measures, Ground water management', p. 74

>> Extracted Key for Success from Bermejo river (Argentina) (6), 'Identify the effects of changes in the basin as the effects of river, lake and estuary ecology', p. 88

Useful Tools

>> Guidelines on Water Release from Hydraulic Power Plant to Secure Environmental Flow, p. 120

3.5.2.2 Defining roles and responsibility

Define roles and responsibilities of river basin management entities for the management of environmental sustainability.

- For realizing integrated management in the river basin, including environment conservation, water use and water-related disaster management, it is recommended to define clear roles and responsibilities of the river basin management entities among other stakeholders.
- Secure and adequate financing for executing the defined role is needed for IWRM to be successful.

- Uncoordinated actions by individuals or organizations can be problematic as environmental conservation/ restoration efforts often involve various sectors that require continuous and cooperative action over a long period of time. Therefore, it is essential to specify in legislation that the management of environmental sustainability is the responsibility of national governments, municipalities and residents, and their respective roles must be clarified. In addition, clarifying the financial responsibilities of national government and municipalities is favourable to ensuring effectiveness.

- Environmental sustainability broadly affects the basin and its stakeholders, therefore it is advisable to clarify the roles of the relevant sectors with regard to the management of environmental sustainability.
  - Clarify the roles of agencies related to the management of environmental sustainability in the basin, especially with regard to the coordination and implementation of their responsibilities, including residents.
  - Define stakeholder (related agencies) participation in the basin during the planning, implementation and review phases.

- Conduct environmental impact assessments to minimize negative impacts on the environment when infrastructures are developed.
- Evaluate results of existing programmes.

- It is necessary to establish a financing framework that allows for stable and continuous investment in the management of environmental sustainability with a long-term perspective, regardless of social and economic changes. The feasibility of realizing such a framework can be enhanced through the following schemes:
  - Ensure that stable and continuous investment is agreed at the national level, and achieve national consensus.
  - Clarify benefits and costs, and monitor the effectiveness of the investment.
  - Coordinate with other sectors, and explore cost-reduction strategies by making projects multi-purpose.

Practical Examples

>> Extracted Key for Success from Werra river (Germany) (3),'Cost-benefit analysis', p. 67

>> Extracted Key for Success from Murray-Darling (Australia) (1), 'Targeted Government Action with Limited Water and Funding', p. 95

4. IWRM Process

4.1 THE 'IWRM SPIRAL' CONCEPTUAL MODEL

4.1.1 The IWRM spiral

The 'IWRM spiral' demonstrates how the dynamic and evolving process of IWRM in a river basin progressively achieves better and more sustainable water resources management.

The model provides the following advantages:

- It helps users to understand both their current situation and where to head next in the IWRM process by integrating a timeframe.
- It enables users to seek better solutions that can adapt to changes.
- It facilitates reaching agreements and increasing ownership at each 'turn of the spiral.'
- It provides a framework for looking ahead and planning for the next 'turn of the spiral.'

IWRM at the river basin level seeks better water resources management through such means as progressively developing water resources in the basin, building a more integrated institutional framework, and improving environmental sustainability. This goal must always be kept in mind wherever you are positioned in the IWRM spiral. However, it should be noted that the process cannot proceed at once in a short period of time; IWRM is an evolving, step-by-step process.

One turn of the spiral includes such phases as: (1) recognizing/identifying pressing issues or needs, (2) conceptualizing the problem itself and locating possible solutions, (3) coordinating and planning among stakeholders to reach an agreement, and (4) implementing/monitoring/evaluating the plan and its outcome. This creates a new IWRM framework or scheme in the basin, which also forms the beginning of the next stage of the spiral. One turn of the spiral may take a long time. In the case of a large water resources development project, such as the construction of a dam, it may take more than ten years to complete one turn. Creating a new institution or organization would also require several years. Each of the practical examples cited in Chapter 5 includes a diagram illustrating their spiral IWRM progression. This can provide ideas on how actual IWRM practices progress in a spiral manner.

4.1.2 Stages of the IWRM spiral

The IWRM spiral begins by recognizing the necessity for IWRM. First, you need to possess an overall picture of the basin. Start with the information already available. This will help you understand the issues and problems existing in the basin, leading to recognition/identification of the need for introducing an IWRM approach. You will then assess the current circumstances and conceptualize possible solutions. Prepare a plan and finalize it through coordination with relevant stakeholders, then implement the plan to create a new IWRM scheme or approach in the basin. This is the first stage of the spiral.

The stages to follow begin with recognizing either the necessity for improving the current IWRM approach/framework or for a new IWRM system. Recognition of needs may be triggered by the intensification of problems left over from the previous stage, such as rapid increase in demands.

4.1.3 Recognizing the stage shift

The stage changes when you recognize the need for change. Moving up the spiral is a time-consuming process, and requires reaching agreements with stakeholders and building consensus. It is important that water resources managers recognize changes or needs and take early action while ensuring public understanding and support.

Significant changes in the basin, such as economic development, changes in social values and demands, and unexpected crisis situations can become the occasion to realize the need for improving or revising water resources management. Such changes can become the driving force for better water resources management, and should be considered as a chance to improve IWRM in your basin.

4.1.4 Where do you stand in the spiral?

Where do you stand in this spiral? Where is your basin situated in the spiral? What phase are you in? Are you in the phase of 'recognizing' changes or 'conceptualizing'? How many stages have you already been through in the IWRM spiral? Take a moment and think about it. It is useful to approximately situate yourself in the spiral when reading these Guidelines in order to find the information you need.

If you cannot find a solution appropriate for you, change your position in the spiral. Looking at different phases or steps in the IWRM process by flipping back and forth through the Guidelines may help you. Thinking about your positioning allows you to check if you have missed any steps in the past, as well as helping you to visualize actions that may be necessary in the future.

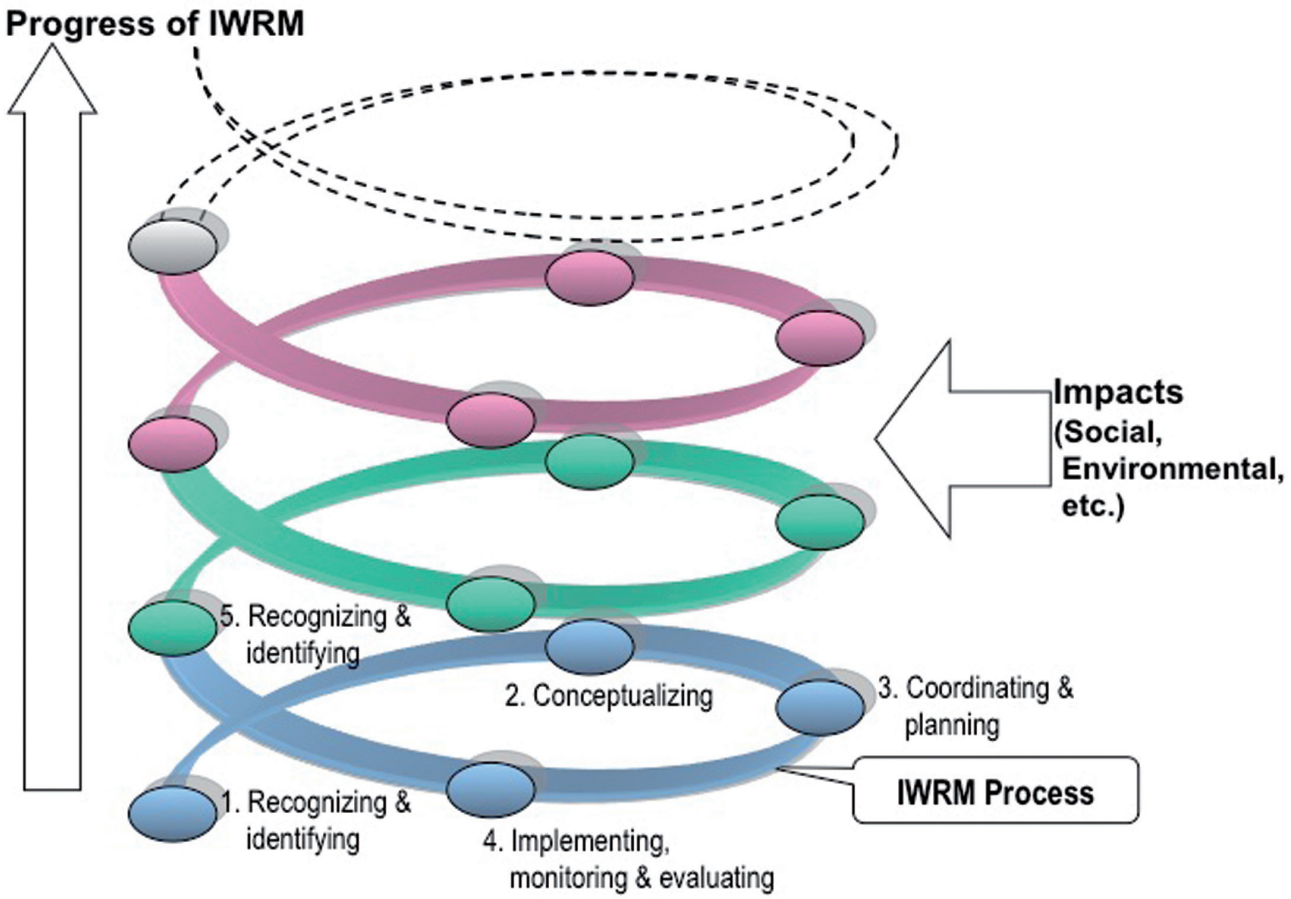


Fig. 4.1 Spiral evolution of IWRM

4.2 PHASES, STEPS AND KEYS FOR SUCCESS IN THE IWRM PROCESS

In the Guidelines, an IWRM process at a given stage is described in terms of four phases. The elements of the process that are related to all phases, such as policies, legal frameworks and financing, are indicated outside of the process flow. Each phase is further explained through the steps it involves.

The IWRM process and its respective steps are each linked to a relevant 'Key for Success' and 'Practical Examples' included respectively in chapters 3 and 5 of these Guidelines.

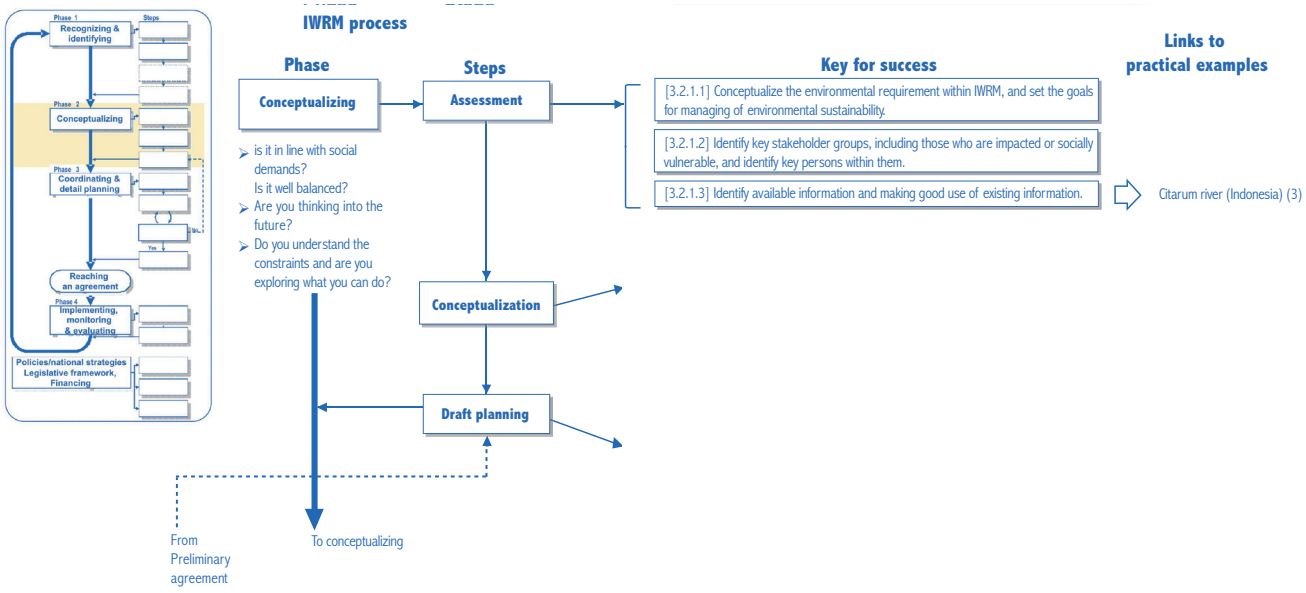


Fig. 4.2 IWRM Process (Phase 2)

4.2.1 Phase 1: Recognizing and identifying

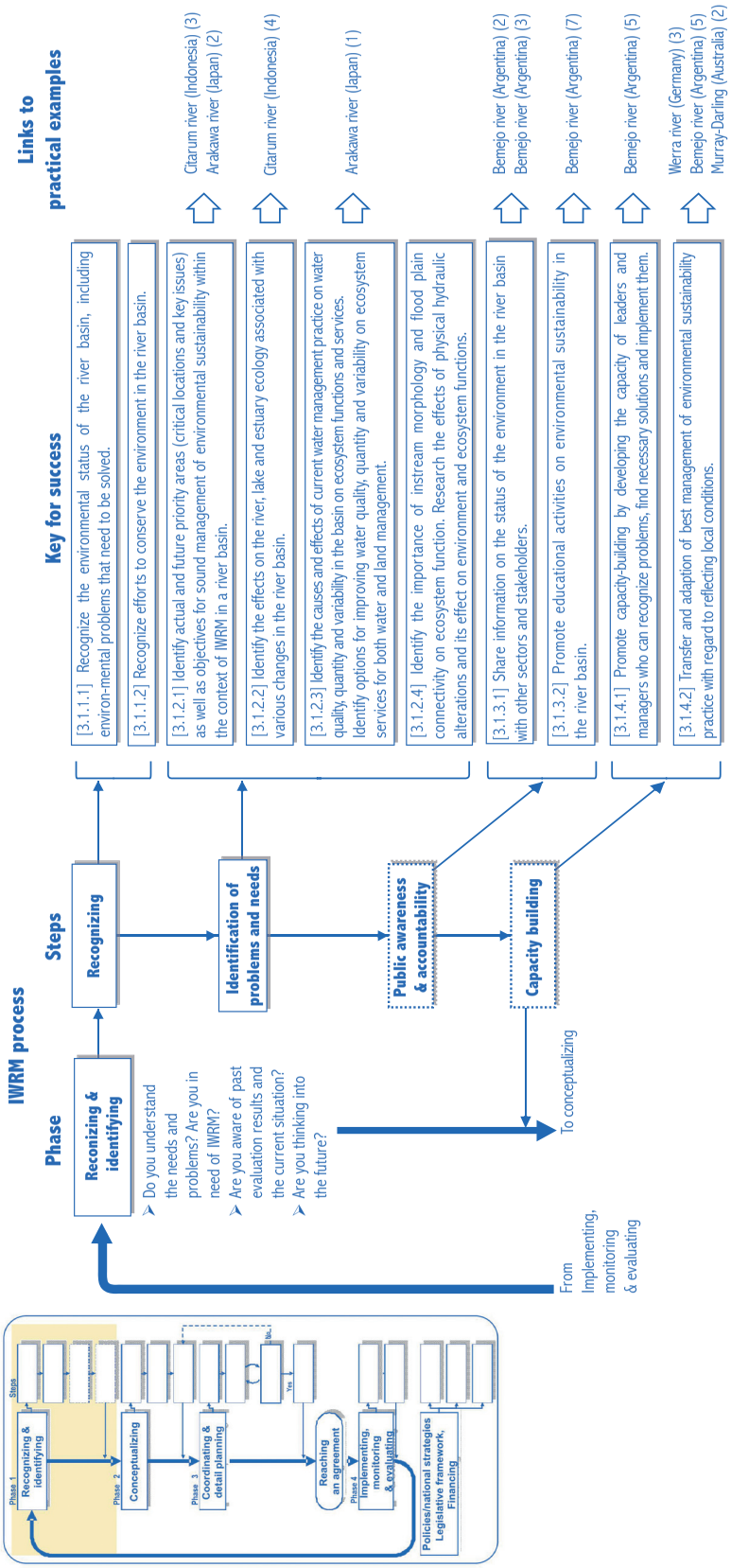
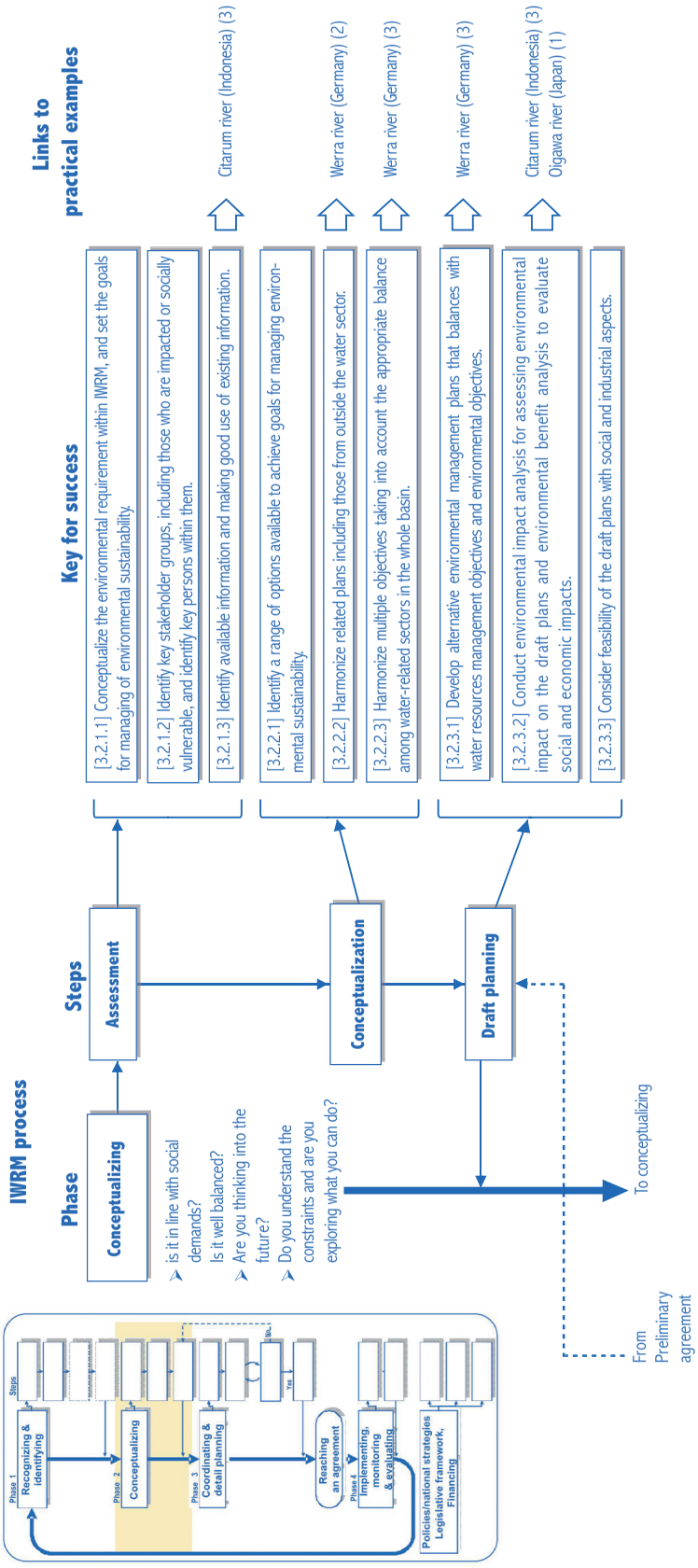


Fig. 4.3 Phase 1: Recognizing and identifying

4.2.2 Phase 2: Conceptualizing



Steps in Phase 2: Conceptualizing

Assessment : Grasp the overall structure of the problem such as 1) problems and needs, 2) natural conditions, and 3) human factors. Interactions with stakeholders have already began at this stage.

Conceptualization : Consider the course of action and the relevant stakeholders and their relationships for tackling the problem based on the assessment conducted above. Conceptualize possible solutions.

Draft planning : Prepare draft plans based on the concepts outlined above. It is most important that multiple alternative solutions are prepared. In cases where coordination in phase 3 does not reach an agreement you may have to come back to this phase again. Carefully drafting proposed plans will avoid such impediment.

Fig. 4.4 Phase 2: Conceptualizing

4.2.3 Phase 3: Coordinating and detail planning

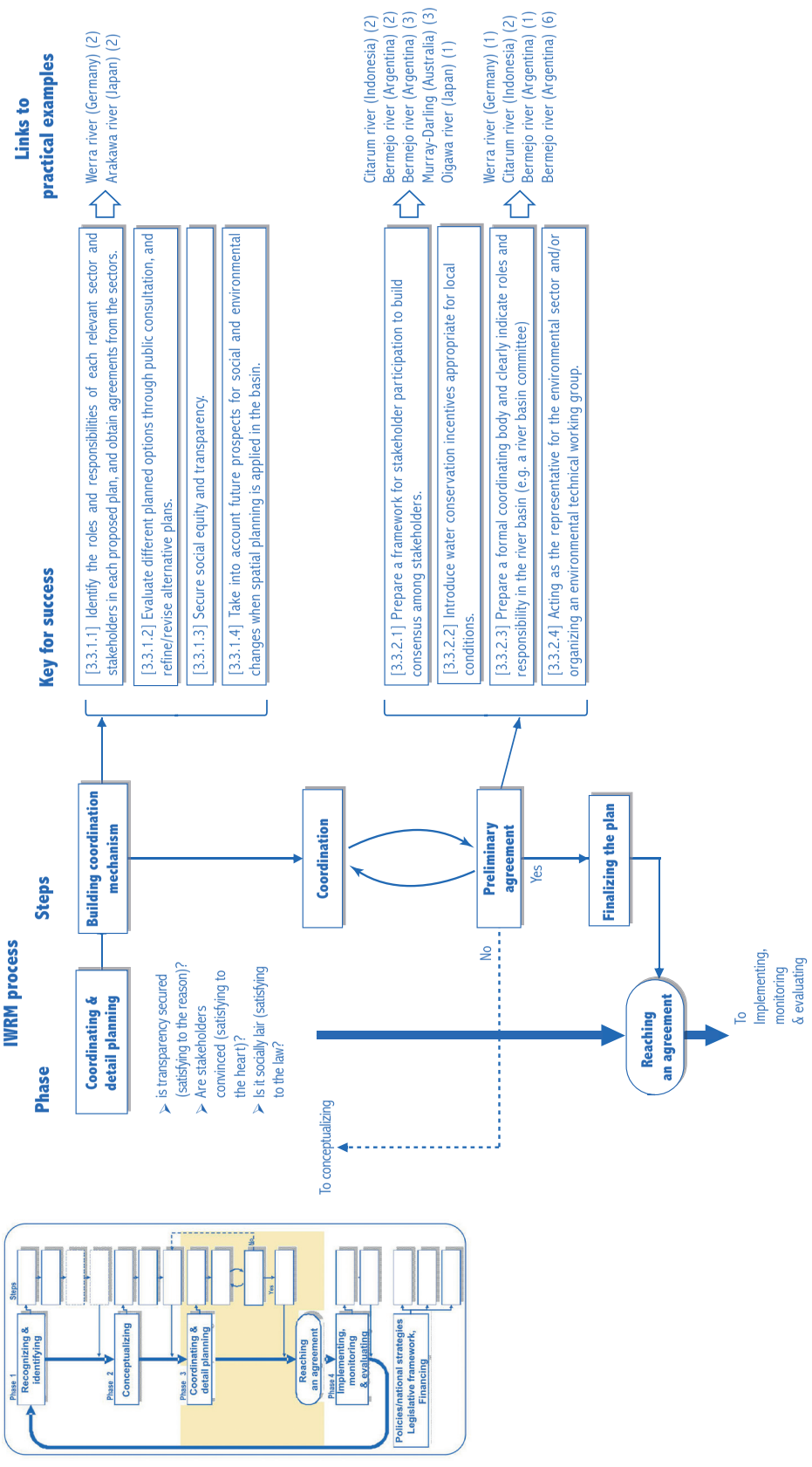


Fig. 4.5 Phase 3: Coordinating and detail planning

4.2.4 Phase 4: Implementing, monitoring and evaluating

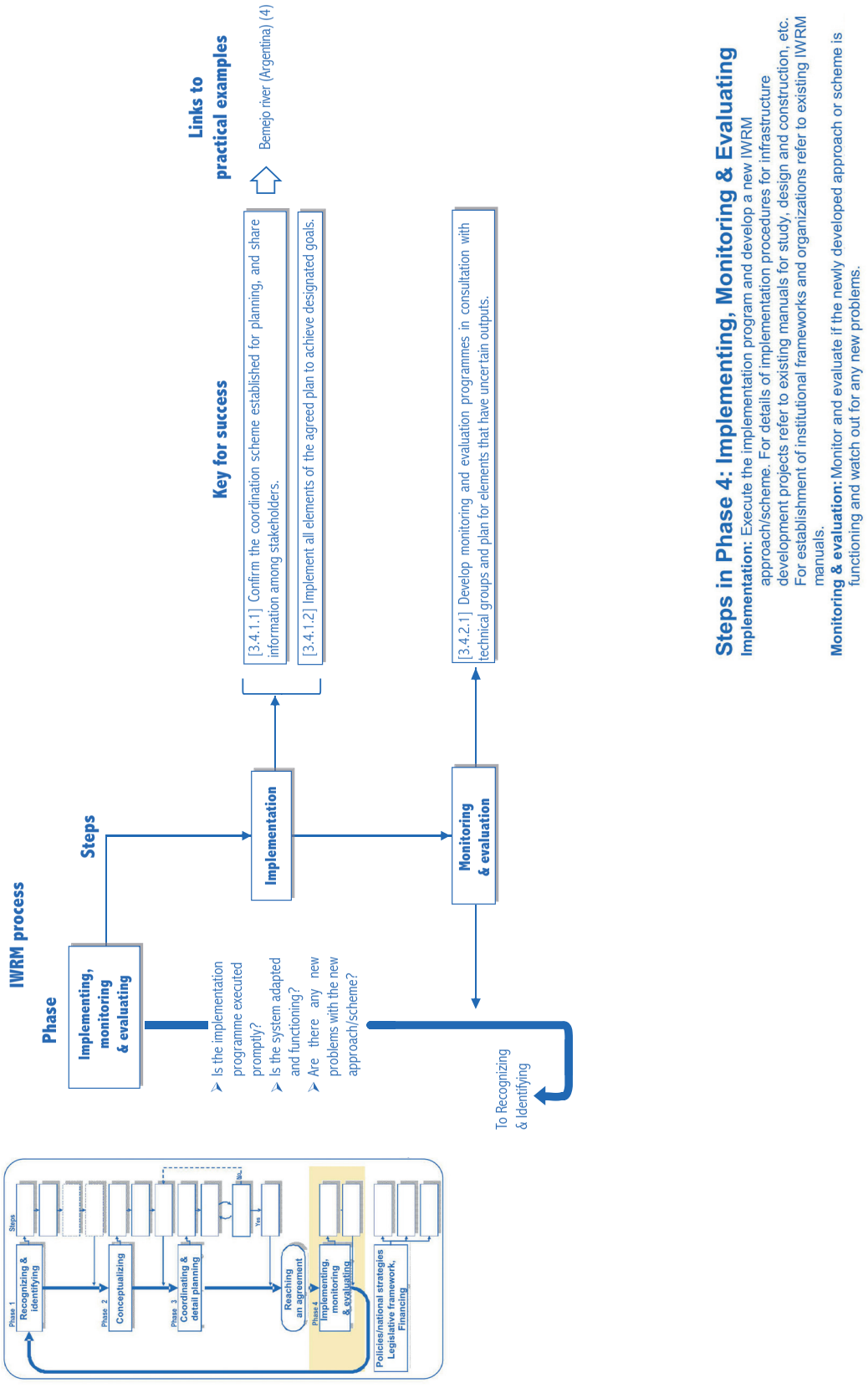


Fig. 4.6 Phase 4: Implementing, monitoring and evaluating

4.2.5 Important aspects of IWRM: Policies/national strategies, legislative framework, financing

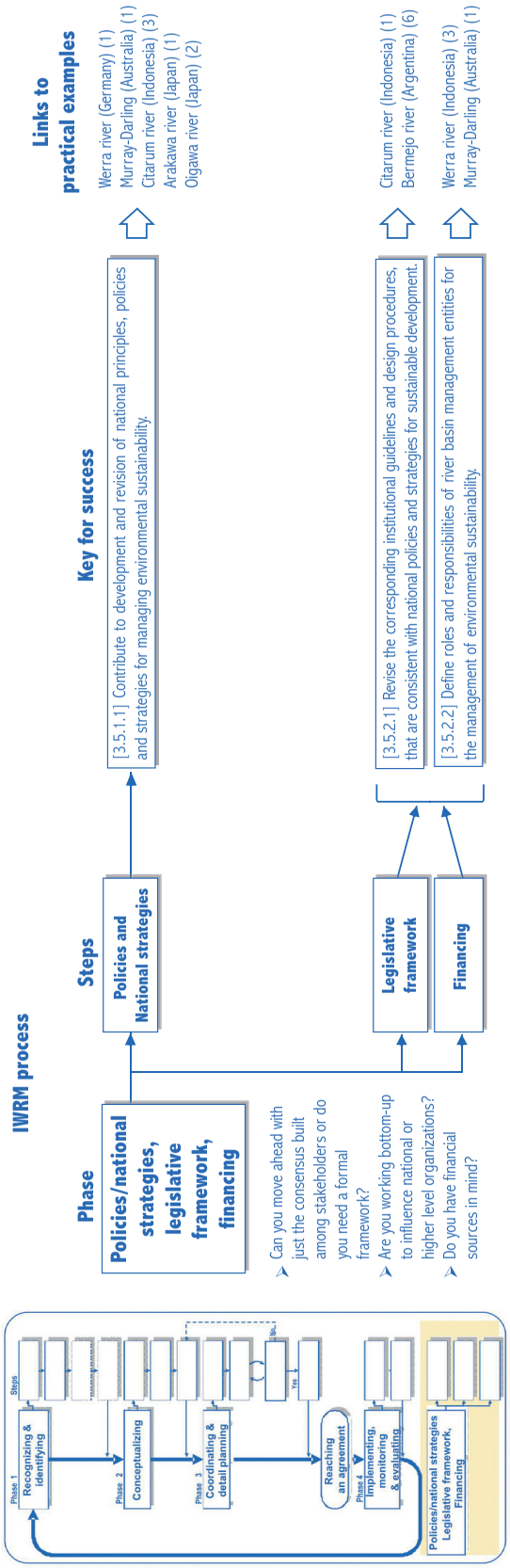


Fig. 4.7 Important aspects of IWRM: Policies/national strategies, legislative framework, financing

5. Practical Examples

This section includes practical examples of IWRM at the river basin level in the form of a 'Case Story' illustrating actual IWRM efforts, and 'Extracted Key for Success' highlighting elements of success for enhancing IWRM, based on interviews conducted at sites.

1) Case Story (explaining the process pathway)

A Case Story lays out the facts in a sequential manner and illustrates the pathway towards the 'Key for Success' (KFS). The Case Story includes links to the 'Extracted Key for Success' so that one can understand how the Key for Success fits into the overall story.

Facts	Ref. to KFS
2. Management phases and institutional strengthening (top-down but bottom-up enablement) … Public education was seen as an important part of the process… Educational programmes were implemented to enhance public awareness and to help increase understanding by the people in the communities. A programme that has been particularly successful is 'Special Forever', which was…	KFS- 5.5.2 (2)

Fig. 5.1 Format and example of a case

2) Extracted Key for Success

The 'Extracted Key for Success' illustrates why the 'Key for Success' was implemented and explains the thought process behind it. In order to ensure the relevance of keys for success to users, 'the Key' is explained in a generalized manner together with conditions and limitations for its application. It also includes references to 'Useful Tools' that may enhance its effectiveness.

[Title] Enhancing public awareness	Problem type to solve
[Situation] Ensuring public awareness and support in implementing policy changes…	Description of the situation
[Problem] It was important to ensure that people in the basin understood the importance of the changes being implemented to the basin's water resources management…	Problems encountered
[How the problem was overcome] Public awareness was enhanced through an environmental education programme implemented in primary schools…	Measures taken to overcome the problem
[The key] Interactive educational activities targeting primary school children facilitated greater awareness on environmental issues in the basin, not only among children but also among their families.	Wisdom behind the measures taken in a generalized terms
[Conditions and limitations in applying the KFS] The programme can be effectively implemented through an organization such as a teaching association…	Conditions and limitations, tools to enhance the application of the KFS, etc.

Fig. 5.2 Format and example of Extracted Key for Success

5.1 WERRA RIVER BASIN (GERMANY)

5.1.1 Case Story (Werra river basin)

Facts	Ref. to KFS

1. Introduction

The Werra river basin has a total area of 5,498 km². The Werra river is part of the river basin district Weser, which empties into the North Sea. It is located in the centre of Germany. The source of the Werra is located at an altitude of 797 metres above sea level, while the confluence with the Fulda River, following a course of 296 km, is situated at an altitude of 117 metres a.s.l. The catchment's long-term precipitation mean is approximately 840 mm. The runoff regime of the Werra shows a typical pluvio-nival pattern. The long-term mean discharge (MQ) at the 'Letzter Heller' gauge is 50.5 m³/s, while the highest flood discharge (1946) is 605 m³/s and the lowest low-flow discharge (1949) is 5.1 m³/s. Figure 1 illustrates the altitude levels of the Werra catchment.

Roughly 43% of the total area of the Werra river basin is tree-covered, while approximately 52% of the area is agricultural land. Areas for settlement, trade and traffic only account for a share of less than 5%. The overall region is rated as structurally weak.

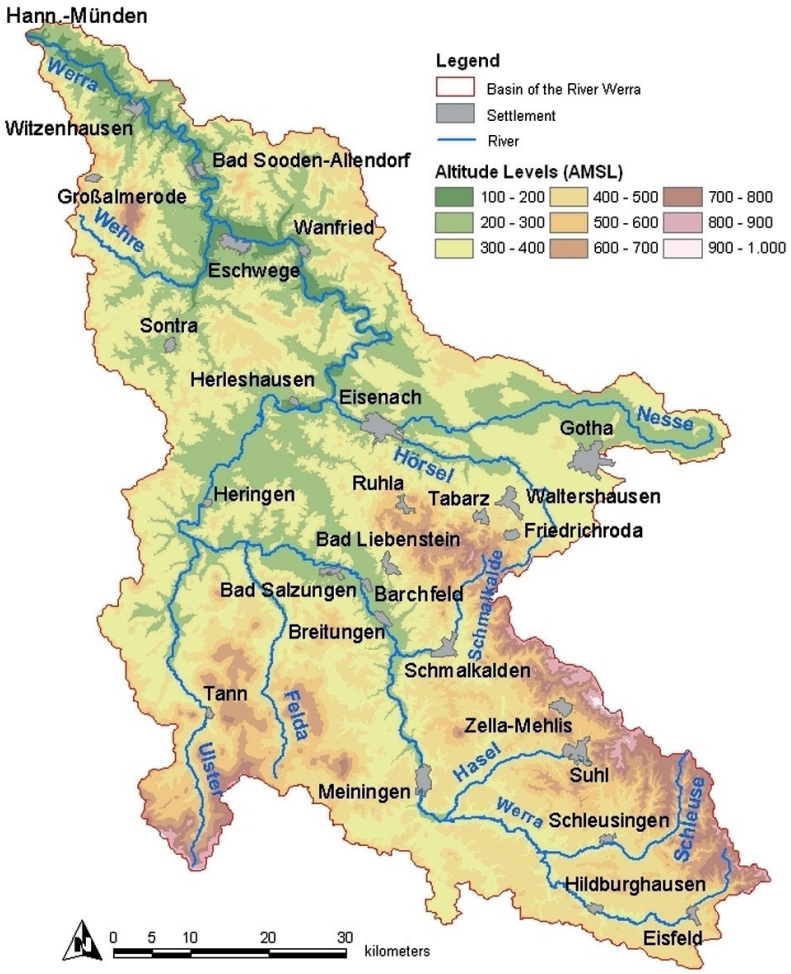
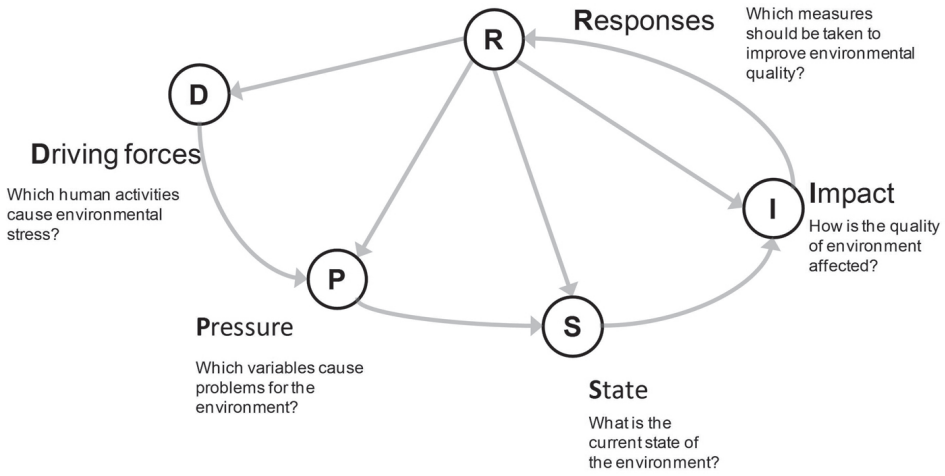
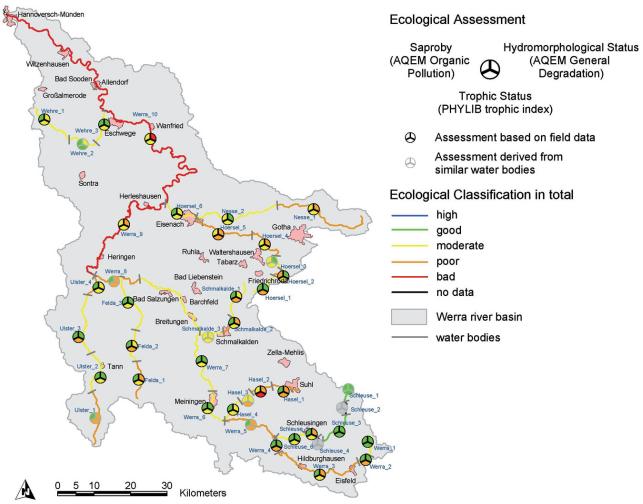


Fig. 5.1.1 Basin of the river Werra

Facts	Ref. to KFS
2. The European Water Framework Directive New demands on water management planning for river basins are a result of the EU Water Framework Directive valid since 22.12.2000 (from Extracted KFS 1_ Situation). The European Water Framework Directive (WFD) specifies the guidelines for integrated river basin management within the European Union for the coming decades. It demands a 'good' status for all surface waters, which has to be specified by ecological criteria; it defines river basins as the spatial units of water management and demands a combined approach of emission limits and river-specific emmission standards. Obviously the complexity of these tasks demands integrated and interdisciplinary cooperation between ecologists, hydrologists, water managers, computer scientists and sociologists. The project's main challenge is the complex task of planning different alternative proposals for a programme of measures, which have to take into account ecological (good status), economic (cost efficiency) and social criteria (participation, acceptance). This target demands a consideration of many different factors and a holistic approach in order to combine results from different disciplines into a joint planning system. It was dealt with an approach characterized by means of the EEA's DPSIR model: the knowledge required for the derivation of responses was provided via cause-and-effect chains between driving forces, pressure, state and impact. The impacts of measures were characterized in view of their environmental quality while concurrently taking account of the impact on driving forces, pressure parameters and expected changes of state in order to identify both effective and efficient measures that – on top of this – comply with the socio-economic objectives and marginal conditions. (from Extracted KFS 1_ How the problem was overcome).  **Fig. 5.1.2** DPSIR model developed by the European Environment Agency (EEA) to describe the interaction between society and environment	KFS-5.1.2 (1)

Facts	Ref. to KFS
3. Ecological evaluation and analysis of deficit The waters' ecological deficits constituted the basis for the definition of measures to achieve the stated good ecological state. This required that specifications for changing the parameters be considered as decisive for ecological conditions. There was a problem to achieve ecological evaluation and analysis of deficit in that a biological, chemical-physical and hydromorphological evaluation of the Werra river and its main tributaries had to be carried out within the scope of the integrated project. This was dealt with a specific evaluation method. The evaluation of the benthic invertebrates biocoenosis is implemented by applying the AQEM method or 'Assessment system for the ecological Quality of streams and rivers throughout Europe using Macrovertabrates'. The lists of species of the diatom and macrophyte societies were evaluated with the aid of the PHYLIB process.  **Fig. 5.1.3** Biocoenotic evaluation of water bodies in the Werra region for the actual state (individual parameters)	
4. Modeling of water balance, balance of materials and water quality A forecast of the changes to be expected in the evaluated biocoenoses for the various action scenarios of the integrated project was produced as well as an assessment of the question as to whether the good ecological state in the individual water bodies can actually be achieved by realizing the planned measures (Schumann et al. 2005)*. Based on an analysis of the chemical loads, differentiated into point and non-point sources of pollution, and a model-based simulation of strategies to modify wastewater treatment and agricultural practices, different aspects to improve water quality were examined. Several problems were encountered when modeling water balance, materials and water quality, described as follows:	KFS-5.1.2 (2)

Facts	Ref. to KFS
– The continuous load from diffuse sources into the river basin was difficult to detect precisely. It is influenced by the rainfall pattern because of the immobilisation of bonded phosphorus and erosion (from Extracted KFS 2_Problem). – Modest use of fertilizer by the farmers (from Extracted KFS 2_Problem). The following actions below were taken to deal with the problems: – The SWAT (Soil & Water Assessment Tool) of the United States Department of Agriculture (USDA) was used (from Extracted KFS 2_How the problem was overcome). – Main point sources (sewage treatment plans) were detected and enhanced to achieve the thresholds (from Extracted KFS 2_ How the problem was overcome). – Guidelines for efficient environmental crop production was prepared (from Extracted KFS 2_ How the problem was overcome).	
5. Socio-economic principles of action planning Manifold uses of the river water and the river itself requires an indepth analysis of benefits and costs (from Extracted KFS 3_Situation). Thus, the socio-economic aspects of planned measures to improve the ecological state were analysed under three categories: costs, benefits and acceptance of planned measures by stakeholders. Several problems were encountered in developing an action plan, described as follows: – Identification of the water users and their interest on the outcome of the river management (from Extracted KFS 3_Problem). – Analysis of the economic benefit of the interests, but economic evaluation of benefits of the different measures was often not practical (high financial and temporal efforts) (from Extracted KFS 3_Problem). The following actions below were taken to deal with the problems: – A decision support system was implemented in the project (from Extracted KFS 3_ How the problem was overcome). – A 'cooperation index' was devleoped, which helped combine the interests of all actors (from Extracted KFS 3_ How the problem was overcome). – Economic analysis of the catalogue of measures was carried out (from Extracted KFS 3_ How the problem was overcome). – A 'Benefit Transfer' approach was taken (Thiele & Wronka, 2002)** (from Extracted KFS 3_ How the problem was overcome).	KFS-5.1.2 (3)
6. Data management in a GIS-based information system The administration and storage of all project-relevant data was realized within the scope of a specially developed space-related information system, constituting the system framework of the decision support system. (Schumann et al. 2005)*	

Facts	Ref. to KFS
7. Decision support system The decision support system was developed with a view to supporting decision-makers in balancing, comparing and assessing different combinations of measures in terms of alternative suggestions for an action programme to improve the ecological state. The decision support system provides a decentralized application option, to allow usage by varied stakeholders and promote public participation. (Schumann et al. 2005)*	

* Schumann, A., J. Dietrich, P. Podraza, D. Borchardt, I. Michels & Petschow, U. (2005): Integration ökologischer, hydrologischer, siedlungswasserwirtschaftlicher, sozio-ökonomischer und entscheidungstheoretischer Aspekte in das Flussgebietsmanagement am Beispiel der Werra. Limnologie aktuell, Bd. 11, 221-235, E. Schweizerbart'sche Verlagsbuchhandlung, Stuttgart. (Integration of ecological, hydrologic, sanitary engineering, socio-economic and decision-theoretical aspects into river basin management using the example of the Werra river).

** Thiele, H. D. and T. C. Wronka (2002), 'Umweltgüter und ihre Bewertung'. Zeitschrift für Umweltpolitik & Umweltrecht 3, pp. 405-414.

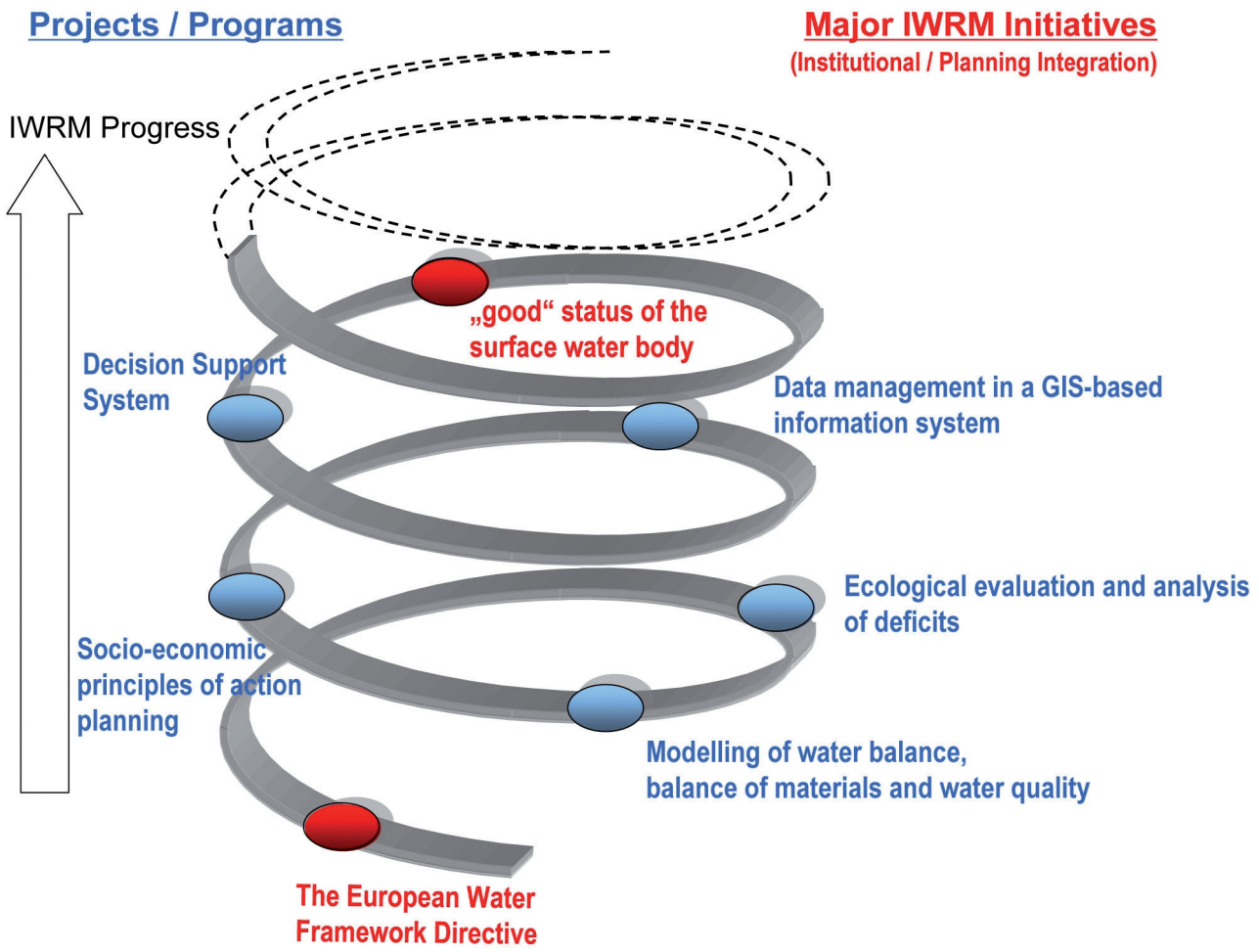


Fig. 5.1.4 IWRM spiral of Werra River

5.1.2 Extracted Key for Success (Werra river basin)

(1) Extracted Key for Success

[Title]
The European Water Framework Directive (EU-WFD)

[Situation]
New demands on water management planning for river basins as a result of the EU Water Framework Directive valid since 22.12.2000. In addition to the already integrative aim of achieving a good ecological condition of streams, the required combined approach of emission and emission observations, the demands made on a socio-economic assessment of measures (especially regarding possible exceptions) or the explicitly stated public participation set a number of framework conditions, which are only to be considered in an interdisciplinary manner.

[Problem]
Attaining a good status for the water bodies comprises ecological as well as economical, physical, hydrological and morphological aspects.

[How the problem was overcome]
Main focus on the hydromorphological impairments and the material balance.
→ preparation of a catalogue of measures.

[The key]
It is advisable to prepare an institutional framework to aggregate experience and knowledge obtained through construction/improvement or operation/maintenance of infrastructure in and out of the basin.

Establish national principles such as policies and strategies on managing environmental sustainability.

[3.3.2.3] Formal coordinating body
Prepare a formal coordinating body and clearly indicate roles and responsibilities in the river basin (e.g. a river basin committee).

[3.5.1.1] National principles for environmental sustainability
Contribute to development and revision of national principles, policies and strategies on managing environmental sustainability.

[Conditions and limitations in applying the KFS]

[Ideas for enhancing the applicability of the KFS]

(2) Extracted Key for Success

[Title]
Balance of material

[Situation]
It was mainly a matter of nitrogen and phosphorus emissions from point and diffuse sources.

[Problem]
- The continuous load from diffuse sources into the river basin is difficult to detect precisely. It is influenced by the rainfall pattern because of the immobilization of bonded phosphorus and erosion.
- Modest use of fertilizer by the farmers.

[How the problem was overcome]
- The SWAT (Soil & Water Assessment Tool) of the United States Department of Agriculture (USDA). (http://swatmodel.tamu.edu/)
- Guidelines for efficient environmental crop production.
- Detect main point sources (sewage treatment plans) and enhance them to achieve the thresholds.

[The key]
It is important to harmonize related plans including those from outside the water sector.

Identify roles and responsibilities of each relevant sector and stakeholders in each proposed plan and obtain agreements from the sectors.

[3.2.2.2] Harmonizing the related plans
Harmonize related plans including those from outside the water sector.

[3.3.1.1] Roles and responsibilities
Identify the roles and responsibilities of each relevant sector and stakeholders in each proposed plan, and obtain agreements from the sectors.

[Conditions and limitations in applying the KFS]

[Ideas for enhancing the applicability of the KFS]

(3) Extracted Key for Success

[Title]
Cost-benefit analysis

[Situation]
Manifold uses of the river water and the river itself requires an indepth analysis of benefits and costs.

[Problem]
- Identification of the water users and their interest on the outcome of river management.
- Analysis of the economic benefit of the interests, but economic evaluation of benefits of the different measures was often not practical (high financial and temporal efforts).

[How the problem was overcome]
- A decision support system was implemented in the project.
- A 'cooperation index' was developed, which helped combine the interests of all actors.
- Economic analysis of the catalogue of measures.
- A 'Benefit Transfer' approach. (Thiele & Wronka 2002)*

[The key]
Set priorities among problems to be solved, taking into account such constraints as time and funds.

Develop technology that fully reflects local conditions.

Develop alternative environmental sustainability management plans.

Secure financial resources for environmental coordination in order to promote IWRM in the basin.

[3.1.4.2] Technology transfer and development
Transfer and adaptation of best management of environmental sustainability practice with regard to reflecting local conditions.

[3.2.2.3] Harmonizing multiple objectives for water management
Harmonize multiple objectives taking into account the appropriate balance among water-related sectors in the whole basin.

[3.2.3.1] Alternative plans
Develop alternative environmental management plans that balance water resources, management objectives and environmental objectives.

[3.5.2.2] Defining roles and responsability
Define roles and responsibilities of river basin management entities for the management of environmental sustainability.

[Conditions and limitations in applying the KFS]

[Ideas for enhancing the applicability of the KFS]

* Thiele, H. D. and T. C. Wronka (2002), 'Umweltgüter und ihre Bewertung'. Zeitschrift für Umweltpolitik & Umweltrecht 3, pp. 405-414.

5.2 CITARUM RIVER BASIN (INDONESIA)

5.2.1 Case Story (Citarum river basin)

Facts	Ref. to KFS

1. Background

Citarum River Basin, West Java, Indonesia is one of the most strategic rivers in Indonesia. It covers an area of 13,000 sq km and is home to 17 million people. The basin supplies 80% of the capital's (Jakarta) water needs, providing irrigation for 390,000 ha and generating 1,400 MW of electricity. Deteriorating infrastructures, competing water demands, rapid urban and industrial growth, and inadequate institutional capacity have led to water supply shortages and unhealthy environmental conditions within the entire basin.

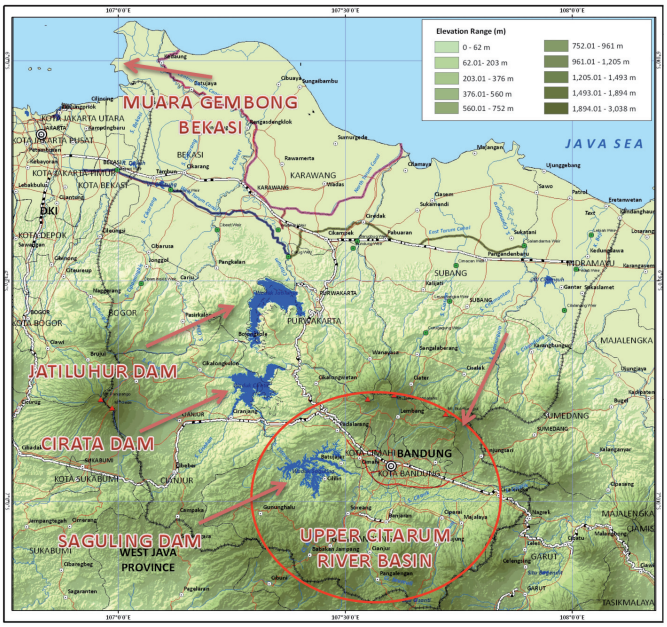
Fig. 5.2.1 Citarum River Basin

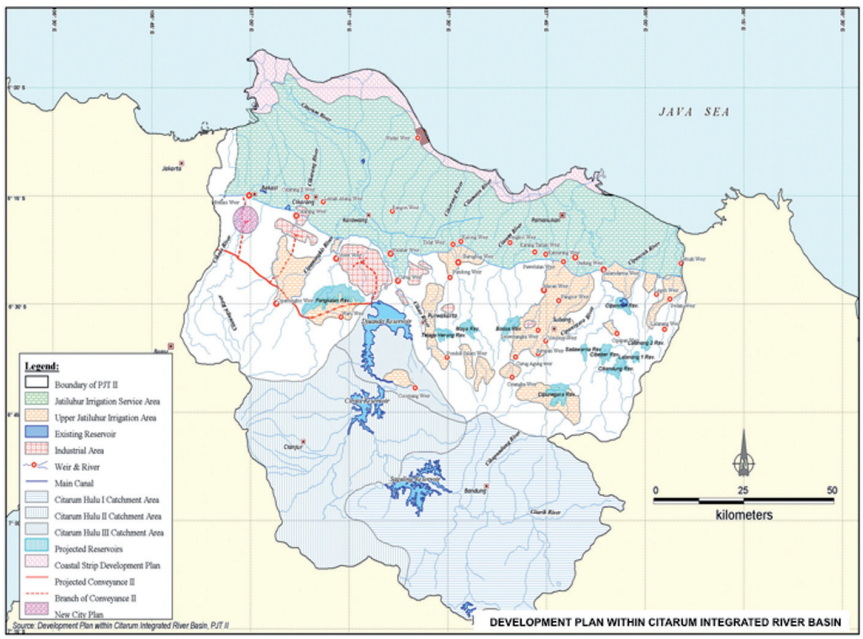
Citarum river originates from mount Wayang (elevation 2,198 metres a.s.l.) south of Bandung the capital city of West Java Province. From a total of 270 km, the first 25 km confluence follows a steep slope before reaching the central portion of the river for about 150 km starting at Bandung. The river meanders for the last 70 km across an alluvial plain before reaching the Java Sea. The average annual precipitation in the region is 2,400 mm, where the upper catchment receives the heaviest rainfall, exceeding 4,000 mm annually.

The basin covers nine districts and two cities with a total population of 17.8 million in 2003, of which 30% work in agriculture, 25% in industry and 45% in the service industry. The population is projected to rise to 21.3 million by 2010.

In 2006, a strategic environmental management plan (EMP) was prepared in parallel with, and as an integral part of, the basin road map formulation. Programme interventions covered: (i) remediating existing environmental problems and enhancing environmental quality, (ii) strengthening environmental management capacity, and (iii) mitigating possible adverse impacts.

The basin road map was prepared with the sustainable management of water resources for economic and social development as the principal goal. The immediate objective was to improve water availability and quality for integrated and participatory water resources management.

Facts	Ref. to KFS
 **Fig. 5.2.2** Wayang Mount	
2. Physical condition There are three major dams as cascade reservoirs in the river: Saguling dam at the vicinity of Bandung city; Cirata sdam situated in the middle, and; Jatiluhur dam in the lower part. The first two dams mainly generate power whereas Jatiluhur dam is a multipurpose dam delivering water through three main canals namely West, North and East Tarum canals. This is a key rice producing area in the country. There are a total of 390,000 ha of irrigated paddy fields, of which a total of 240,000 ha is served by the Jatiluhur reservoir. The basin serves two major and heavily populated and urbanized cities. These are Bekasi, a satellite city of Jakarta, and Bandung, the capital city of West Java province. Industrial locations are generally interwoven with settlements and clustered along the expressway corridor linking Jakarta and Bandung.  **Fig. 5.2.3** Location of major dams and Citarum River Basin	

Facts	Ref. to KFS
3. Environmental management frameworks An innovative cooperation-based approach to industrial pollution control had been conducted in the late 1980s. The Clean River Program showed big promise but apparently has not been sustained in the basin and throughout the country due to a change of government in 1998, among other things. An update of the environmental management framework (EMF) was conducted in 2006 with the environmental management plan (EMP) based on the environmental management framework in 2006. Three sets of environmental management activities were discussed during the update of EMF with related stakeholders: • Remediation or amelioration of adverse water related environmental conditions. • Capacity development in environmental management. • Mitigation measures to address some potentially adverse impacts resulting mainly from the water utilization programme's key area.  **Fig. 5.2.4** Development plan within Citarum Integrated River Basin	
4. Capacity development for environmental management The identified needs for capacity development resulting from a diagnostic of the current capacities of the various agencies involved will be implemented gradually from 2010 to 2014 as part of the IWRM roadmap activities. This will be carried out in parallel with the establishment of the water council and institutional reform. **Improved Basin Management Organization** To address current institutional arrangements characterized by highly sectoral divisions of work and a lack of coordination.	

Facts	Ref. to KFS
Improvement of a Regulatory and Enforcement System With weak and fragmented regulatory and authority systems, the government turned towards a cooperation approach to deal with the pollution problems. The programme was only limited to big polluters. **New management strategies (raw water and wastewater charges)** Utilizing economic instruments and other forms of incentives and disincentives in order to induce voluntary restraint on water use and wastewater disposal. **Water Quality Monitoring** Water quality is the key indicator of IWRM effectiveness and sustainability. Therefore quality monitoring is expanded to address policy and planning needs specifically for area-wide water quality management. These not only include industries but also various diffuse and unregulated sources. **Environmental Impact Mitigation and Monitoring Measures** Establishing modeling for a decision support system in mitigation and monitoring measures.	
5. The case story The pattern of urbanization in the region is clustered along a rapidly urbanizing corridor defined by a expressway connecting Jakarta and Bandung established in 2004. It is predicted that urbanization will continue its expansion toward the upper catchments. This aspect has significant impact on the water supply since domestic water supply passes along the same corridor through West Tarum Canal. Settlements and industrial establishments are intrusive and will consequently threaten both water quality and water supply security. Poor surface water supply services force households and industries to extract water from groundwater sources. Actual extraction is believed to be above the official records. The lowering of the groundwater level is reported to be up to 5 metres per year. In the downstream, West Tarum canal supplies 80% of Jakarta's raw water supply and hence is vital to the well-being of 8 million inhabitants. Reduction of conveyance capacity is due to both sediment deposits and the prolific growth of aquatic plants. These plants trap silt and accelerate the shallowing of the canal. A programme priority is to manage the overuse of groundwater resources with the development of surface water to replace groundwater, in particular to address industry's over-dependence on groundwater. This is planned for the period 2012–2016. In terms of water quality, the combination of untreated domestic sewage, solid waste disposal and industrial effluent have significantly increased pollution loads in the Citarum. In the late 1990s, river effluent in the upper basin from Bandung vicinity flowed into Saguling reservoir with an average annual BOD concentration as high as 300mg/l. Control measures successfully reduced the BOD load to 200 mg/l by year in 2000, and further reduced up to 55 mg/l in subsequent years. However, BOD concentration remains as high as 130 mg/l during the dry season.	KFS-5.2.2 (1) KFS-5.2.2 (2)

Facts	Ref. to KFS
As a result, emphasis has been placed on multi-stakeholder participation that includes developing management schemes that combine the use of regulatory methods (command-and-control), cooperation and market oriented instruments (raw water fees and pollution charges). Moreover, the lack of proper solid waste management contributes to both pollution and flooding. In 2004, average daily solid waste generation was 6,500 m^3/day, of which an estimated 1,500 m^3/day was not collected and properly disposed. The annual uncollected garbage accumulating in the drainage system in rivers amounts to 500,000 m^3. The estimated inflow of solid waste into the reservoir is 250,000 m^3 per year. In areas with high industrial density, there is a need for more targeted pollution reduction planning, scheduled for the period 2010–2014. Managing pollution from these industries needs to address toxic pollutant discharges. In the upper part of Citarum, hilly-land farming is extensive for planting vegetables and annual crops, which do not provide adequate protection against soil erosion. In fact, upland farming areas increased from 6,000 ha in 1992 to 37,000 ha in 2001 at the expense of forest areas. The forested area has declined with only 10.2% remaining of the total area, most of which is in fragmented condition further reducing ecosystem viability making the areas vulnerable to encroachment. Watershed erosion is a serious problem especially in the upper river basin. The annual sediment flow was estimated to be upwards of 8 million m^3 at Saguling reservoir, which is equivalent to an erosion rate of 3 mm per year. The sediment load is also deposited in the canal bed resuting in a reduction of canal capacity. Flooding has become more frequent and severe in Bandung area. The problem is due to many reasons: (i) watershed degradation, (ii) straightening of river course resulting in higher peak flows downstream, (iii) land subsidence due to the over-extraction of groundwater, (iv) excessive garbage clogging the channels. Watershed management, which started with piloting in the Citarik sub-catchment in the 1990s and will be upscaled during the period 2010–2014, is principally based on the need to rehabilitate the upper catchments in order to abate adverse effects on basin water supply and water quality.	KFS-5.2.2 (3) KFS-5.2.2 (4)

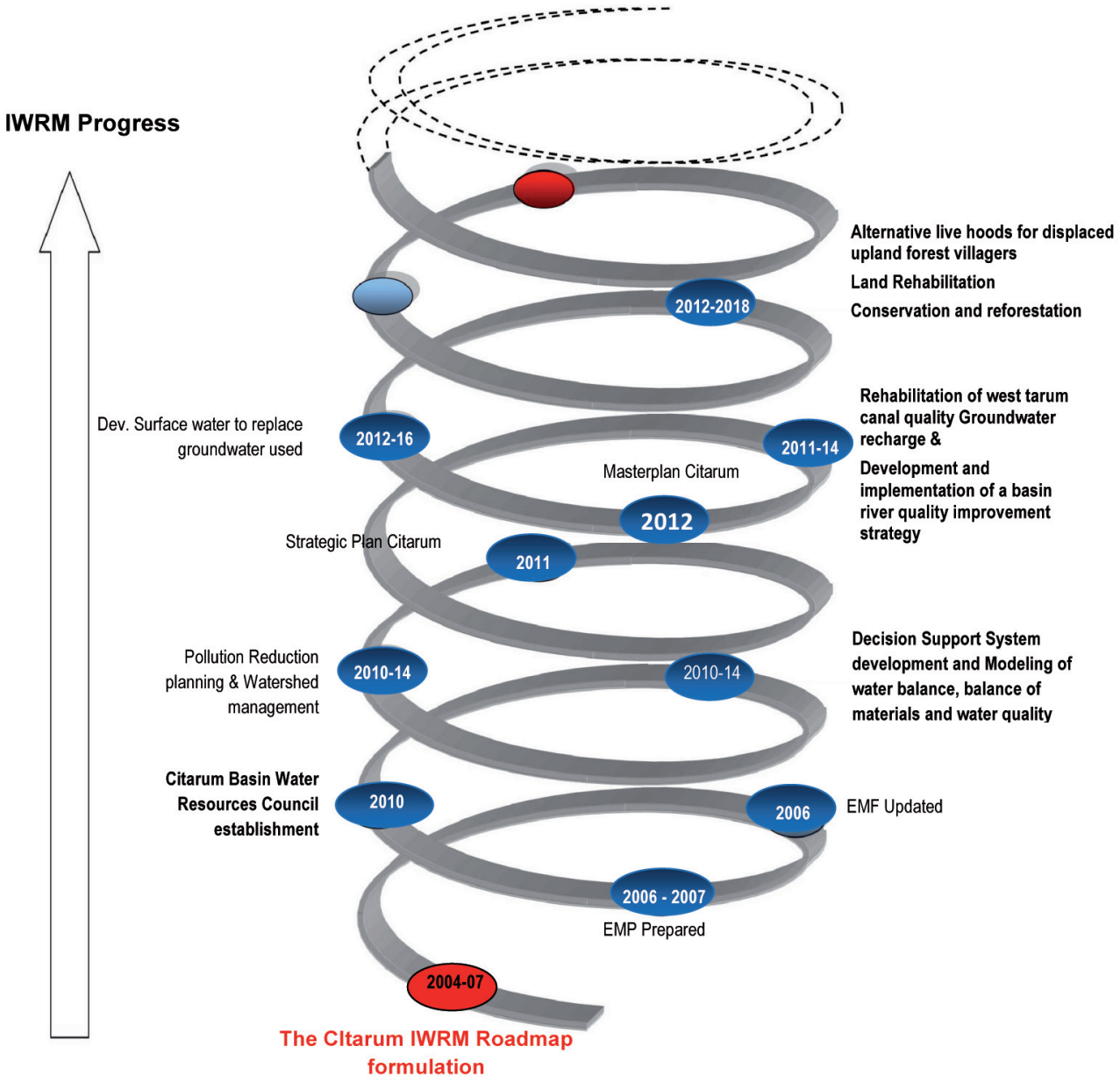


Fig. 5.2.5 IWRM Spiral of Citarum River Basin

5.2.2 Extracted Key for Success (Citarum River Basin)

(1) Extracted Key for Success

[Title]
Remediation Measures
Groundwater management

[Situation]
- Poor services of surface water supply forces households and industries to extract water from groundwater. Actual extraction is believed to be above the official records. The lowering of the groundwater level is reported to be up to 5 metres per year.
- The pattern of urbanization in the region is clustered along a rapidly urbanizing corridor defined by the expressway connecting Jakarta and Bandung. It is predicted that urbanization will continue its expansion toward the upper catchments. This aspect has significant impact on the water supply since domestic water supply passes along the same corridor through West Tarum Canal. Settlements and industrial establishment are intruding and will consequently threaten both water quality and water supply security.

[Problem]
In the downstream, West Tarum canal supplies 80% of Jakarta's raw water supply and hence is vital to the well-being of 8 million inhabitants. Reduction of conveyance capacity is due to both sediment deposits and the prolific growth of aquatic plants. These plants trap silt and accelerate canal shallowing.

[How the problem was overcome]
The programme priority for managing the over-used groundwater resources involves the development of surface water to replace groundwater, in particular to address industry's over-dependence on groundwater.

[The key]
Water supply options and improved groundwater management are needed to reverse the dependence on groundwater resources as a primary source of water by developing surface water supply options. This requires proper institutional instruments such as pricing and incentives that will support the switch from groundwater to surface water.

[3.5.2.1] Revising institutional frameworks
Revise the corresponding institutional guidelines and design procedures, that are consistent with national policies and strategies for sustainable development.

[Conditions and limitations in applying the KFS]
Development of strategies and an action plan for improved effectiveness of regulation of groundwater use, including recommendations for changes to the existing regulatory framework.
Establishment of, and ongoing support for, a stakeholder forum.

[Ideas for enhancing the applicability of the KFS]
Rehabilitation of West Tarum canal for quality groundwater recharge.
Improvement in groundwater pricing and licensing regulation.
Stakeholder forum for Bandung sub-Basin under Citarum Basin Water Resources Council.

(2) Extracted Key for Success

[Title]
Basin-wide Water Quality management

[Situation]
In terms of water quality, the combination of untreated domestic sewage, solid waste disposal and industrial effluent have significantly increased pollution loads in the Citarum. In the upper basin, river effluent from Bandung vicinity flows into Saguling reservoir and in the late 1990s had an average annual BOD concentration as high as 300mg/l.

[Problem]
Control measures successfully reduced the BOD load to 200 mg/l by year 2000, which was further reduced up to 55 mg/l in subsequent years. However, BOD concentration still remains as high as 130 mg/l during the dry season.

[How the problem was overcome]
As a result, emphasis has been placed on multi-stakeholder participation that includes developing management schemes that combine the use of regulatory methods (command-and-control), cooperation and market oriented instruments (raw water fees and pollution charges).

[The key]
Development and implementation of a basin river quality improvement strategy and action plans is required, along with effective monitoring and reporting mechanisms. In addition, information exchange among the implementing agencies and other basin stakeholders, including communities, civil society organizations (CSOs) and the private sector, will improve overall performance and minimize wasted effort caused by overlaps in water quality improvements.

[3.2.3.2] Environmental assessment
Conduct environmental impact analysis in the draft plans for assessing environmental impacts, and environmental benefit analysis to evaluate social and economic impacts.
[3.2.2.1] Stakeholder participation
Prepare a framework for stakeholder participation to build consensus among stakeholders.
[3.2.2.3] Formal coordinating body
Prepare a formal coordinating body with clearly indicated roles and responsibilities in the river basin (e.g. a river basin committee).

[Conditions and limitations in applying the KFS]
Policies and procedures for water quality management.
Development of organizational capacity.

[Ideas for enhancing the applicability of the KFS]
Reduce, Reuse, Recycle (3R) facilities.
Individual biogas generation plants.
Improved solid waste management in Bandung, Bekasi, Cikarang and Karawang.

(3) Extracted Key for Success

[Title]
Area pollution sources management

[Situation]
Moreover, lack of proper solid waste management contributes to both pollution and flooding. Average daily solid waste generation is 6,500 m^3/day, of which an estimated 1,500 m^3/day is neither collected nor properly disposed of.

[Problem]
The annual uncollected garbage accumulating in the drainage system in rivers amounts to 500,000 m^3. The estimated inflow of solid waste into the reservoir is 250,000 m^3 per year.

[How the problem was overcome]
In areas with high industrial density, there is a need for more targeted pollution reduction planning. Managing pollution from these industries needs to address toxic pollutant discharges.

[The key]
Preparation and implementation of Area-Based pollution sources management is required to implement specific action plans for pollution source management throughout the basin in places such as Bandung, Bekasi and other highly urbanized areas. The overall objective is to improve water quality within the Citarum River Basin (CRB) through strong coordination among sectors. Main immediate objectives are:

(i) To have a sound and comprehensive water quality database upon which planning, policy and operational decisions can be based (with respect to water management).
(ii) To have appropriate and effective policies and procedures in place for water quality management.
(iii) To make measurable improvements in key water quality parameters across the basin.

[3.1.2.1] Identification of actual and future priority area
Identify actual and future priority areas (critical locations and key issues) as well as objectives for sound management of environmental sustainability within the context of IWRM in a river basin.
[3.2.1.3] Identifying available information and additional needed data
Identify available information and make good use of existing information
[3.5.1.1] National principles for environmental sustainability
Contribute to the development and revision of national principles, policies and strategies for managing environmental sustainability.

[Conditions and limitations in applying the KFS]
Public awareness and understanding of the community in terms of solid waste management.
Lack of sanitation and wastewater treatment facilities.

[Ideas for enhancing the applicability of the KFS]
Low cost of water treatment technology.
Provision of sanitation facilities.
Conduct pollution sources inventories and pollution load assessment in key water quality management area (prioritize Bandung and Bekasi).
Capacity-building.

(4) Extracted Key for Success

[Title]
Rehabilitation of Degraded Watersheds

[Situation]
- The pattern of urbanization in the region is clustered along a rapidly urbanizing corridor defined by the expressway connecting Jakarta and Bandung. It is predicted that urbanization will continue its expansion towards the upper catchments. This aspect has a significant impact on the water supply since domestic water supply passes along the same corridor through West Tarum Canal. Settlements and industrial establishment are intruding and will consequently threaten both water quality and water supply security.
- In the upper-part of Citarum, hilly-land farming is extensive for planting vegetables and annual crops, which do not provide adequate protection against soil erosion. In fact, upland farming areas increased from 6,000 ha in 1992 to 37,000 ha in 2001 at the expense of forest areas. The forested area has declined with only 10.2% remaining of the total area, most of which is in fragmented condition further reducing ecosystem viability making the areas vulnerable to encroachment.
- Flooding has become more frequent and severe in Bandung area. The problem is due to many reasons: (i) watershed degradation, (ii) straightening of river course, resulting in higher peak flows downstream, (iii) land subsidence due to the over-extraction of groundwater, (iv) excessive garbage clogging the channels.

[Problem]
Watershed erosion is a serious problem especially in the upper river basin. The annual sediment flow was estimated upwards to 8 million m^3 at Saguling reservoir, which is equivalent to an erosion rate of 3 mm per year. The sediment load is also deposited in the canal bed and resulted in a reduction of canal capacity.

[How the problem was overcome]
Watershed management is principally based on the need to rehabilitate the upper catchments in order to abate adverse effects on basin water supply and water quality.

[The key]
Objectives of watershed management and biodiversity conservation are to:
(i) Conserve the unique internationally important biological diversity found in remnant patches of the West Java Montane Forest type in CRB.
(ii) Establish protocols and models of best conservation management design and practice in an Indonesian Model National Park and a variety of other protected area (PA) types, and leverage these practices to other Indonesian PAs.
(iii) Reduce threats to biodiversity values in PAs and surrounding landscapes in CRB.
(iv) Achieve effective community based conservation management in both PAs and strategic parts of the production landscapes.
(v) Achieve improved environmental and biodiversity stewardship in CRB by local communities.

[3.1.2.2] Assessing the long-term environmental changes in the basin
Identify the effects on the river, lake and estuary ecology associated with various changes in the river basin.

[Conditions and limitations in applying the KFS]
Gain multi-stakeholder acceptance for reforestation on a spatial plan brokered by a water resources council, as well as allowing for broad public scrutiny.
Village actions plans for reforestation.

[Ideas for enhancing the applicability of the KFS]
Land Rehabilitation.
Alternative livelihoods for displaced upland forest villagers.
Land rehabilitation.
Conservation and reforestation.

5.3 BERMEJO RIVER BASIN (ARGENTINA)

5.3.1 Case Story (Bermejo river Basin)

Facts	Ref. to KFS

1. Background

The Bermejo River Basin in southern South America extends over some 123,000 km^2 and originates in the Andes mountains of northwestern Argentina and southern Bolivia. The population is estimated at 1.2 million, the majority being rural workers, small farmers and indigenous communities, with the lowest levels of income, education and sanitary conditions.

The river, which flows some 1,300 km, links two major geographic features: the Andean Cordillera and the Paraguay-Paraná rivers. It is the only river that completely crosses the huge expanse of the Chaco Plains, acting as a corridor for the connection of biotic elements of both the Andean mountains and the Chaco Plains. Radically differing weather and topographic conditions in the large basin support an array of rainforests, humid valleys, and mountain deserts in the Upper Basin, and dry forests as well as humid and gallery forests in the Lower Basin. There is exceptional habitat diversity along the watercourse.

The basin has a history of 'extractive' exploitation of forests, which has resulted in diminished biodiversity and impoverished natural resources. Clearing of land for cultivation and widespread overgrazing has created problems of erosion and desertification, aggravating sediment mobilization that has contributed to downstream environmental degradation.

Sediment loadings in the Bermejo waters are some of the highest in the world (8 kg/m^3). Total discharge of sediment is in the order of 100 million tons/year. The amount of sediment deposited along the course of the Lower Basin during floods regularly changes the course of the river, impeding a rational use of water and land resources.

Water quality protection and restoration is also a growing concern as the Bermejo region develops. In the Bolivian section of the Upper Basin, where water-quality deterioration problems appear to be localized, 68% of the surveyed sites suffered restrictions due to bacteriological contamination.

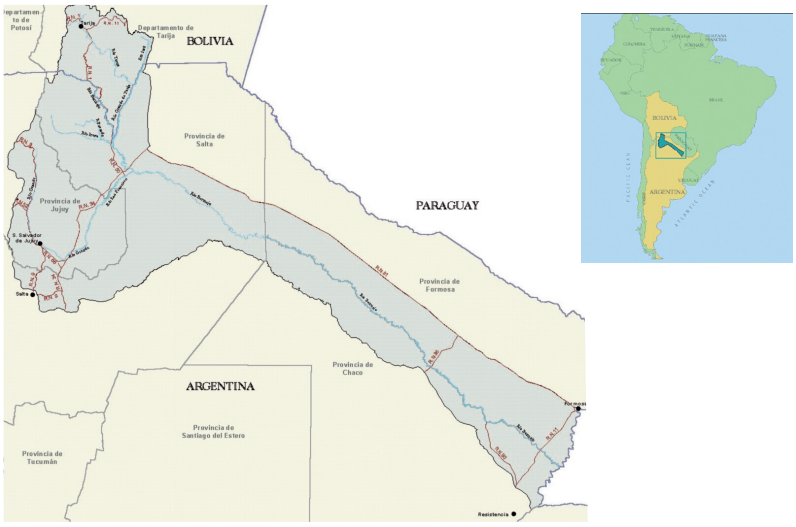


Fig. 5.3.1 Bermejo River Basin

Facts	Ref. to KFS
2. Formulation of Strategic Action Program (SAP)	
In 1995, the governments of Argentina and Bolivia created the Binational Commission for the Upper Bermejo and Grande de Tarija River Basins as a permanent legal and technical mechanism responsible for managing those river basins, sought to achieve the sustainable development of its area of influence, optimize the use of its natural resources, generate employment, attract investment, and provide for rational and equitable use of its water resources.	KFS-5.3.2 (1)
In the same year, the Binational Commission requested assistance from the Global Environment Facility (GEF) for the preparation of a water resources management programme in the watershed. This assistance helped with the preparation of a project proposal for the formulation of a Strategic Action Program (SAP) seeking to solve the priority transboundary environmental problems affecting the basin.	
A Transboundary Diagnostic Analysis (TDA) and the preparation of the SAP were carried out between 1997 and 2000 comprising the identification of priority transboundary environmental concerns and related sectoral issues, the implementation of pilot demonstration projects to assess the feasibility and relative costs of specific remedial measures, and the establishment of a comprehensive public participation and consultation process for the planning and implementation of development projects in the basin.	
Six transboundary priority areas for ecosystem level conservation, rehabilitation and preservation were identified in the TDA: (1) soil degradation, primarily due to erosion and desertification processes; (2) water scarcity and availability restrictions; (3) water degradation; (4) habitat and biodiversity losses and deterioration of terrestrial and aquatic biotic resources; (5) losses due to flood-related and other natural hazard events; and, (6) deterioration of quality of life in the basin population and loss of cultural resources. These issues are endemic throughout the basin and most have both a natural and an anthropogenic component.	KFS-5.3.2 (2)
Put forward by both governments, the SAP represents a comprehensive 20-year, US$470 million proposal envisioned by basin stakeholders as a long-term action plan designed not only to address the root causes of the critical environmental degradation processes affecting the basin, but also to promote the sustainable development of basin communities. The programme leading towards sustainable development is composed of 136 projects to be implemented in a 20-year period. More than 70% of the foreseen investment corresponds to water resource development projects, mainly structures for irrigation and drinking water supply, reflecting a long-awaited aspiration of the basin communities. The strengthening of basin institutions, the building of agency and organizational capacity, and the integration of environmental concerns into economic development activities are also key elements of the programme.	KFS-5.3.2 (3)
3. High priority actions of Strategic Action Program (SAP)	
To help lay the groundwork and initiate the implementation process, a small number of high priority actions were selected from each programme component, and subsequently approved for GEF financing.	KFS-5.3.2 (4)

Facts	Ref. to KFS
Actions were grouped in four categories as follows: **(1) Environmental prevention, protection and rehabilitation** The activities programmed for this component deal with soil management and erosion control, the consolidation of protected areas, the protection of biodiversity, basic natural resource studies, and the maintenance of the quality of the basin's water resources. Actions undertaken, including engineering works, equipment and training, has brought more and better infrastructure, capacity and information for the control of erosion, retention of sediments, consolidation of riverbeds and prevention of floods. Water channels for drinking and irrigation have been extended in selected areas. Through a focus on watershed management, including training in water and soil management techniques, these actions have provided production alternatives and improved health conditions in impoverished communities, and helped reduce soil erosion in critical areas. Integrated, community-based units have been created to serve the ecotourism market, helping to establish buffer zones and environmental corridors to reduce human impacts on areas of significant habitat value. Sustainable and cost-effective sanitation strategies have been successfully implemented with high local impact and replication potential. A bi-national hydrometeorological network has been implemented, including specialized equipment in provincial laboratories, that allow for precise quantification and monitoring of water quality, quantity and sediment loads. Specific actions taken under this component are: (a) Structural and nonstructural measures for soil conservation and erosion control in selected critical areas of the basin, such as construction of soil and gabion dikes; introduction, dissemination and training in sustainable agroforestry and cattle-raising management practices; implementation of a bi-national environmental information system and monitoring network; implementation of small-scale irrigation works and regeneration of vegetative cover and erosion control; and introduction of sustainable production practices and application of techniques for the protection, conservation, management, and rehabilitation of natural habitats. (b) Restoration of water quality in watercourses along pre-established critical stretches, including wastewater pilot treatment plants; wastewater drainage networks; water collection systems; and an integrated waste management system implemented with the active participation of local communities; equipment and training to strengthen water quality monitoring capacity in provincial water agencies; and bi-national site assessments conducted to analyse the physical, chemical and biological parameters of water and sediments. (c) Protection of biodiversity, including implementation of alternative management plans for reserves; a comprehensive biodiversity study for the Upper Bermejo Basin, and a study for the evaluation of sub-Andean rangelands in the Central Valley of Tarija. **(2) Sustainable development of natural resources** This component is aimed to encourage the adoption of alternative production modes that are environmentally friendly or at least minimizes environmental degradation, providing at the same time greater economic opportunities for the local population in a context of integrated management of water resources and planning for the basin as a whole. The initial action under this component was to formulate an integrated management programme for the basin's water resources, which draws upon – and at the same time establishes – a regional framework for the execution of the remaining activities.	KFS-5.3.2 (5) KFS-5.3.2 (6)

Facts	Ref. to KFS
Progress to date includes technological packages for soil and water management designed and implemented in irrigated areas and marginal zones; optimizing soil and water use; increasing crop productivity and controlling soil erosion; implementation of a native forest nursery; technical assistance and implementation of sustainable practices for cattle-raising, forest exploitation, soil and water management; introduction of alternative production in several locations, including small-scale industries and artisanship; and introduction of sound agro-silvo-pastoral systems and sustainable management practices in indigenous communities **(3) Institutional development and strengthening** Activities undertaken within this component addressed weaknesses within the current organizational base that hinder the effective, holistic management of the water resources of the Bermejo River Basin. This will ensure the institutional capacity to implement the new laws, regulations, and procedures necessary for sustainable watershed management, to increase participation in decision-making within the basin, and to enhance and underpin the ability of the Bi-national Commission not only to carry out its current mandate but also to assume additional responsibilities relating to information-sharing and coordination among stakeholders. **(4) Public awareness and participation.** The SAP identified the need for environmental education programmes as a key element in support of sustainable programmes for protecting and rehabilitating the environment and promoting economic development. This activity continues and extends its focus to this community throughout the Bermejo Basin. It also contributes to the development and distribution of curricula and materials for use in training teachers, and includes community and private sector initiatives in the scope of education programming. One element of this activity is specifically designed to improve educational opportunities in the most vulnerable communities. The results of this activity saw an increase of awareness among communities in the basin as well as a better understanding of ways to improve their living standards and bring about positive environmental change at the local level. The output of the activity includes the preparation of appropriate curricula at the different educational levels, publicity materials for promoting public awareness, and materials and manuals for use in teaching and teacher training. The development of the SAP was the outcome of a highly transparent, public interaction process that identified community-based mechanisms for the protection of the water resources of this river system. The public was not only consulted throughout the SAP formulation process but actively participated in it. The effort involved work by community level organizations, non-governmental institutions, official local, state and federal agencies, and the private sector. **References** This case story has been prepared on the basis of the following publications: *Strategic Action Program for the Binational Basin of the Bermejo River, Executive Summary.* http://www.oas.org/DSD/PDF_files/Bermejoeng.PDF (Accessed 8 July 2010)	KFS-5.3.2 (7)

Facts	Ref. to KFS
Organization of American States, Office for Sustainable Development & Environment, Bermejo river basin, (October 2005), *Implementation of the Strategic Action Program for the Binational Basin of the Bermejo River, Water Project Series, Number 1* http://www.oas.org/dsd/Events/english/Documents/OSDE_1Bermejo.pdf (Accessed 8 July 2010)	

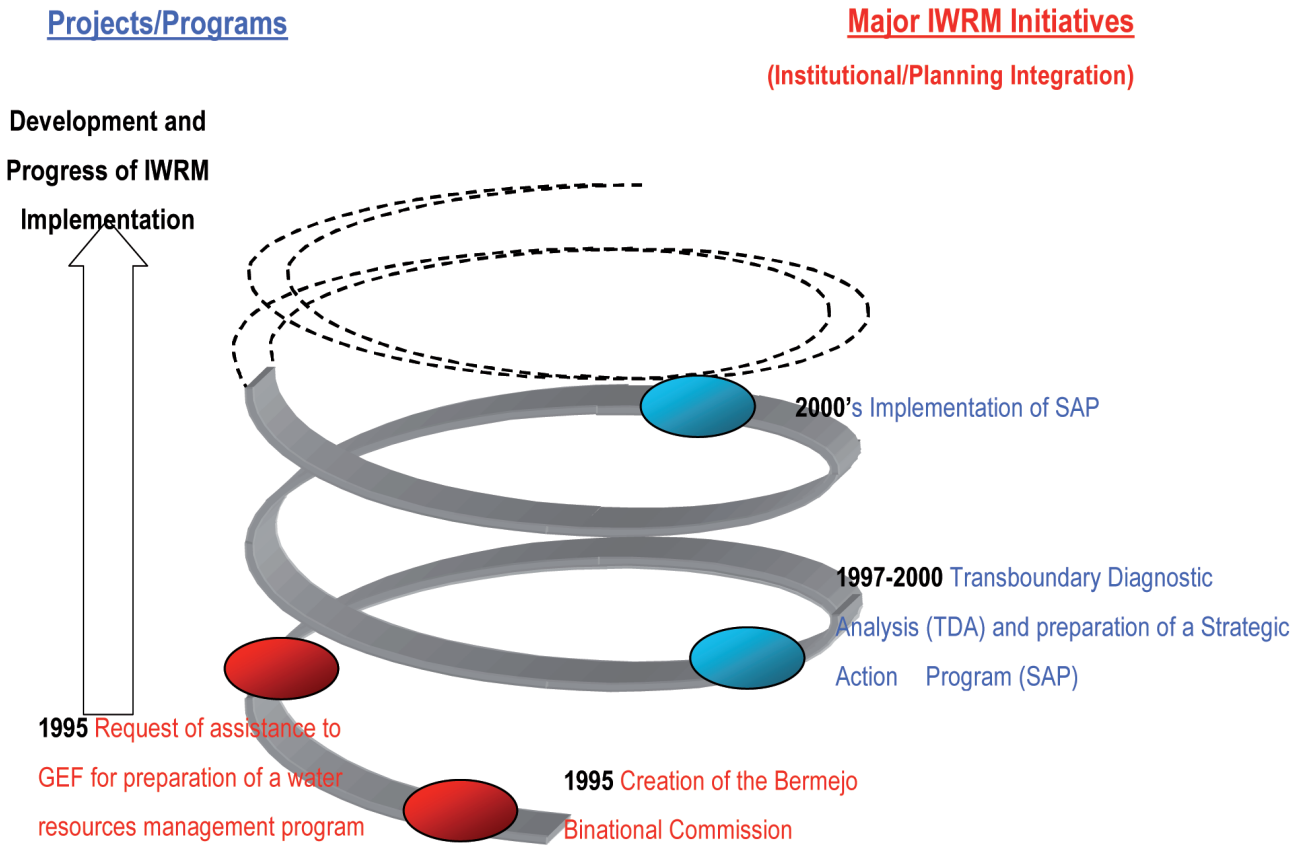


Fig. 5.3.2: IWRM spiral of Bermejo River Basin

5.3.2 Extracted Key for Success (Bermejo River Basin)

(1) Extracted Key for Success

[Title] Establish a formal coordinating body in the river basin (e.g. a river basin committee).
[Situation] Weaknesses within the current organizational base hinder the effective, holistic management of the water resources of the Bermejo River Basin.
[Problem] The governments of Argentina and Bolivia aimed to achieve the sustainable development of the area of influence of the Upper Bermejo and Grande de Tarija River Basins, optimize the use of its natural resources, generate employment, attract investment, and provide for rational and equitable use of its water resources.
[How the problem was overcome] In 1995, the governments of Argentina and Bolivia created the Bi-national Commission for the Upper Bermejo and Grande de Tarija River Basins as a permanent legal and technical mechanism responsible for managing the river basins.
[The key] In the same year, the Bi-national Commission requested assistance from the Global Environment Facility (GEF) for the preparation of a water resources management programme in the watershed. This assistance helped with the preparation of a project proposal for the formulation of a Strategic Action Program (SAP) seeking to solve the priority transboundary environmental problems affecting the basin. **[3.3.2.3] Formal coordinating body** Prepare a formal coordinating body and clearly indicate roles and responsibilities in the river basin (e.g. a river basin committee).
[Conditions and limitations in applying the KFS]
[Ideas for enhancing the applicability of the KFS]

(2) Extracted Key for Success

[Title]
Identify key needs in potential priority areas (critical locations and key issues) for IWRM implementation in the basin. Identify the ecosystem management objectives.

[Situation]
Six transboundary priority areas for ecosystem level conservation, rehabilitation and preservation were identified in the Transboundary Diagnostic Analysis (TDA).

[Problem]
Issues addressed: (1) soil degradation, primarily due to erosion and desertification processes, (2) water scarcity and availability restrictions, (3) water degradation, (4) habitat and biodiversity losses and deterioration of terrestrial and aquatic biotic resources, (5) losses due to flood-related and other natural hazard events, and (6) deterioration of quality of life in the basin population and loss of cultural resources. These issues are endemic throughout the basin and most have both a natural and an anthropogenic component.

[How the problem was overcome]
The formulation of a Strategic Action Program (SAP) seeking to solve the priority transboundary environmental problems affecting the basin. The SAP represents a comprehensive proposal envisioned by basin stakeholders as a long-term action plan designed not only to address the root causes of the critical environmental degradation processes affecting the basin but also to promote the sustainable development of basin communities. The programme leading towards sustainable development is composed of 136 projects to be implemented in a 20-year period. More than 70% of the foreseen investment corresponds to water resource development projects, mainly structures for irrigation and drinking-water supply, reflecting a long-awaited aspiration of the basin communities. The strengthening of basin institutions, the building of agency and organizational capacity, and the integration of environmental concerns into economic development activities are also key elements of the programme.

[The key]
The development of the SAP was the outcome of a highly transparent, public interaction process that has identified community-based mechanisms for the protection of water resources in this river system. The public was not only consulted throughout the SAP formulation process but actively participated in it. The effort involved work by community level organizations, non-governmental institutions, official local, state and federal agencies, and the private sector.

[3.1.3.1] Public awareness, transparency and accountability
Share information on the status of the environment in the river basin with other sectors and stakeholders.
[3.3.2.1] Stakeholder participation
Prepare a framework for stakeholder participation to build consensus among stakeholders.

[Conditions and limitations in applying the KFS]

[Ideas for enhancing the applicability of the KFS]

(3) Extracted Key for Success

[Title] Develop alternative environment management plans
[Situation] A comprehensive Strategic Action Program (SAP) was put forward by the governments of Argentina and Bolivia.
[Problem] The SAP represents a US$470 million proposal envisioned by basin stakeholders as a long-term action plan designed not only to address the root causes of the critical environmental degradation processes affecting the basin, but also to promote the sustainable development of basin communities.
[How the problem was overcome] The programme leading towards sustainable development is composed of 136 projects to be implemented in a 20-year period. More than 70% of the foreseen investment corresponds to water resource development projects, mainly structures for irrigation and drinking-water supply, reflecting a long-awaited aspiration of the basin communities. The strengthening of basin institutions, the building of agency and organizational capacity, and the integration of environmental concerns into economic development activities are also key elements of the programme.
[The key] The development of the SAP was the outcome of a highly transparent, public interaction process that identified community-based mechanisms for the protection of water resources in this river system. The public was not only consulted throughout the SAP formulation process, but actively participated in it. The effort involved work by community level organizations, non-governmental institutions, official local, state and federal agencies, and the private sector. **[3.1.3.1] Public awareness, transparency and accountability** Share information on the status of the environment in the river basin with other sectors and stakeholders. **[3.3.2.1] Stakeholder participation** Prepare a framework for stakeholder participation to build consensus among stakeholders.
[Conditions and limitations in applying the KFS]
[Ideas for enhancing the applicability of the KFS]

(4) Extracted Key for Success

[Title]
Implement basin management plans in an integrated manner.

[Situation]
The Strategic Action Program (SAP) is an action plan designed to address the root causes of the critical environmental degradation processes affecting the basin as well as to promote the sustainable development of basin communities.

[Problem]
The programme leading towards sustainable development is to be implemented in a 20-year period. More than 70% of the foreseen investment corresponds to water resource development projects. The strengthening of basin institutions, the building of agency and organizational capacity, and the integration of environmental concerns into economic development activities are also key elements of the programme.

[How the problem was overcome]
To help lay the groundwork and initiate the implementation process, a small number of high priority actions were selected from each programme component. Actions were grouped into four categories: (1) environmental protection and rehabilitation, (2) sustainable development of natural resources, (3) institutional development and strengthening, and (4) public awareness and participation.

[The key]
To implement water resource development projects together with the strengthening of basin institutions and the integration of environmental concerns into economic development activities.

[3.4.1.1] Coordination scheme
Confirm the coordination scheme established for planning, and share information among stakeholders.

[Conditions and limitations in applying the KFS]

[Ideas for enhancing the applicability of the KFS]

(5) Extracted Key for Success

[Title]
Recognize status of environment of the river basin. What needs fixing?

[Situation]
Sediment loadings in the Bermejo waters are some of the highest in the world (8 kg/m^3). Total discharge of sediment is of the order of 100 million tons/year. Water quality protection and restoration is also a growing concern as the Bermejo region develops.

[Problem]
The amount of sediment deposited along the course of the Lower Basin during floods regularly changes the course of the river, impeding a rational use of water and land resources. In the Bolivian section of the Upper Basin, where water-quality deterioration problems appear to be localized, 68% of the surveyed sites had suffered restrictions due to bacteriological contamination.

[How the problem was overcome]
Actions undertaken, including engineering works, equipment and training, has brought more and better infrastructure, capacity and information for the control of erosion, retention of sediments, consolidation of riverbeds and the prevention of floods. With a focus on watershed management, including training in water and soil management techniques, these actions have provided production alternatives and improved health conditions in impoverished communities, and helped reduce soil erosion in critical areas. Sustainable and cost-effective sanitation strategies have been successfully implemented with high local impact and replication potential. A bi-national hydrometeorological network has been implemented, including specialized equipment in provincial laboratories, that allows for precise quantification and monitoring of water quality, quantity and sediment loads.

[The key]
The focus on watershed management, which included training in water and soil management techniques, the provision of production alternatives and improved health conditions in impoverished communities, as well as the implementation of sustainable and cost-effective sanitation strategies.

[3.1.4.1] Promotion and development of necessary knowledge and capability
Promote capacity-building by developing the capacity of leaders and managers who can recognize problems, find necessary solutions and implement them.
[3.1.4.2] Technology transfer and development
Transfer and adaptation of best management of environmental sustainability practice that fully reflects local conditions.

[Conditions and limitations in applying the KFS]

[Ideas for enhancing the applicability of the KFS]

(6) Extracted Key for Success

[Title]
Identify the effects of changes in the basin as the effects of river, lake and estuary ecology

[Situation]
The basin has a history of 'extractive' exploitation of forests, which has resulted in diminished biodiversity and impoverished natural resources.

[Problem]
Clearing of land for cultivation and widespread overgrazing has caused a diminution of biodiversity and created problems of erosion and desertification aggravating sediment mobilization that has contributed to downstream environmental degradation.

[How the problem was overcome]
Encouragement of the adoption of alternative production modes that are environmentally friendly or that at least minimizes environmental degradation providing at the same time greater economic opportunities for the local population in a context of integrated management of water resources and planning for the basin as a whole. Progress to date includes technological packages for soil and water management designed and implemented in irrigated areas and marginal zones; optimizing soil and water use; increasing crop productivity and controlling soil erosion; implementation of a native forest nursery; technical assistance and implementation of sustainable practices for cattle-raising; forest exploitation; soil and water management; introduction of alternative production in several locations, including small-scale industries and artisanship; and the introduction of sound agro-silvo-pastoral systems and sustainable management practices in indigenous communities.

[The key]
The formulation of an integrated management programme for the basin's water resources, which draws upon, and at the same time establishes, a regional framework for the execution of the remaining activities.

[3.3.2.3] Formal coordinating body
Prepare a formal coordinating body and clearly indicate roles and responsibilities in the river basin (e.g.a river basin committee).
[3.5.2.1] Revising institutional frameworks
Revise the corresponding institutional guidelines and design procedures that are consistent with national policies and strategies for sustainable development.

[Conditions and limitations in applying the KFS]

[Ideas for enhancing the applicability of the KFS]

(7) Extracted Key for Success

[Title] Promote education of the river basin environment
[Situation] The river basin is an appropriate unit to learn the importance as well as the complexity and difficulty of sustainable development.
[Problem] The Strategic Action Program (SAP) identified the need for environmental education programmes as a key element in support of sustainable programmes for protecting and rehabilitating the environment and promoting economic development.
[How the problem was overcome] This activity extends the community focus throughout the Bermejo Basin. It also contributes to the development and distribution of curricula and materials for use in teacher training and includes community and private sector initiatives in education programming. One element of this activity is specifically designed to improve educational opportunities in the most vulnerable communities.
[The key] To increase awareness among communities in the basin as well as a better understanding of ways to improve their living standards, and bring about positive environmental change at the local level. **[3.1.3.2] Environmental education** Promote educational activities on environmental sustainability in the river basin.
[Conditions and limitations in applying the KFS]
[Ideas for enhancing the applicability of the KFS]

5.4 MURRAY-DARLING BASIN (AUSTRALIA)

5.4.1 Case Story (Murray-Darling Basin)

Facts	Ref. to KFS
1. Background The Murray-Darling Basin (MDB) is the sixth largest river basin in the world covering 1,073,000 km^2. It supports a population of approximately two million, in addition to another million who are externally dependent. The majority of the land is arid or semi-arid with evaporation (mean of 1,200 mm/year) generally exceeding rainfall (mean of 450 mm/year). Flow is highly variable with annual runoff ranging from 2,500 to 40,000 GL, averaging 24,000 GL, of which about 11,250 GL/ year is diverted mainly for irrigation. There have been no substantial flows to the sea for a number of years. The difference between inflows and diversions is lost through evaporation and seepage. Much of the basin is also characterized by a very low gradient with a decrease in elevation of only 200 m over 1,000 km. Consequently, the basin has little capacity to flush itself of salts and sediments making the system more vulnerable to water quality issues.	KFS-5.4.2 (1)

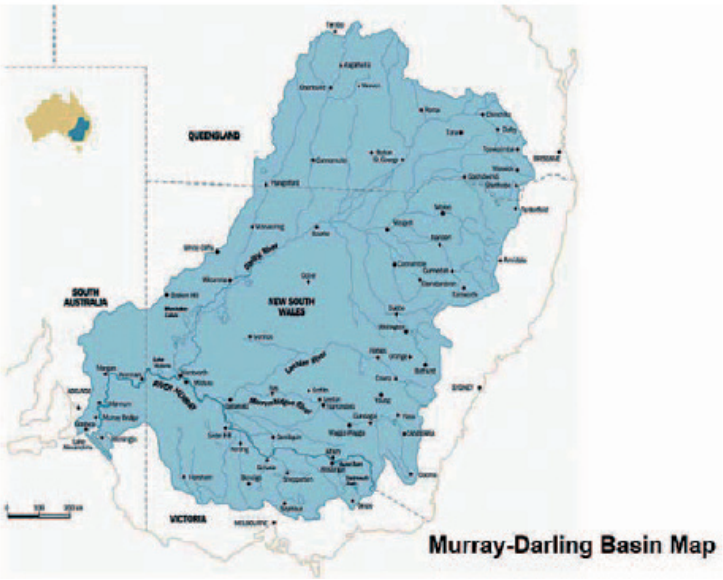


Fig. 5.4.1 Murray-Darling River Basin

The basin produces approximately 40% of the nation's agricultural income. As well as being a major source of Australia's irrigation water, the basin is also the major source for stock and domestic water supply in South Australia. Approximately two thirds of the basin's flow (90–95%) is primarily diverted for irrigation. This water diversion has generated many economic and social benefits, however this on top of widespread native vegetation clearing has led to a drastic decline in the ecological health of the basin's rivers and wetlands. A number of catchments and aquifers in the MDB suffer from over-use of their water resources.

Until recently, in Australia the states have been responsible for the management of water resources. This has been a fundamental challenge for the MDB as it comprises parts of five separate jurisdictions. With the new institutional arrangements for managing the MDB, created by the Commonwealth government's Water Act 2007/8 and a referral of powers by the states, this has now changed. The new organization, which has replaced the Murray-Darling Basin Commission, is the Murray-Darling Basin Authority. Previously, the

Facts	Ref. to KFS
institutional and regulatory fragmentation made it difficult to effectively address the basin's key natural resource management problems. The key challenges for the MDB include over-allocation of water resources, increasing conflict between competing water users in the face of climate variability and restoring the environmental condition of the system.	
2. Living Murray Initiative - Australia During the 1990s, there was a problem of degrading ecological quality of the river due to continued over abstraction of the river for irrigation and other uses with limited water being recoverable under the existing water allocation laws and the limited available funding. The situation changed in 2004 when the Murray-Darling Basin Ministerial Council committed AUS$500 million (AUS$200 million from the Australian Government) over five years to recover an annual average of up to 500 gigalitres of water for the environment. The Australian Government has reiterated its commitment to the Living Murray Initiative through Water for the Future. The water recovered through the Living Murray Initiative is being used to improve the health of six icon sites (Figure 5.4.2): • Barmah-Millewa Forest • Gunbower and Koondrook-Perricoota Forests • Hattah Lakes • Chowilla Floodplain (including Lindsay-Wallpolla) • Lower Lakes, Coorong and Murray Mouth • River Murray channel  **Fig. 5.4.2** The Six icon Sites across Victoria, New South Wales and South Australia (Source: Living Murray website) At the same time, the Murray-Darling Basin Ministerial Council committed a complementary investment of AUS$150 million under the Living Murray Environmental Works and Measures Program. This programme facilitates effective application of recovered water through the design and construction of site-specific infrastructure and other measures.	

Facts	Ref. to KFS
Since November 2003, existing water available to the environment (not including any Living Murray water) and infrastructure has been actively managed collaboratively by jurisdictions and the Murray-Darling Basin Commission. This work has contributed towards meeting the ecological objectives for the Living Murray (TLM) First Step decision's six Icon Sites. In this context, the 2005-06 season was the most active season of environmental management in the history of river regulation. Over 36 000 Ha of the natural environment of the River Murray system and Icon Sites were deliberately watered for environmental purposes in 2005/06 (to February). The sources of water used included a combination of: • the accumulated Barmah-Millewa Forest Environmental Water Allocation (BMF EWA); • other existing state-based environmental allocations (e.g. Victorian Murray Flora and Fauna Entitlement, NSW Adaptive Environmental Water); • River Murray surplus flows and Above Entitlement Flows to South Australia (part thereof); and • River Murray Increased Flows from the Snowy available under the River Red Gum Rescue Package agreed to by Ministerial Council in September 2005. Given that no 'new' TLM water has yet been recovered, the positive environmental benefits observed - especially in 2005-06 - have been the result of intelligent use of existing water available to the environment, use of new and existing infrastructure and improved planning and cooperation developed through the Living Murray process. Environmental actions and outcomes in 2005-06 included the: (a) Release of an accumulated 5 years worth of the Barmah-Millewa Forest Environmental Water Allocation (~510 GL) to achieve one of the most significant colonial nesting waterbird breeding events in recent decades and the spawning of threatened fish such as Silver Perch; (b) Delivery of environmental water through various means such as flow enhancement, pumping/siphoning, weir manipulation (Lock 1, 4, 5, 6, 8 and 26), and use of regulated creeks/channels to reinvigorate stressed floodplain vegetation including River Red Gums, and to fill wetlands across Gunbower Forest, Hattah Lakes, Chowilla Floodplain (including Lindsay-Wallpolla) and the River Murray Channel; (c) Release of water through the Barrages at the Murray Mouth which provided temporary freshening of parts of the Coorong; and 7 months continuous operation of fishways (to February, but continuing until about April 2006) allowing the passage of thousands of small-bodied native fish and collectively using less than 100 ML/day to operate. Benefits to the Icon Sites have not been equal. Of the six sites, Barmah-Millewa Forest is the only one to have met all of the major ecological objectives, a result possible only because of the availability of the pre-existing environmental water allocation. Furthermore, the actions at other Icon Sites have contributed only partially to meeting their objectives. An example is the River Red Gum Rescue where results have been positive to date, but limited in scale by the capacity to deliver the water to the sites by means other than elevating river levels. This necessitated a focus on a small range of species (i.e. River Red Gum communities) &/or relatively discrete floodplain/wetland areas. As such, larger areas of floodplain continue to decline in health (e.g. Chowilla Floodplain).	

Facts	Ref. to KFS
3. Methods for environmental water application From 2001 to 2007, the MDB recorded its equal driest six-year period (BOM, 2007), including 2006, which had the lowest rainfall levels recorded since 1900. Extended dry periods together with a high pressure on the system due to high irrigation water demand and high temperature was causing severe water shortages in the basin. The Murray-Darling Basin system had never experienced such pressure on the system. The commission predicted that if the low inflow continued there was a high chance that the reserves would become empty and that some of the critical urban water requirement in South Australia wouldn't be met. The existing water allocation needed to be reviewed The water available for environmental use in 2004/05 and 2005/06 was delivered to sites using various methods: (a) 'flow enhancement'- involves releasing additional water from storages to enhance flow rates and raise river levels downstream; (b) 'weir manipulation' - involves raising or lowering the upstream weir pool level to flood or dry areas in the vicinity of the Lock/Weir; (c) 'regulated creeks/channels' – involves use of creeks/anabranches &/or irrigation supply channels to gravity feed water into wetlands; (d) 'pumping/siphons'- involves pumping or siphoning water from the river to discrete wetland systems; and (e) 'Barrage release' - involves releasing water from the Lower Lakes through the Barrage gates and fishways into the Coorong and Murray Mouth	KFS-5.4.2 (2)
4. Coordination of Environmental Monitoring Problems of environmental degradation escalated in the basin, and it had become apparent that such issues extended across state boundaries and thus cooperation between states was needed. Institutional framework for basin management cooperation among states had to be reformed to address the environmental problems requiring coordinated and effective planning and management of the basin. In addressing the water needs of each states as well as the environmental degradation issue, which extends across state boundaries, cooperation between states needed to be strengthened. Several operational "committees" convened by the Commission Office (River Murray Environmental Manager & River Murray Water), participated in regular teleconferences to coordinate the real time management of the environmental watering actions. These included: (a) Barmah-Millewa Forest Operations Committee; (b) Lock 8 Operations Committee; (c) Locks 1, 4, 5 and 6 Operations Committee (convened by DWLBC); and the (d) Barrages Operating Committee. The membership of these "committees" includes lead Icon Site Managers and representatives from State Natural Resource Management Agencies, Catchment Management Authorities, research organisations and State Constructing Authorities. Critical matters relating to system operation, water accounting and water availability have been referred as necessary to the Water Liaison Working Group (formerly the Water Liaison Committee) and the Environmental Watering Group (EWG).	KFS-5.4.2 (3)

Fig. 5.4.3 Wetland vegetation response to watering, Hut Lake, Barmah Forest (Photo: Goulburn-Broken CMA)

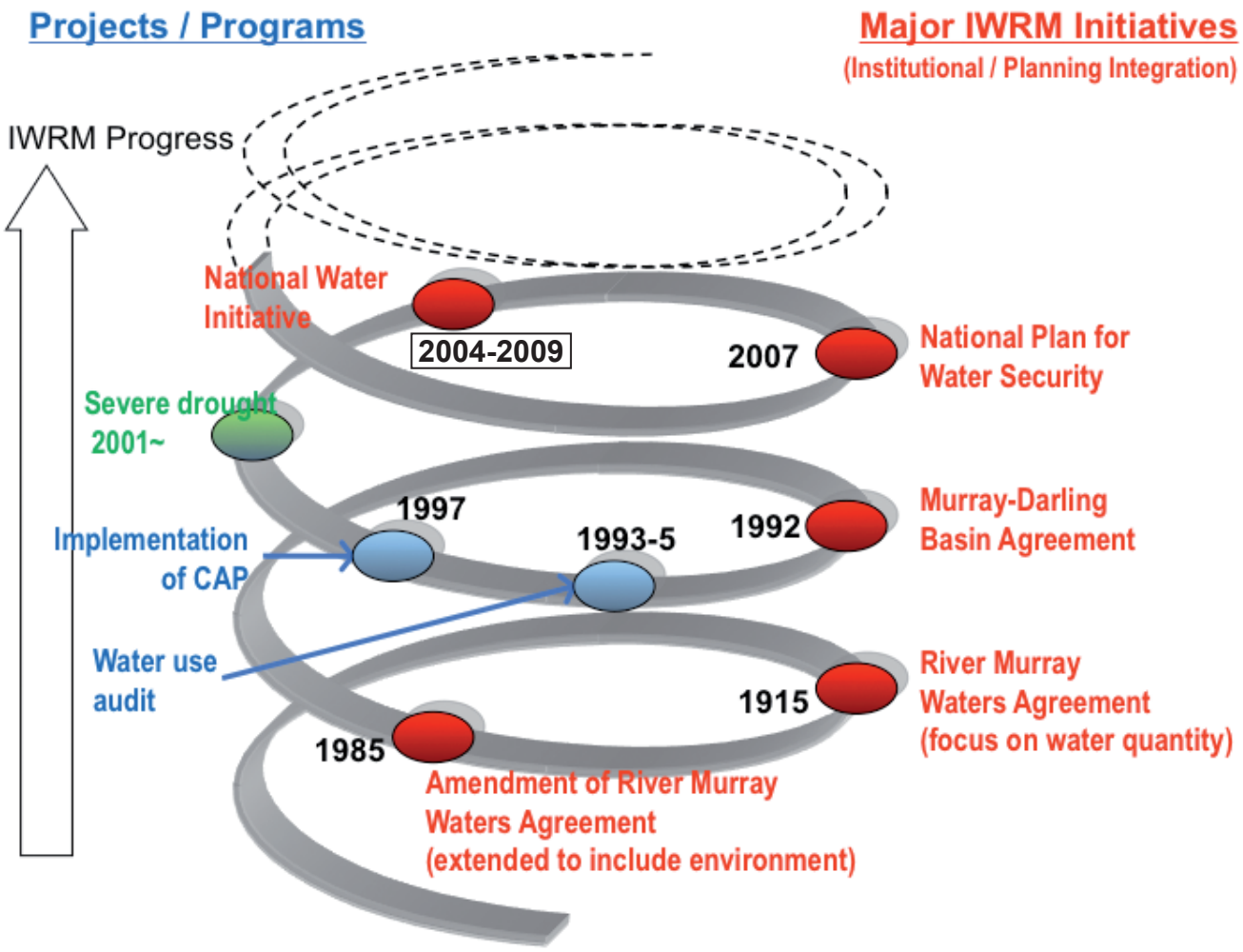


Fig. 5.4.4 IWRM spiral of Murray Darling Basin

5.4.2 Extracted Key for Success (Murray-Darling basin)

(1) Extracted Key for Success

[Title]
Targeted Government Action with Limited Water and Funding

[Situation]
Degrading ecological quality of the river due to continued over abstraction of the river for irrigation and other uses.
From 2001 to 2007, the MDB recorded its driest six-year period (Australian Government Bureau Of Meteorology, 2007), with 2006 recording the lowest rainfall levels since 1900. Extended dry periods together with a high pressure on the system due to high irrigation water demand and high temperature caused severe water shortages in the basin.

[Problem]
Limited water could be recovered under the existing water allocation laws and therefore there was a need to buy environmental water.
The basin produces approximately 40% of the nation's agricultural income and is a major source of irrigation water for both stock and the domestic water supply. Due to the severe and prolonged drought period, the basin's economic activities were impacted. It was important to ensure that water was only allocated for critical needs and that the benefits of limited water supplies be maximized.

[How the problem was overcome]
Targeting recovery of six icon sites with limited water resources.
The Murray-Darling Basin Ministerial Council committed AUS$500 million (AUS$200 million from the Australian Government) over five years to recover an annual average of up to 500 gigalitres of water for the environment.

[The key]
Government targeted action backed by appropriate funding mechanisms secured sustainable funding to buy environmental flows.
The Australian Government has reiterated its commitment to the Living Murray Initiative through Water for the Future. The water recovered through the Living Murray Initiative is being used to improve the health of six icon sites.

[3.5.1.1] National principles for environmental sustainability
Contribute to the development and revision of national principles, policies and strategies for managing environmental sustainability.
[3.5.2.2] Defining roles and responsibility
Define roles and responsibilities of river basin management entities for the management of environmental sustainability.

[Conditions and limitations in applying the KFS]
Political goodwill and greater interest of the states responsible for water management.

[Ideas for enhancing the applicability of the KFS]
National regulation to reallocate water to the environment.

(2) Extracted Key for Success

[Title]
Innovative methods of application of environmental flows

[Situation]
Limited water flows needed to be delivered to the icon sites at different locations and elevations.
From 2001 to 2007, the MDB recorded its driest six-year period (Australian Government Bureau Of Meteorology, 2007) with 2006 recording the lowest rainfall levels since 1900. Extended dry periods together with a high pressure on the system due to high irrigation water demand and high temperature caused severe water shortages in the basin.

[Problem]
Limited water could be recovered under the existing water allocation laws and the limited available funding.
The Murray-Darling Basin system had never experienced such pressure on the system. The commission predicted that if the low inflow were to continue there was a high chance that the reserves would become empty and that some of the critical urban water requirement in South Australia wouldn't be met. The existing water allocation therefore needed to be reviewed.

[How the problem was overcome]
The Murray-Darling Basin Ministerial Council committed a complementary investment of AUS$150 million under the Living Murray Environmental Works and Measures Program. This programme facilitates the effective application of recovered water through the design and construction of site-specific infrastructure and other measures.
The water available for environmental use in 2004/05 and 2005/06 was delivered to sites using various methods:
(a) 'flow enhancement' – involves releasing additional water from storage to enhance flow rates and raise river levels downstream.
(b) 'weir manipulation' – involves raising or lowering the upstream weir pool level to flood or dry areas in the vicinity of the Lock/Weir.
(c) 'regulated creeks/channels' – involves use of creeks/anabranches and/or irrigation supply channels to gravity feed water into wetlands.
(d) 'pumping/siphons' – involves pumping or siphoning water from the river to discrete wetland systems.
(e) 'Barrage release' – involves releasing water from the Lower Lakes through the Barrage gates and fishways into the Coorong and Murray Mouth.

[The key]
Local innovations for effective use of environment flows.
Existing water available to the environment (not including any Living Murray water) and infrastructure has been actively managed in a collaborative way by jurisdictions and the Murray-Darling Basin Commission. This work has contributed towards meeting the ecological objectives of the Living Murray (TLM) First Step decision's six Icon Sites.
Use of new and existing infrastructure and improved planning and cooperation developed through the Living Murray process.

[3.1.4.2] Technology transfer and development
Transfer and adaptation of best management of environmental sustainability practice that fully reflects local conditions.

[Conditions and limitations in applying the KFS]
Good flow and ecological data backed by scientific analysis and engineering design.

[Ideas for enhancing the applicability of the KFS]

(3) Extracted Key for Success

[Title]
Managers involvement in deciding environmental flow releases

[Situation]
Need for effective coordination among different water management groups to achieve real time management of environmental water actions.
Problems of environmental degradation escalated in the basin and it had become apparent that such issues extended across state boundaries and thus cooperation between states was needed. The institutional framework for basin management cooperation among states had to be reformed to address the environmental problems, requiring coordinated and effective planning and management of the basin.

[Problem]
Water flows across different jurisdictions and catchments.
In addressing the water needs of each state as well as the environmental degradation issue, which extends across state boundaries, cooperation between states needed to be strengthened.

[How the problem was overcome]
Several operational 'committees' convened by the Murray Darling Commission Office (River Murray Environmental Manager & River Murray Water), participated in regular teleconferences to coordinate the real time management of the environmental watering actions. These included:
(a) Barmah-Millewa Forest Operations Committee.
(b) Lock 8 Operations Committee.
(c) Locks 1, 4, 5 and 6 Operations Committee (convened by DWLBC).
(d) Barrages Operating Committee.
The membership of these 'committees' includes lead Icon Site Managers and representatives from State Natural Resource Management Agencies, Catchment Management Authorities, research organizations and State Constructing Authorities.

[The key]
Involvement of key stakeholders across states.
Critical matters relating to system operation, water accounting and water availability have been referred as necessary to the Water Liaison Working Group (formerly the Water Liaison Committee) and the Environmental Watering Group (EWG).

[3.3.2.1] Stakeholder participation
Prepare a framework for stakeholder participation to build consensus among stakeholders.

[Conditions and limitations in applying the KFS]
Well functioning coordination mechanisms among different stakeholder and manager groups.

[Ideas for enhancing the applicability of the KFS]

5.5 ARAKAWA RIVER BASIN (JAPAN)

5.5.1 Case Story (Arakawa River Basin)

Facts	Ref. to KFS

1. Introduction

The Arakawa River is a Class-1 river originating in Mt. Kobushi-dake at 2,475-metre elevation, flowing into Tokyo Bay and spanning 173 kilometres. The drainage basin covers 2,940 km^2 in the two prefectures of Saitama and Tokyo.

The population of the Arakawa basin is approximately 9.3 million people, accounting for about one fourteenth of the total population in Japan. Most of the population is concentrated in the alluvial lowland, plateaus and hillsides in the middle and lower reaches of the river. The population density along the river in Tokyo Prefecture is 12,900 inhabitants/km^2, which is the highest among the basins of Class-1 rivers in Japan. Because Arakawa River flows through the Tokyo Metropolitan Area – the political, economic, and cultural centre of Japan – it is considered an extremely important river in terms of water utilization and flood control. Moreover, the Arakawa is serving a vital role as a source of agricultural, industrial and city water for the Tokyo Metropolitan Area.

Since early times, the Arakawa basin has been widely inhabited by people who benefited from the river. Arakawa was part of the Tone River System until the early Edo era when the Shogunate decided to divert its course by constructing a channel that connected Arakawa to Iruma River, which remains unchanged today. This boosted the utilization of Arakawa as a source of agricultural water and as a waterway for transportation. The Arakawa basin has an inland Pacific-type climate with hot and humid summers and cold and dry winters. The annual precipitation of the various districts of the basin area ranges from 1,200 mm to 1,800 mm, averaging 1,400 mm, which is lower than the national average of 1,700 mm.

The annual precipitation per capita is only one tenth of the national average.

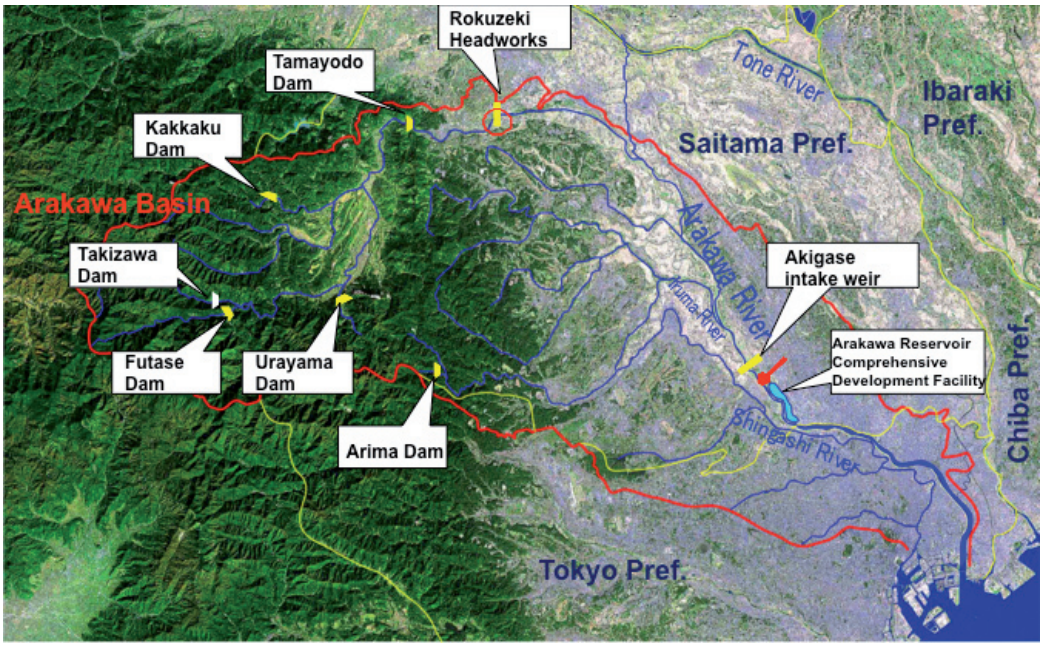


Fig. 5.5.1 Arakawa Basin Map

Facts	Ref. to KFS
2. Overview of Water Utilization of Arakawa River Water from Arakawa River is utilized primarily for hydroelectric power generation in the upper reaches, as agricultural water in the middle reaches and – coupled with water drawn from Tone River – as city water in the lower reaches. The Rokuzeki Headworks situated in the middle reaches over the two districts of Fukawa City and Hanazono-Cho, Osato-gun of Saitama Prefecture draws nearly 50% of total water taken from Arakawa River for agricultural purposes. Rokuzeki is a collective name for six weirs and channels that take water from Arakawa. These weirs were integrated into Rokuzeki Headworks in 1938. Since then, the facility has greatly contributed to the increased food production policy of the Japanese government.	
3. Problem **Occurrence of Riverbed Exposure and Interrupted Fish Migrations** Due to an increased demand for city water in recent years, Arakawa has experienced frequent droughts resulting in water intake restrictions in the Metropolitan Area and rationing or shutoff of the water supply in wider areas affecting people's lives. It was difficult to discharge water to downstream areas due to the absence of water discharge functions at the weirs. To rectify the situation, dam construction plans were formulated to secure a sufficient volume of service water for urban areas, for which the downstream weirs needed to be renovated such that they could also hold sufficient water to maintain the capacity of the dams. Also, due to influent seepage through the gravel riverbed of middle Arakawa, water flow was often intercepted around the Arakawa Great Bridge during droughts, which exposed the riverbed. This caused the death of many fish and negatively affected the ecosystem as well as the fisheries industry, the landscape, outdoor leisure and other activities.  **Fig. 5.5.2** Occurrence of Exposed Riverbed (June 1996)  **Fig. 5.5.3** Death of Fish due to Exposed Riverbed (June 1996) Structures were constructed around the Rokuzeki Headworks, Akedo Siphon and other river-crossings. However, these facilities had no or insufficiently functioning fishways, which were preventing fish from migrating upstream or downstream. In addition, the old Rokuzeki Headworks formed a bottleneck interrupting the down flow of water in times of flooding and thus it became a problem in flood control. Also, it was ageing and needed immediate renovation.	

Facts	Ref. to KFS

Fig. 5.5.4 Akedo Siphon

Fig. 5.5.5 Fish ladder at former Rokuzeki Headworks

Despite the numerous problems of flood control and the environment as a result of the former Rokuzeki Headworks, as described above, practical solutions were not implemented. The reason being that it had to accommodate both the needs of a continuous facility operation for agricultural water utilization by water intake administrators (Ministry of Agriculture, Forestry and Fisheries (MAFF)), which has jurisdiction over agricultural water and is responsible for the management of Rokuzeki Headworks, and the need to improve the facility by restructuring basin-wide water utilization.

4. Action

(1) Setting Up a Discussion Table

In 1992, the discussion forum for coordination among relevant sectors was organized and MLIT (Ministry of Land, Infrastructure, Transport and Tourism) as the secretariat, gave its support and in fact played a key role in its establishment. It was organized for stakeholders from the various sectors such as MLIT, MAFF, and water users of the Rokuzeki Headworks, Akigase Intake Weir and so on, to present their respective problems, identify common objectives, and define a division of work. After a series of discussions, it was decided in 1993 to renovate the Rokuzeki Headworks and construct a flow improvement channel and fishways. The construction work began in 1998 and was completed in 2003. As a result, riverbed exposure downstream of the meadworks was eliminated and breeding grounds and habitats for fish and other aquatic species were restored.

KFS-5.5.2 (2)

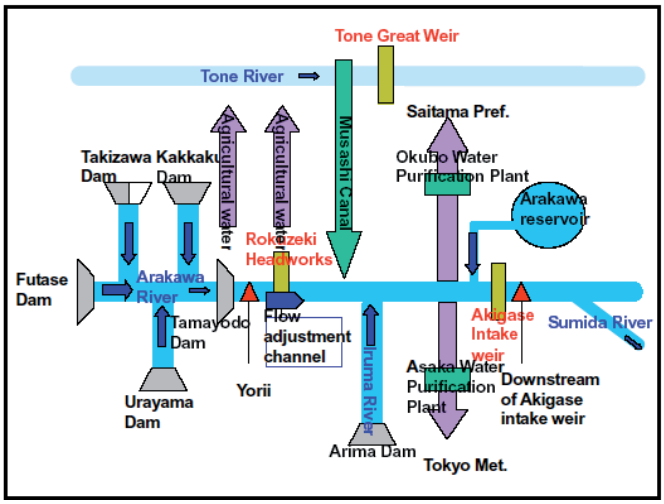


Fig. 5.5.6 Water Flow Management of Arakawa River

Facts	Ref. to KFS

The reconstruction was not just aimed at reconstructing the facility but to achieve the restructuring for the advanced water utilization and environmental restoration of the entire Arakawa Basin. It was also decided to build and manage facilities that would properly regulate the discharge of water supplied from the upstream dams through Rokuzeki Headworks by centrally controlling the discharge rates and other flow conditions downstream of Musashi Canal, Iruma River and Akigase Intake Weir, and by managing the intake and discharge rates of Futase Dam, Urayama Dam, Arakawa Reservoir and other facilities in an integrated manner.

(2) Division of Work

After a series of discussions and coordination among MLIT, MAFF and other organizations concerned, and by taking into account the role and needs of Arakawa River, it was decided to construct a flow improvement channel to be used as a bypass to efficiently regulate the flow rate, as well as a mild slope fishway to help fish with weak swimming abilities to migrate upstream. In this way, improvement of water utilization, environment and flood control achieved through the reconstruction of the facilities managed by each sector and helped by the coordination among water users in the basin, while the river administrator played a key role in the entire process.

Project / Challenge	MLIT Comprehensive Middle Arakawa Flow Improvement Project	MAFF Comprehensive Disaster Prevention Project in Osato National Agricultural Land
• Water flow control Prevention riverbed exposure	• Appropriate discharge of water supplied from dams to downstream by constructing a flow improvement channel. • Discharge of water to prevent riverbed exposure by constructing a flow improvement channel.	–
• Disrupted upstream/ downstream fish migration	• Construction of a flow improvement channel (which also works as a priming channel) and mild slope fishways.	• Construction of fish ladders (ice-harbor type) (along the right and left banks) • Discharge of water to prevent riverbed exposure by constructing a flow improvement channel.
• Aged facilities • Lack of discharge capacity	• Channel widening, revetment/embankment	• Renovation of Rokuzeki Headworks and removal of Akedo Siphon • Channel widening, revetment/embankment

Table. 5.5.1 Division of Work by Project and Challenge

Facts	Ref. to KFS
(3) Eco-Friendly Facilities *1) Construction of Flow Improvement Channel* The flow improvement channel, which was constructed on the right bank side of the Rokuzeki Headworks, also serves as a priming channel discharging water at 3m³/s during normal operations so as to prevent riverbed exposure, while releasing water reserved in upstream dams to be used as city water.	KFS-5.5.2 (1)

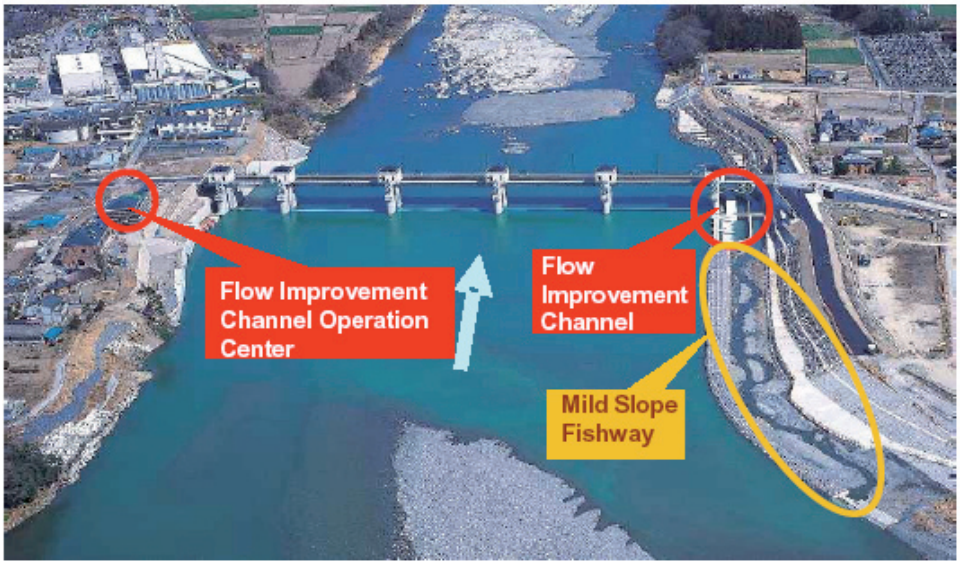


Fig. 5.5.7 New Rokuzeki Headworks, Flow Improvement Channel, and Mild Slope Fishway

2) Construction of Fishways

Fish ladders were installed on either side of the river as well as a mild slope fishway on the right bank side along the flow improvement channel. The mild slope fishway enables fish with weak swimming abilities, found downstream of Rokuzeki Headworks, to ascend and descend.

This fishway was designed at a 0.6m/s flow velocity, 0.2m water depth, 1/110 gradient and a flow rate of around 0.4m³/s based on the physiology of targeted fish species. The fishway was constructed in partnership with MAFF, the institution responsible for reconstructing the fish ladders as part of its guarantee to maintain its prior function, while taking into consideration the fish species inhabiting Arakawa River, the landscape, maintenance and other factors.

Fig. 5.5.8 Mild Slope Fishway (seen from downstream)

Fig. 5.5.9 Mild Slope Fishway (from upstream)

Facts	Ref. to KFS

Since their installment, the fishways have been monitored for accountability and, by setting up an observation area by the mild slope fishway, they have been utilized for educational purposes by local junior high and elementary school children as well as the general public. Continuous monitoring and provision of learning opportunities are making sustainable operations of the fishways possible.

Targeted Fish Species	*Oncorhynchus masou*	*Plecoglossus altivelis altivelis*	*Tribolodon hakonensis*	*Carassius auratu*	*Anguilla japonica*	*Rhinogobius brunneus*
Mild Slope Fishway	O	O	O	O		
Fish Ladders		O	O	O	O	O

Table. 5.5.2 Fishway Types & Targeted Fish Species

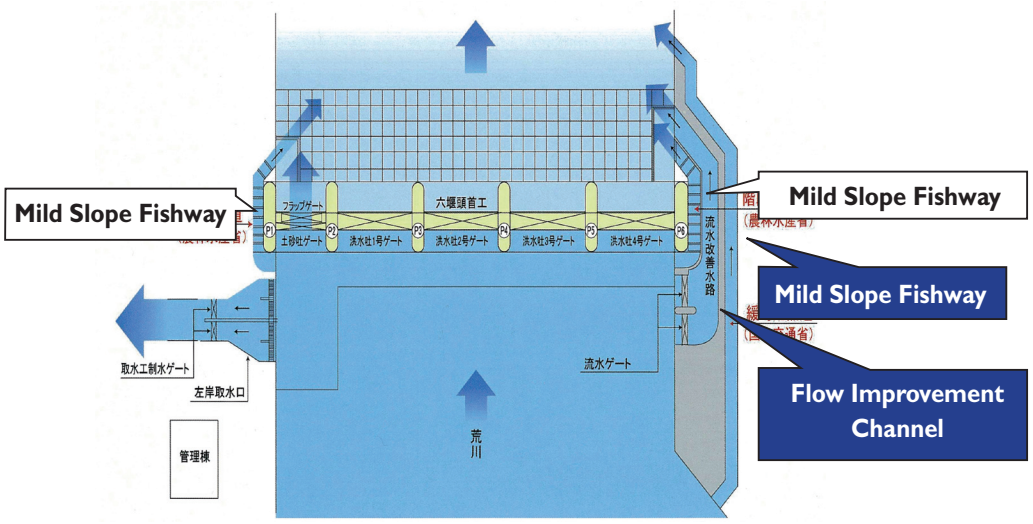


Fig. 5.5.10 Positions of Mild Slope Fishway and Fish Ladders

5. Effect

Before the construction of the flow improvement channel, Rokuzeki Headworks was discharging water at a flow rate of 3m^3/s or less for a total of 467 days during the four-year period between 1994 and 1997. Following the installation of the channel, the number of below 3m^3/s days decreased considerably to 87 days out of four years from 2003 and 2006. Furthermore, no riverbed exposure occurred in the mainstream Arakawa downstream of Rokuzeki Headworks since the construction of the flow improvement channel.

In addition, water supplied from upstream dams (Futase Dam, Urayama Dam, and Kakkau Dam), which was not discharged downstream steadily through Rokuzeki Headworks before the construction of the flow improvement channel, is now properly discharged to Akigase Intake Weir, and thus supplying a stable intake of water to urban areas.

Facts	Ref. to KFS

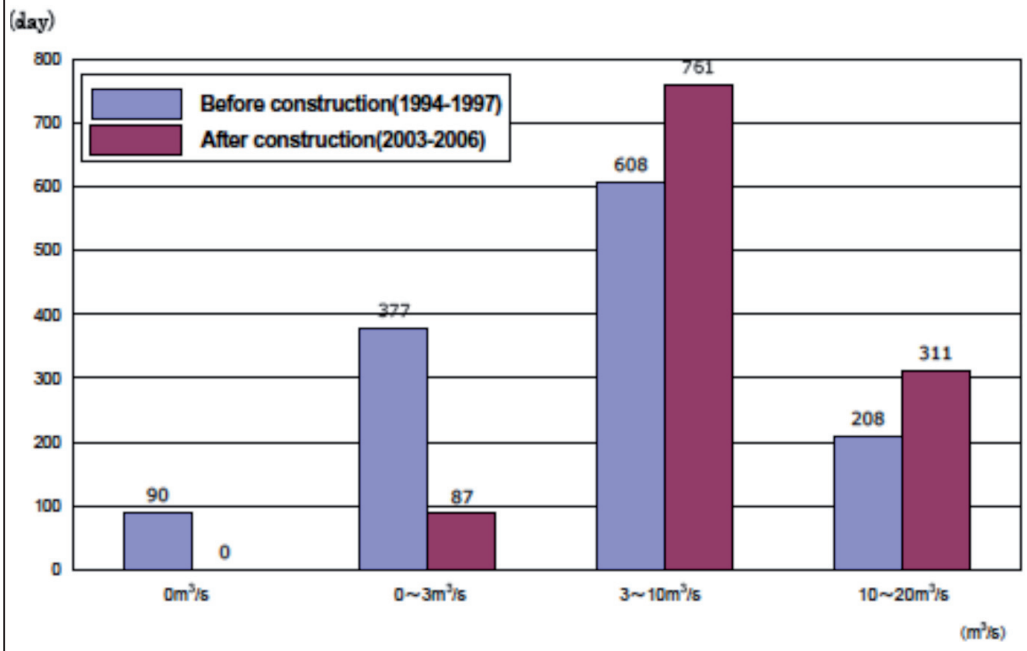


Fig. 5.5.11 Cumulative no. of days by discharge volume from Rokuzeki Headworks before and after the construction of a flow improvement channel

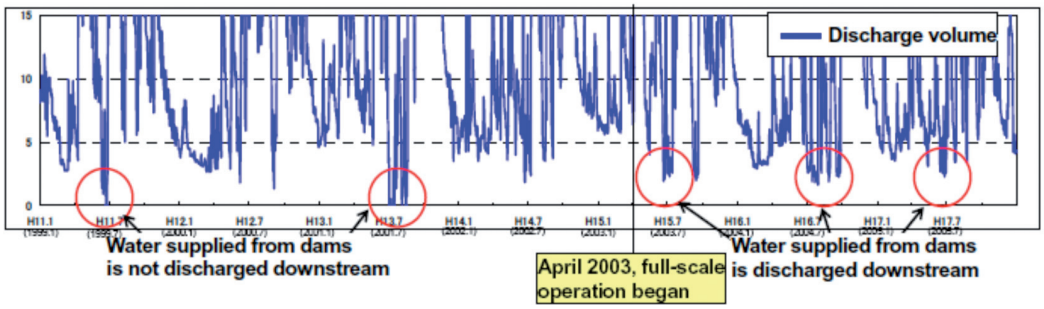


Fig. 5.5.12 Discharge of Water to Downstream of Rokuzeki Headworks

In the gentle slope fishway, fish species with weak swimming abilities such as *Phoxinus lagowskii steindachneri, Gnathopogon elongatus, Cobitis biwae* and *Rhinogobius brunneus* are being observed in large numbers, indicating that the newly installed fishway has taken effect.

Facts	Ref. to KFS

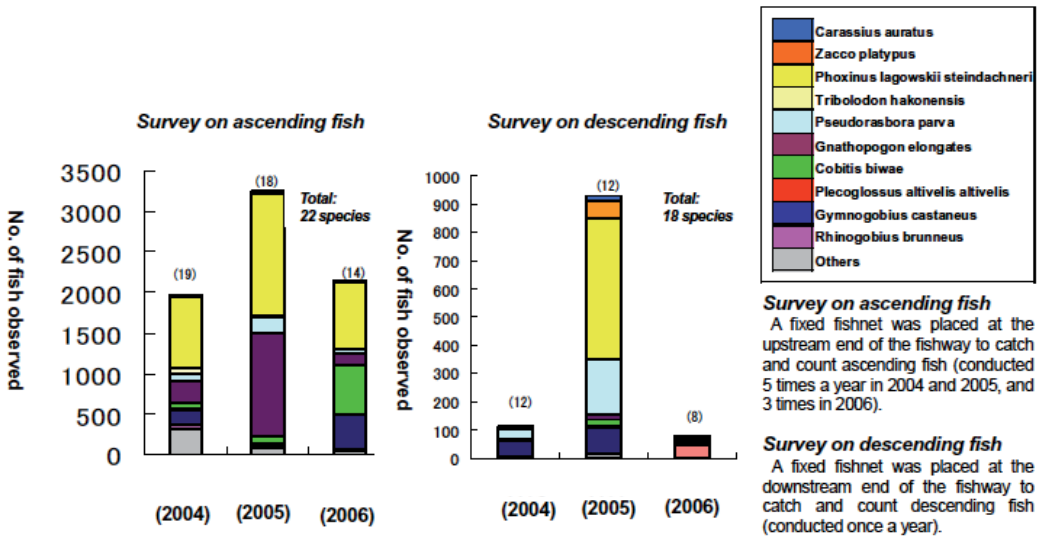


Fig. 5.5.13 No. of fish observed in gentle slope fishway

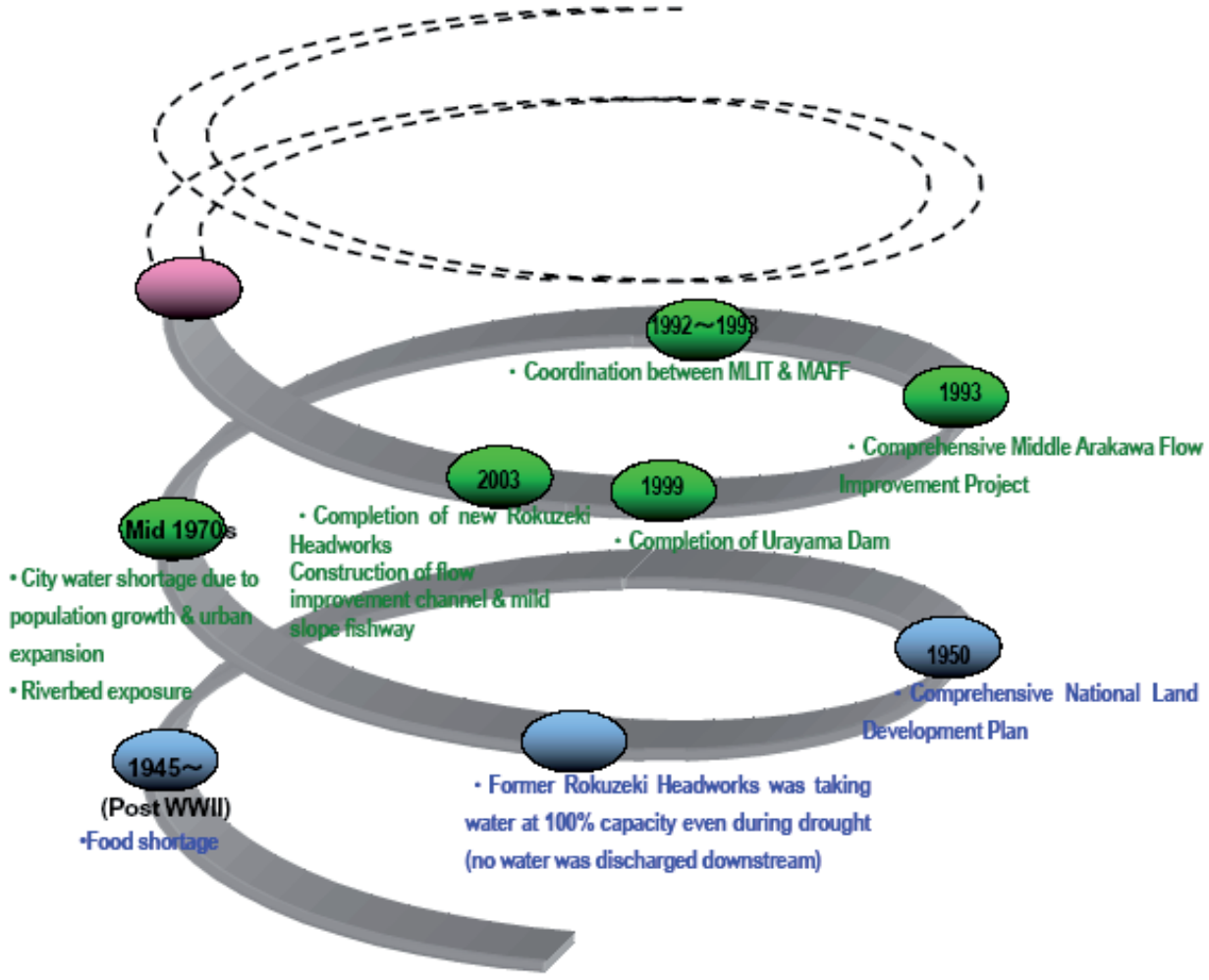


Fig. 5.5.14 Arakawa River Spiral

5.5.2 Extracted Key for success (Arakawa River Basin)

(1) Extracted Key for Success

[Title]
Preservation of the Ecosystem

[Situation]
Frequent drought and riverbed exposure and the deteriorating environment in the midstream area were causes for concern.
Due to the increased demand for city water in recent years, Arakawa River experienced frequent drought resulting in water intake restrictions in the Metropolitan Area and rationing or shutoff of water supply in wider areas affecting people's lives. Releasing sufficient volumes of water to downstream areas was difficult due to the absence or malfunctioning of water discharge equipment at the weirs.
Also, due to influent seepage through the gravel riverbed of middle Arakawa, water flow was often interrupted during drought around Arakawa Great Bridge exposing the riverbed. This caused the death of many fish, which negatively affected the ecosystem as well as the fisheries industry, the landscape, outdoor leisure and other activities.

[Problem]
Sufficient water supply and a continuity of river flow (preservation of healthy environment) had to be realized for the entire Arakawa Basin.
Arakawa River serves as an important source of water for various purposes from the upper reaches to the lower reaches in the Tokyo Metropolitan Area and, at the same time, it is expected to provide a precious natural environment for city dwellers who seek to enjoy the landscape, outdoor leisure, and other recreational activities. The challenge was to satisfy the conflicting needs for both water supply and environmental protection (continuous river flow).

[How the problem was overcome]
Environmental improvement was realized through the elimination of riverbed exposure and the securing of the water supply through stable replenishment. Aimed towards advanced water utilization and environmental restoration of the entire Arakawa Basin, it was decided to build and manage facilities that would properly regulate the discharge of water supplied from upstream dams through Rokuzeki Headworks so as to realize efficient water utilization by integrally monitoring such river flow conditions as the tributary inflow and discharge rates of other weirs, as well as by managing the intake and discharge rates of dams reservoirs, and other facilities in an integrated manner.
The completion of the flow improvement channel greatly reduced the number of days when the discharge rate from Rokuzeki Headworks fell below $3m^3/s$, resulting in the elimination of riverbed exposure and an improvement of the fish habitat.
The flow improvement channel properly brings water from upstream dams, which occasionally did not flow to Rokuzeki Headworks before its installment, to the downstream through the weir such that a stable intake of water is supplied to urban areas.
Also, the construction of the mild slope fishway enabled fishes that previously had difficulty overcoming the fish ladders to migrate more freely. Through the reconstruction of the facilities, water utilization, environment and flood control was improved. This was managed by each sector and coordinated among water users in the basin, while the river administrator played a key role in the whole process.

[The key]

– Establishment of the centralized water management and facility operation systems for the entire basin enabled the proper control of water discharge from upstream dams to downstream facilities. Also, monitoring of the ecosystem both upstream and downstream of the Rokuzeki Headworks led to the construction and improvement of fishways, which consequently restored ecological continuity.
– Indentify the effects of water quality, quantity and variability in the basin on ecosystem functions and services. Identify options for water quality, quantity and variability on ecosystem services for both water and land management.
– Establish national principles of managing environmental sustainability.

[3.1.2.3] Hydrological variability in terms of water quality and quantity

Identify the causes and effects of current water management practice on water quality, quantity and variability in the basin on ecosystem functions and services.

Identify options for improving water quality, quantity and variability on ecosystem services for both water and land management.

[3.5.1.1] National principles for environmental sustainability

Contribute to development and a revision of national principles, policies and strategies for managing environmental sustainability.

[Conditions and limitations in applying the KFS]

[Ideas for enhancing the applicability of the KFS]

Guidance on Assessing Normal River Flow (draft).
Guidelines for Designing Fishways.

(2) Extracted Key for Success

[Title]
Formation of Consensus through Participation of Stakeholders

[Situation]
With regard to Rokuzeki Headworks, the river administrator (Ministry of Land, Infrastructure, Transport and Tourism (MLIT)), which implements flood control measures and water resource development projects, and the water intake administrator (Ministry of Agriculture, Forestry and Fisheries (MAFF)) with jurisdiction over agricultural water, were faced with different problems.
For the river administrator (MLIT), the old Rokuzeki Headworks presented a problem in terms of flood control as it was forming a bottleneck and could not sufficiently release water due to a lack of discharge facility.
For the water intake administrator (MAFF), the urgent issue was the renovation of an aged and deteriorating Rokuzeki Headworks. In addition, water rights holders of the lower reaches sought to draw adequate and stable volumes of water from the dams.

[Problem]
Despite various problems faced by the different sectors with regard to Rokuzeki Headworks, conditions to implement solutions were not met due to a lack of coordination between the river administrator (MLIT) and the water intake administrator (MAFF).

[How the problem was overcome]
A discussion forum was organized by stakeholders to identify common goals and problems and to define a division of responsibilities.
The discussion forum, supported by MLIT as the secretariat tasked with coordination among relevant sectors, was organized with the active involvement of MLIT.
Stakeholders from the various sectors each with different purposes, such as MLIT, MAFF, and water users of Rokuzeki Headworks, Akigase Intake Weir and other downstream facilities, formed a discussion forum to present their respective problems, identify common objectives and define responsibilities. After a series of discussions, it was decided to renovate Rokuzeki Headworks and construct a flow improvement channel with fishways.
As a result, riverbed exposure downstream of the Headworks was eliminated, and spawning grounds and habitats for fish and other aquatic species were restored.

[The key]
- By taking into consideration the water utilization and the environmental protection of the entire basin, MLIT, MAFF, other relevant organizations and water users of Rokuzeki Headworks, Akigase Intake Weir, and so on – each with their own purpose and interests – discussed and negotiated to find common understanding and to define the sharing of responsibilities based on their respective problems.
- Identify key needs potential priority areas (critical locations and key issues) for IWRM implementation in the basin. Identify your ecosystem management objectives.
- Obtain agreement on responsibility.

[3.1.2.1] Identification of actual and future priority area
Identify actual and future priority areas (critical locations and key issues) as well as objectives for sound management of environmental sustainability within the context of IWRM in a river basin.
[3.3.1.1] Roles and responsibilities
Identify the roles and responsibilities of each relevant sector and stakeholders in each proposed plan, and obtain agreements from the sectors.

[Conditions and limitations in applying the KFS]

[Ideas for enhancing the applicability of the KFS]

5.6 OIGAWA RIVER BASIN (JAPAN)

5.6.1 Case Story (Oigawa River Basin)

Facts	Ref. to KFS

1. Introduction

The Oigawa River is a Class-1 river with a basin area of 1,280 km^2 and a channel length of 168 km. It originates from the Ainodake peak (at elevation of 3,189 meters) located at the boundaries of the Shizuoka, Nagano, and Yamanashi Prefectures, and runs in the middle of the Shizuoka Prefecture to the south through a delta that fans out of Shimada City merging with tributaries such as Sumatagawa and Sasamagawa rivers and flowing into the Suruga Bay.

The river basin area is comprised of the four cities of Shizuoka, Shimada, Fujieda and Yaezu, and the two towns of Yoshida-cho and Kawanehon-cho. Mountains account for about 94% of the total basin area, agricultural fields account for about 4%, and urban districts, including residential areas, account for about 2%.

Oi Plain in the lower reaches

Fig. 5.6.1 Oigawa Basin Map

Facts	Ref. to KFS

2. History of Hydroelectric Power Generation in Oigawa River

In 1906, a British-Japanese joint venture company, the Anglo-Japanese Hydroelectric Company, was established with private investors to begin operating the first hydroelectric power plant in the Oigawa River system. In the late 1920s, dam and conduit type power stations were introduced and five dams were constructed by around 1940. In order to mitigate serious power shortages during the period of rapid economic growth in post-war Japan, development of electrical power resources progressed in even greater strides. In Oigawa River, hydroelectric power generation with six dams began and has since been contributing greatly to Japan's economic development.

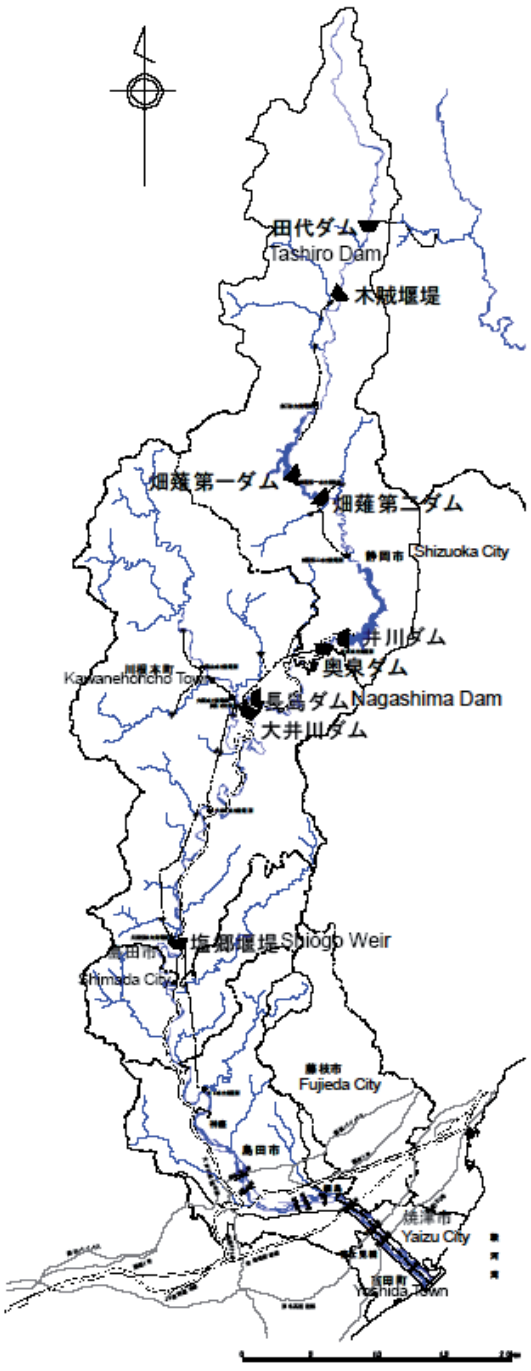


Fig. 5.6.2 Oigawa Basin Map

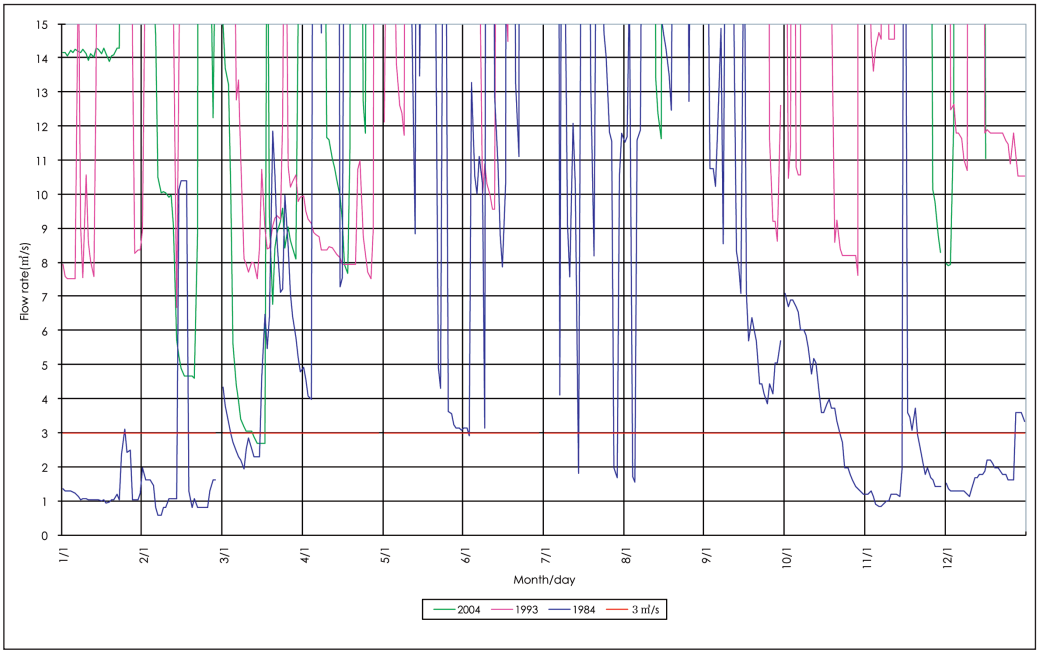
3. Problem – 'Give Our Water Back' Movement by Residents Against Interrupted River Flow

In 1960, Shiogo Weir was completed for a hydroelectric power located at the most downstream part of Oigawa River. The weir dammed up the flow of Oigawa's mainstream, and water flow was intercepted for 20 km downstream from the intake point adversely affecting the ecosystem and natural environment of the area.

Local residents began to strongly voice their desire to have Oigawa restored to its original pristine state, which led to the 'Give Our Water Back' movement of Oigawa.

In 1975, a series of discussions and negotiations were held over various issues, such as returning water rights to the residents to restore the flow volume of Oigawa at the time when the water rights for upstream power generation dams were being renewed. As a result, an agreement was reached with the electric company in 1976 to release water from Shiogo Weir at a rate of 1 m^3/s, which, however, was not enough to resolve the discontentment of the people living in the area.

Facts	Ref. to KFS
4. Action - Establishment of the Middle Oigawa Basin Council Local residents' 'Give Our Water Back' demands intensified as the renewal of water rights for Shiogo Weir, which was scheduled in 1989, drew close. In response to the residents' demands, the Ministry of Construction, the authority granting water rights, organized the Middle Oigawa Basin Council in 1985, which comprised of Shizuoka Prefecture (river administrator), Chubu Electric Company (water rights holder), three municipalities, and other stakeholders, to discuss ways to restore the flow volume in Oigawa River. According to the government ordinance article 10 of the River Law, appropriate discharge rates (maintenance flow rates) were to be decided with comprehensive consideration of various standpoints including the restoration of the landscape, preservation of river control facilities, retention of the groundwater level, protection of fauna and flora, and maintenance of the purity of river water. Thus, with regard to the discharge rates of the Oigawa river basin, the aspects mentioned in the above were examined, and the final solutions were worked out from the viewpoints of landscape and fauna and flora protection. For the restoration of the landscape it was concluded that the water level needed to be raised to the extent where the formation of a smooth continuous flow path both upstream and downstream of the weir would be ensured throughout the year. For the protection of fauna and flora, the water volume had to be increased to maintain roughly 15 cm or greater water depth in the habitats for such fishes as sweetfish, Japanese dace and pale chub. As a result, it was agreed in 1989 to discharge water from Shiogo Weir at 3m^3/s, which eliminated the problem of riverbed exposure downstream of Shiogo Weir and restored the spawning grounds and habitats of fishes.	KFS-5.6.2 (1)
5. Establishment of guidelines on water release from the hydraulic power plant to secure environmental flow. Increasing demands for the restoration of river environments is not unique to Oigawa River. This is a common problem shared by other communities suffering from depleted river water caused by a diversion of large volumes of water for power generation. In regions where tourism is the main industry, demand for recovering abundant river flow to enhance their attractiveness is increasing. In order to facilitate negotiations between local communities and water permit holders for power generation, it was necessary to establish standards based on which parties concerned could work out amicable solutions. In the process of licensing water rights, it is important to build consensus among relevant stakeholders including other water users and municipalities in addition to adequate due consideration of the river environment. Thus, in order to promote a proper coordination by river administrators, MLIT proposed guidelines in 1988 on water release from hydraulic power plant to secure environmental flow to secure sufficient maintenance discharge levels at the time of water rights renewal for power generation. The guidelines stated that the maintenance flow rate shall be newly established or revised in terms of water utilization for power generation, which significantly hindered river management, and shall be based upon the comprehensive consideration of its effects including the width and depth of river channels, conditions of river side areas, water quality in the section with flow volume recession, and ecosystems. Furthermore, the guidelines	KFS-5.6.2 (2)

Facts	Ref. to KFS
state the need for sufficient and due consideration on the impact on power generation capacity. – An example of the conditions laid out in the guidelines relates to the water usage that causes a reduction of water levels in a 10 km or longer river section with a catchment area of 200km^2 or larger upstream of the intake point. – The minimum maintenance flow rates of a river shall be established numerically (about 0.1 – 0.3 m^3/s per 100 km^2 catchment area).	
6. Establishment of Maintenance Flow Rates for the Entire Basin After the adoption of the guidelines on water release from the hydraulic power plant to secure environmental flow, maintenance flow rates were established for other dams located upstream of Shiogo Weir based on the guidelines, which consequently improved the river environment of the entire basin area.	
7. Effect The graph below reveals changes in the flow rate a few years prior (1984) and after (1993 and 2004) Shiogo Weir began discharging water at 3 m^3/s in 1989. The flow rates were measured at Kanza, located downstream of Shiogo Weir. The graph indicates that the flow volume of the river has been restored by the increased discharge.  **Fig. 5.6.3** Changes in flow rate downstream of Shiogo Weir (Kanza)	

Facts	Ref. to KFS
The graph below shows the number of fishes observed in Kanza in 1993 shortly after the discharge rate was increased, and in 2004. Compared to the 1993 figures, a greater number of species and fish were observed in 2004, indicating the restoration of the ecosystem.	

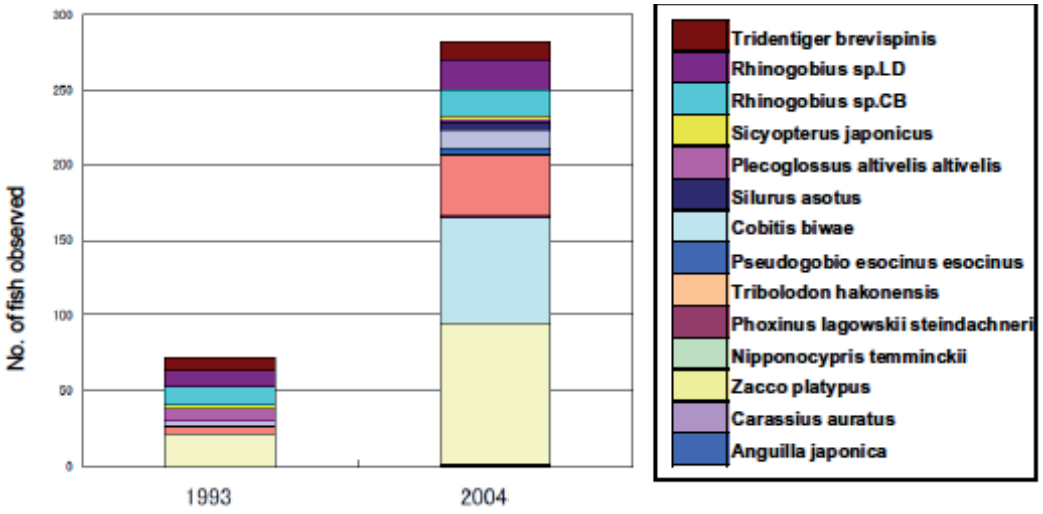


Fig. 5.6.4 Result of fish survey downstream of Shiogo Weir (Kanza)

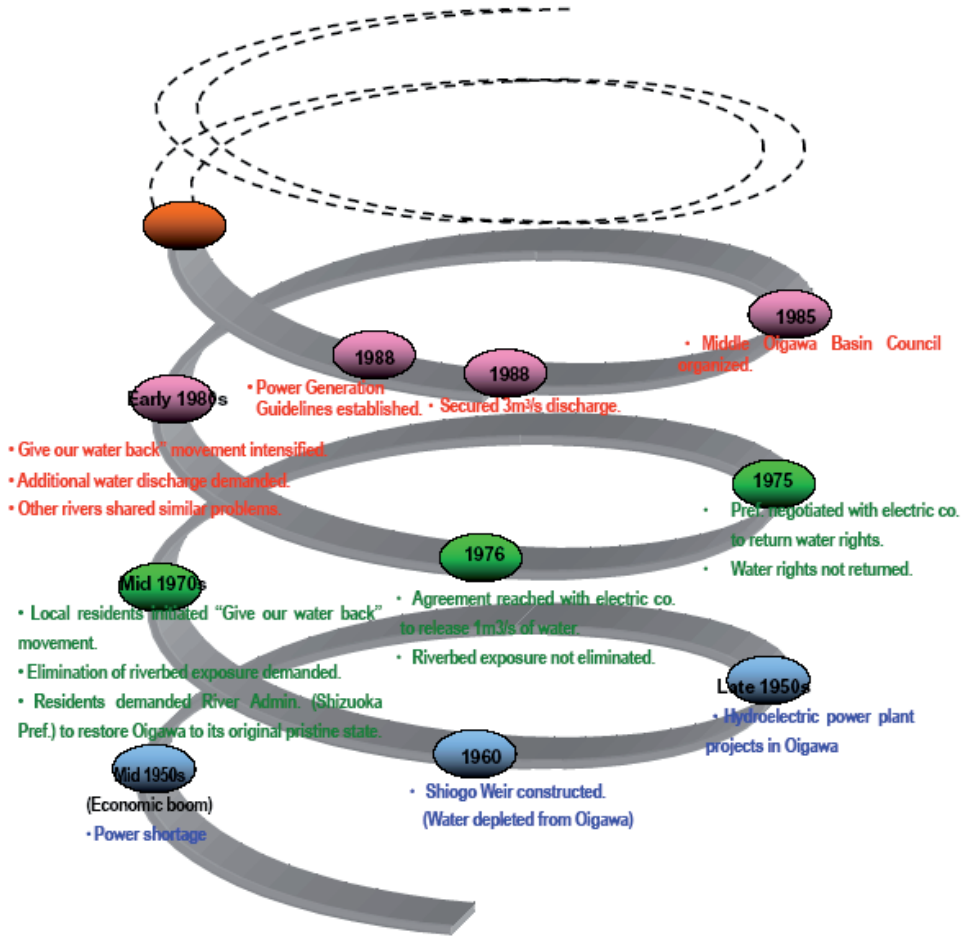


Fig. 5.6.5 Result of fish survey downstream of Shiogo Weir (Kanza)

5.6.2 Extracted key for success (Oigawa River Basin)

(1) Extracted Key for Success

[Title]
Formation of Consensus through Participation of Stakeholders

[Situation]
Local residents' concern and frustration grew over the deteriorating river environment and intercepted river flow.

Pursuant to the agreement between the prefectural government and the electric power company, water was discharged from Shiogo Weir at the rate of 1 m^3/s, which, however, did not eliminate the exposure of the riverbed caused by intercepted river flow. This also affected the progress of other dams that were under planning at that time. Local residents' discontent with the electric power company's unflinching refusal to return the water rights gradually grew to an uncontainable level.

Subsequently, the residents' 'Give Our Water Back' movement intensified at the time when the water rights renewal of Shiogo Dam drew close.

[Problem]
It was near impossible to restore the river flow to a satisfactory level through discussions between the electric power company and the prefectural government representing the local residents.

Various discussions and negotiations were held to demand that the electric power company return the water rights at the time of its renewal, for power generation at upstream dams so as to restore the river flow. As a result, an agreement was concluded with the electric power company to release 1 m^3/s from Shiogo Weir, which, however, was not enough to resolve the discontent of the local residents.

[How the problem was overcome]
Triggered by the citizens' movement, a council was established to reach a consensus on the appropriate flow rate.

– Local residents' 'Give Our Water Back' movement gradually intensified at a time when the renewal of the water rights for Shiogo Weir drew close. In response to the residents' demand, the Ministry of Construction, the authority granting water rights, organized the Middle Oigawa Basin Council comprised of Shizuoka Prefecture (river administrator), Chubu Electric Power Company (water rights holder), three municipalities, and other stakeholders, to discuss ways to restore the flow in Oigawa River.

Consequently, it was agreed to release 3 m^3/s from Shiogo Weir, which eliminated the riverbed exposure caused by intercepted river flow and restored the natural habitat and spawning grounds of fishes and other species.

[The key]

Local residents organized a citizens' movement from the realization that water intake for use in power generation was intercepting the river flow and causing the aquatic environment to deteriorate. This had an impact on the central and prefectural governments and placed sufficient pressure on the electric power company to take part in the council and discuss the environmental problems caused by its water intake. At the council, the two seemingly contradicting requirements of securing a sufficient water intake level and maintaining an appropriate flow rate were discussed, and it was decided that the electric power company would release enough water to maintain an adequate river flow to restore the environment even at the sacrifice of lesser revenues.

- Prepare a framework for stakeholder participation to build consensus among stakeholders.
- Impact analysis, modeling, environmental benefit analysis including social impact analysis (trade off analysis).

[3.3.2.1] Stakeholder participation

Prepare a framework for stakeholder participation to build consensus among stakeholders.

[3.2.3.2] Environmental Assessment

Conduct environmental impact analysis for assessing environmental impact and environmental benefit analysis in the draft plans to evaluate social and economic impacts.

[Conditions and limitations in applying the KFS]

- The national government is required to consult with the prefectural governor before granting water rights.

[Ideas for enhancing the applicability of the KFS]

(2) Extracted Key for Success

[Title]
Securing River Maintenance Flow

[Situation]
The deterioration of the river environment caused by water intake for power generation was becoming a burning issue.

Water intake for power generation at Shiogo Weir caused an interruption of river flow over 20 km in the lower Oigawa, adversely affecting the ecosystem and the environment along the river.

This is a common problem shared by other communities suffering from depleted river water caused by a diversion of large volumes of water for power generation. In tourist regions, there was a growing demand to recover river flow to enhance the attractiveness of the regions.

[Problem]
The discharge rate that was agreed upon in the absence of reliable standards could not resolve the residents' discontent.

While an agreement was reached to release water from Shiogo Weir at a rate of 1 m^3/s in the absence of water discharge standards from weirs, it was not enough to restore the river's ecosystem and therefore did not resolve the residents' discontent.

[How the problem was overcome]
River flow requirements were examined from various standpoints to determine the appropriate discharge rate. Subsequently, guidelines were established that provided certain conditions towards maintaining an adequate river flow in exchange for water rights renewal, including restrictions on water intake for power generation.

The appropriate river flow (maintenance flow) was examined from various viewpoints including the landscape, protection of river management facilities, retention of groundwater levels, preservation of fauna and flora, and maintenance of purity of river water. Finally, solutions were worked out from the standpoints of landscape and fauna and flora preservation.

In the process of licensing water rights, it is important to build consensus among relevant stakeholders including other water users and municipalities in addition to adequate due consideration of the river environment. Thus, in order to promote a proper coordination by river administrators, MLIT proposed guidelines in 1988 on water release from hydraulic power plant to secure environmental flow to secure sufficient maintenance discharge levels at the time of water rights renewal for power generation.

[The key]
- The clearly defined requirements for water discharge from water intake weirs for power generation in Oigawa River provided other areas in Japan, which had been suffering from similar problems caused by depleted river flows, a basis to resolve their own problems. As a result, these areas were also able to restore river flows, enhance the landscape and increase competitiveness in tourism and other sectors.
- Establish national principles for managing environmental sustainability.

[3.5.1.1] National principles for environmental sustainability
Contribute to the development and revision of national principles, policies and strategies for managing environmental sustainability.

[Conditions and limitations in applying the KFS]
Establishment of water rights systems and renewal requirements.

[Ideas for enhancing the applicability of the KFS]
Guidelines on water release from hydraulic power plant to secure environmental flow.

6. Useful Tools

Useful Tools provide useful ideas/information for explaining or understanding complex issues that one might face during IWRM implementation to ensure good environmental status. Good utilization of these tools will allow for the effective and efficient implementation of IWRM.

6.1 ECOHYDROLOGICAL APPROACH

Ecohydrology is the transdisciplinary science defined as a sub-discipline of hydrology which focuses on ecological processes occurring within the hydrological cycle and strives to utilize such processes for enhancing environmental sustainability and provides a systemic approach for solving problems associated with water use and ecological conservation. Ecohydrology considers the freshwater ecosystem form the catchments perspective and contains the following aspects: the fundamental aspects of environmental sciences based on empirical analysis of the structure and the functional relationships between the various abiotic and biotic components of the environment and the distillation of the general patterns from surrounding commonalities.

The Ecohydrological Approach is expressed in three principles:

- **Hydrological Principle:** quantification of hydrological cycle analysis of a basin. It can be the template for functional integration of hydrological and biological processes from the point of view of socio-economic and spatial-temporal dynamic versus various forms of human impact.
- **Ecological Principle:** the analysis of distribution of various types of bioconosis and its potential to enhance resilience and absorbing capacity for human impact. It is necessary to regulate ecosystem structure and processes toward increasing the carrying capacity.
- **Ecotechnological Principle:** ability to adapt terrestrial and aquatic organisms to water dynamics and using the understanding of such feedbacks to control hydrological processes and water quality improvement and vice versa.

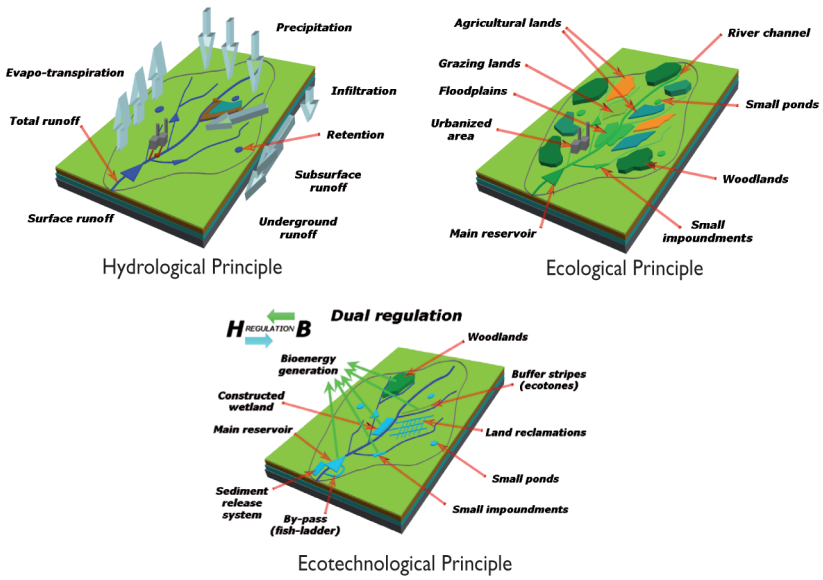


Fig. 6.1.1 Illustration of the three principles of Ecohydrology (Zalewski 2010)

One of the implicit but primary goals of Ecohydrology is to achieve sustainability, and ecohydrological goals as a problem-solving science include:

- slowing down the transfer of water from the atmosphere to the sea (considering flood and drought control as priorities);
- reducing input and regulating the allocation of excess nutrients and pollutants in aquatic ecosystems to improve water quality, biodiversity and human health; and
- enhancing of ecosystem carrying capacity (resilience, biodiversity, ecosystem services for society) in harmonization with societal needs.

The above mentioned goals are achieved in a way that regulates water allocation, with special consideration of the reverse of water quality degradation, and to reduces input and regulates the excess nutrients and pollutants allocation in aquatic system toward "non-available pool" e.g. at soil, sediments vascular plant biomass or even selected species from algae toward zooplankton and fish.

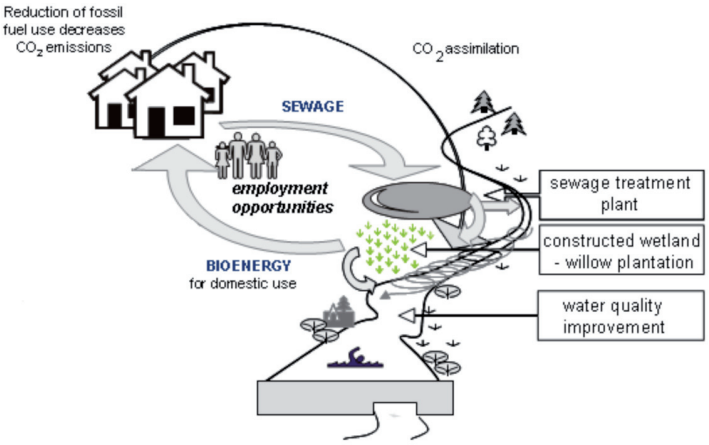


Fig. 6.1.2 System solutions based on three principles: improvement of ecological flow, water quality, human health and quality of life (modified from Zalewski 2002).

6.2 ENVIRONMENTAL STATUS MAPPING TOOLS

Tools to link ecological responses with flow regimes in order to decide on environmental flows, for example, the RANA model developed in Costa Rica.

The RANA – ICE methodology integrates hydrological, biological and socio-economic information of river sections where the impact of hydropower developments is envisaged. Natural hydrological patterns are studied first and different water use demands are identified, including those of the ecosystem, to determine a minimum acceptable flow satisfying these demands. These demands are used as constraints and are evaluated against different flow regulation scenarios to recommend the environmental flow pattern that provides a sustainable use of water resources.

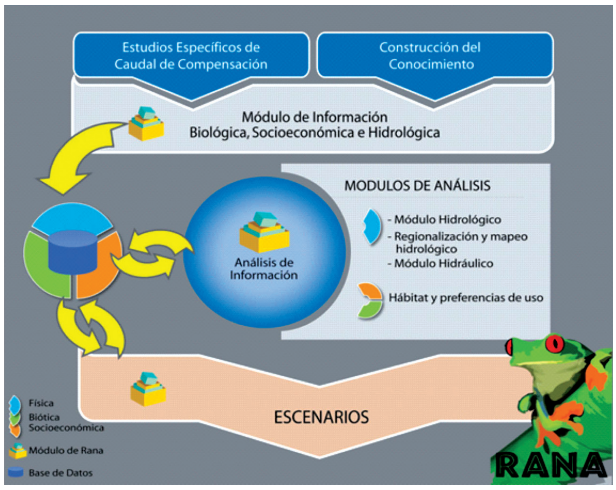


Fig. 6.2.1 RANA Components

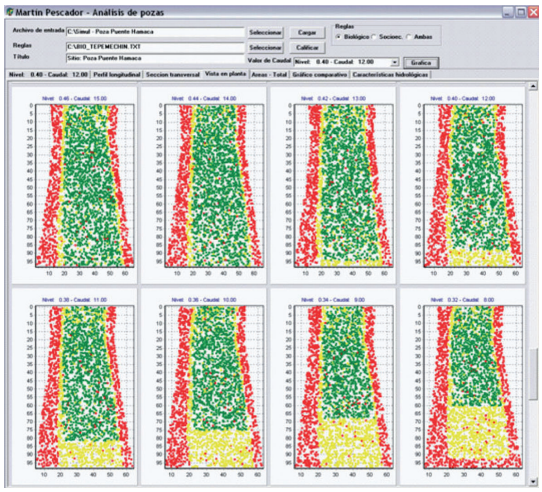


Fig. 6.2.2 Principal views of preferred habitat conditions for a fish species

6.3 MOTION CHARTS FOR VISUALIZING LONG-TERM WATER QUALITY

In order to deal with the problems associated with low natural discharge and high effluent loads, South African water managers needed to make best use of all data at their disposal. Visualization is an effective method for evaluating long-term data and the GoogleTM Docs Motion Chart provides a free platform for comparing water quality variables, particularly ratios of troublesome ions such as sulphate.

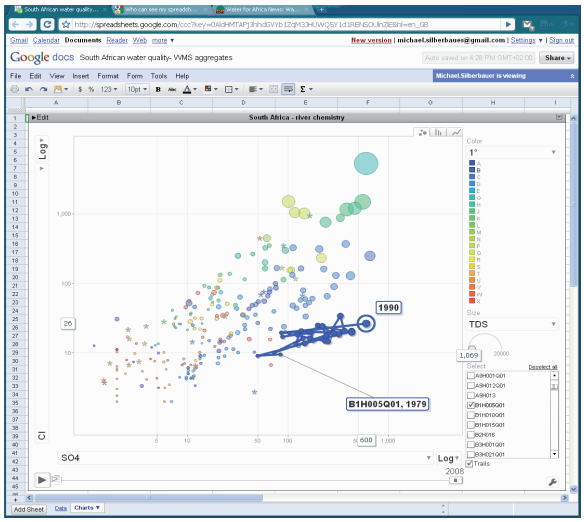


Fig. 6.3.1 Snapshot of a Google Motion Chart of chloride against sulphate, highlighting the differences between a site affected by mine drainage (B1H005Q01, where a trail connects the complete time series) against the background of 251 other sites.

6.4 DECISION SUPPORT SYSTEM

MFAT is a decision support system that relates river flow to potential habitat conditions for river and floodplain environments. MFAT can help governments and communities make informed decisions on environmental flows.

The results from the MFAT can then be used to facilitate an informed trade-off process between environmental and human flow requirements.

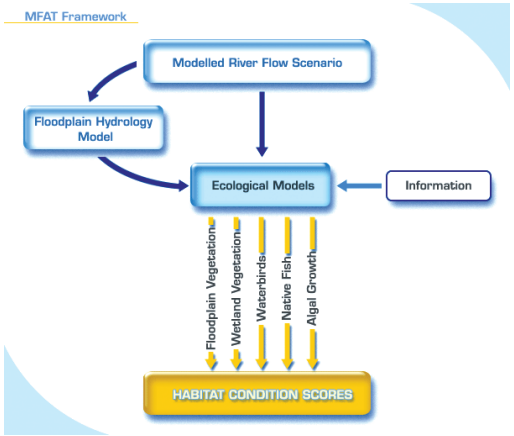


Fig. 6.4.1 MFAT Framework

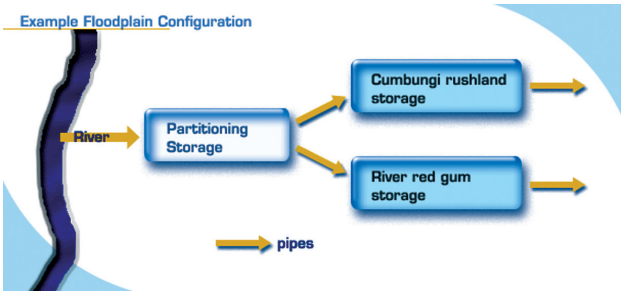


Fig. 6.4.2 MFAT Framework

6.5 GUIDELINES ON WATER RELEASE FROM HYDRAULIC POWER PLANT TO SECURE ENVIRONMENTAL FLOW

These guidelines aim to conserve as well as improve conditions of the river environment at the downstream of hydropower plants by securing environmental flow. In the process of license renewal of water rights for hydropower generation, the regulation on water intake – or how much water each hydropower plant can use – is added in order to maintain adequate environmental flow according to the guidelines.

In the case of Japan, for the hydropower plant with the catchment area of 100 km^2, water flow of approximately 0.1 to 0.3 m^3/s is designed as environmental flow.

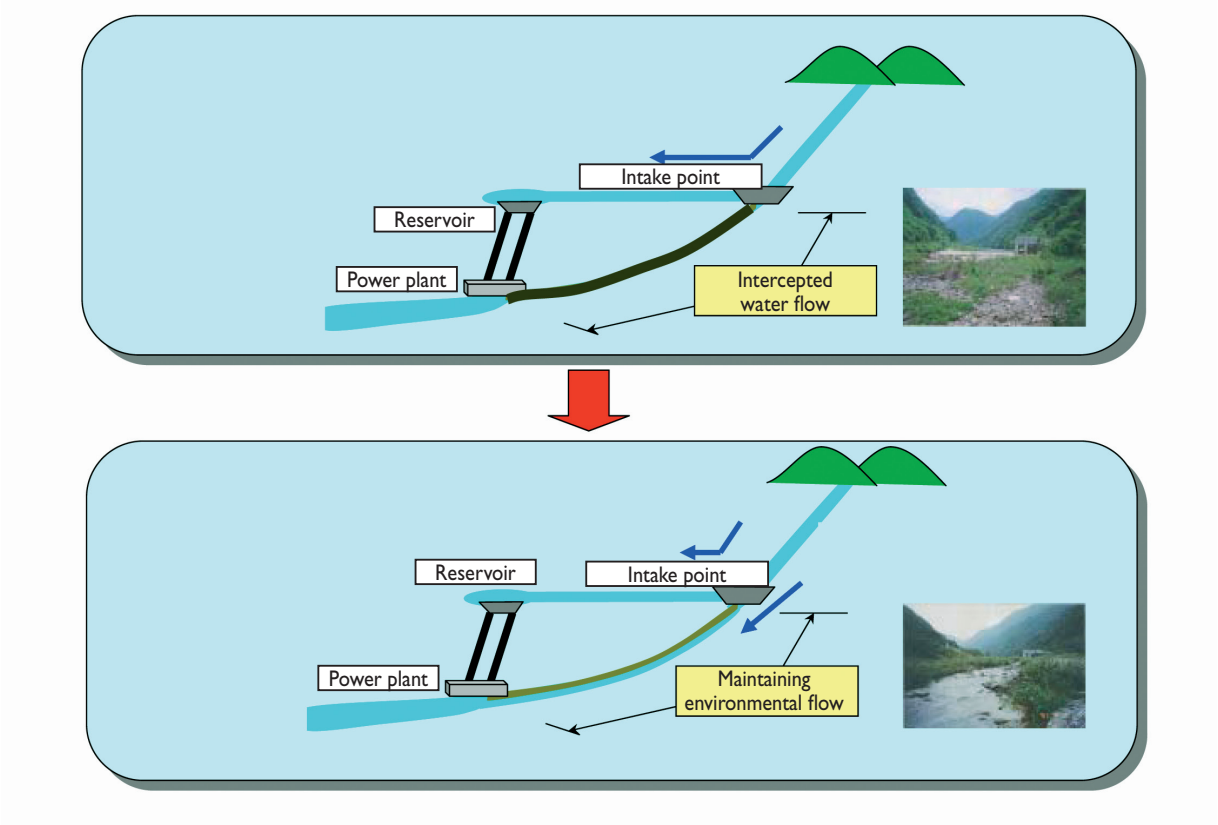


Fig. 6.5.1 The image of maintaining environmental flow

Bibliography

Aigars, J. *et al.* (2008) *Ecological quality boundary-setting procedures: the Gulf of Riga case study, Environmental Monitoring and Assessment, Vol. 138, No. 1–3, pp. 313–326.*

Amman, K. (2005) *Effects of biotechnology on biodiversity: herbicide tolerant and insect-resistant GM crops.*

Bressers, H. *et al.* (2004) *Integrated governance and water basin management: conditions for regime change and sustainability.*

Conner, A. J. (2003) *The release of genetically modified crops into the environment.*

Convention on Biological Diversity (CBD) (2010). The Conference of the Parties Inland Waters Biodiversity.

Devine, G. J. and Furlong, M. J. (2007) *Insecticide use: Contexts and ecological consequences. Agriculture and Human Values, Vol. 24, No. 3, pp. 281–306.*

Downs P.W. *et al.* (2004) *River Channel Management Towards Sustainable Catchment Hydrosystems.*

Duelli, P. (1997) *Biodiversity evaluation in agricultural landscapes: An approach at two different scales.*

European Commission, JRC, Institute for Environment and Sustainability (IES) (2007) *Ecological Quality Ratios for ecological quality assessment in inland and marine waters.*

Feldman, D. L. (2007) *Water policy for sustainable development, Johns Hopkins University Press, Baltimore, MD, 371 pp.*

Fisher, D. (2009) *The Law and Governance of Water Resources: the Challenge of Sustainability.*

GWP and UNDP (2005) *Integrated Water Resources Management Plans - Training Manual and Operational Guide.*

Hirji, R. and Davis, R. (2009) *Strategic environmental assessment: improving water resources governance and decision making.*

Hughes, F.M.R. (1997) *Floodplain biogeomorphology, Progress in Physical Geography, Vol. 21, No. 4, pp.501–529.*

Institute of Arable Crop Research (IACR) (2001) *The impact of herbicides on weed abundance and biodiversity.*

IUCN (2003) Flow: *The essentials of environmental flows.*

Jarvis, D. I. et al. (2007) Managing biodiversity in agricultural ecosystems. Columbia

University Press. 492 p.

Kakoli Ghosh et al. (2006) *Genetically modified organisms in crop production and their effects on the environment:methodologies for monitoring and the way ahead.*

Kantor, S. Naiman, R. J. and Bilby, R. E. (1998) *River Ecology and Management Lessons from the Pacific Coastal Ecoregion.*

Kingsford R. T. (2000) *Ecological impacts of dams, water diversions and river.*

Lindenmayer, D *et al.* (2007) *Ecology Letters.*

Parasiewicz, P. (2007) *Using MesoHABSIM to develop reference habitat template and ecological management scenarios.*

Petts, G (1987) *Ecological management of regulated rivers; A European perspective. Regulated Rivers: Research & Management, Vol. 1, no. 4, pp. 363-369*

Petts, G. E. (1985) *Impounded rivers: perspectives for ecological management.* Chichester: John Wiley. xviii + 326 p.

OSPAR (2005) *Ecological Quality Objectives.*

Piégay, H. *et al.* (1998) *Promoting ecological management of riparian forests on the Drôme River, France.*

Relyea, R.A. (2005) *The Impact of Insecticides and Herbicides on the Biodiversity and Productivity of Aquatic Communities.*

Schroevers, P.J. (2004) *The need of an ecological quality-concept.*

Simboura, N. (2008) *Ecological Quality in Marine Ecosystems.*

Srivastava, J. *et al.* (1996) *Biodiversity and agriculture: implications for conservation and development.*

Stanford J.A. *et al.* (2004) *The hyporheic habitat of river ecosystems.*

STRIVER Policy Brief (2008) *Environmental Flows (EF) in IWRM.*

TNC (2004) *The Nature Conservancy and Environmental Flows.*

UN-Water and GWP (2008) *Roadmapping for Advancing Integrated Water Resources Management (IWRM) Processes.*

UNESCO (2006) UN World Water Assessment Programme.

United Nations Environment Programme (2006) *Water Quality For Ecosystem and Human Health.*

Ward, J.V. and Stanford, J.A. (2006) *Ecological connectivity in alluvial river ecosystems and its disruption by flow regulation.*

World Bank (2009) *Environmental Flows in Water Resources Policies, Plans, and Projects*

World Bank (2008) *Environmental sustainability: an evaluation of World Bank Group support*

World Bank (2004) *Approach paper IEG evolution of Bank Group support for water*

World Bank (1994) *Water supply, sanitation, and environmental sustainability: the financing challenge.*

World Resources Institute (2005) *Ecosystems and human well- being Wetland and Water.*

Yongbo Liu, Yaning Chen (2000) *Impact of population growth and land-use change on water resources and ecosystems of the arid Tarim River Basin in Western China.*

Zalewski M. (2002) *Guidelines for the Integrated Management of the Watershed - Phytotechnology and Ecohydrology.*

Zalewski M. (2010) Encyclopedia of Agrophysics.