Climate Change Adaptation and Ecosystem-Based Management Using Integrated Water Resources Management Tools

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Acronyms

ACSAD	Arab Center for the Studies of Arid Zones and Dry Lands
ACWUA	Arab Countries Water Utilities Association
CBD	Convention on Biological Diversity
CCA	climate change adaptation
CEHA	Centre for Environmental Health Activities (WHO)
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CMS	Convention on Migratory Species
DPSIR	driving force pressure state impact response
EBA	ecosystem-based adaptation
ES	ecosystem services
ESCWA	Economic and Social Commission for Western Asia
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH
IAS	invasive alien species
IWRM	integrated water resources management
LAS	League of Arab States
LECZ	low elevation coastal zone
NAMA	nationally appropriate mitigation actions
NBSAP	national biodiversity strategy and action plans
NGO	non-governmental organization
RICCAR	Regional Initiative for the Assessment of Climate Change Impacts on Water Resources and Socio-Economic Vulnerability in the Arab Region
RSLR	relative sea level rise
SDG	sustainable development goals
SLR	sea level rise
UNDA	United Nations Development Account
UN Environment	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
WHO	World Health Organization

CH. 1

Introduction

Wadi Shab, Oman. © maraduchetti - Fotolia_142879423

Introduction

About the training manual

The training manual has been developed within the activities of the United Nations Development Account (UNDA) project on developing the capacities of Arab countries for climate change adaptation (CCA) by applying integrated water resources management (IWRM) tools. The project aims to provide a set of regionally appropriate IWRM tools for supporting climate change adaptation in five key sectors namely agriculture, economic development, environment, health, and human settlements by deriving a training manual that includes the five modules on the selected sectors.

The project was led by the United Nations Economic and Social Commission for Western Asia (ESCWA) in cooperation with the United Nations Environment Programme Regional Office for West Asia (UN Environment), and was implemented in partnership with the following organisations for three out of the five modules:

- Agriculture module: Arab Center for the Studies of Arid Zones and Dry Lands (ACSAD) and Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ);
- Health module: World Health Organization Centre for Environmental Health Activities (WHO/CEHA);
- Human settlements module: Arab Countries Water Utilities Association (ACWUA).

The Environment module and the Economic development module were prepared by UN Environment and ESCWA, respectively. This UNDA project builds on the results of the Regional Initiative for the Assessment of Climate Change Impacts on Water Resources and Socio-Economic Vulnerability in the Arab Region (RICCAR) that is led by ESCWA and implemented by the League of Arab States (LAS) and United Nations organizations.

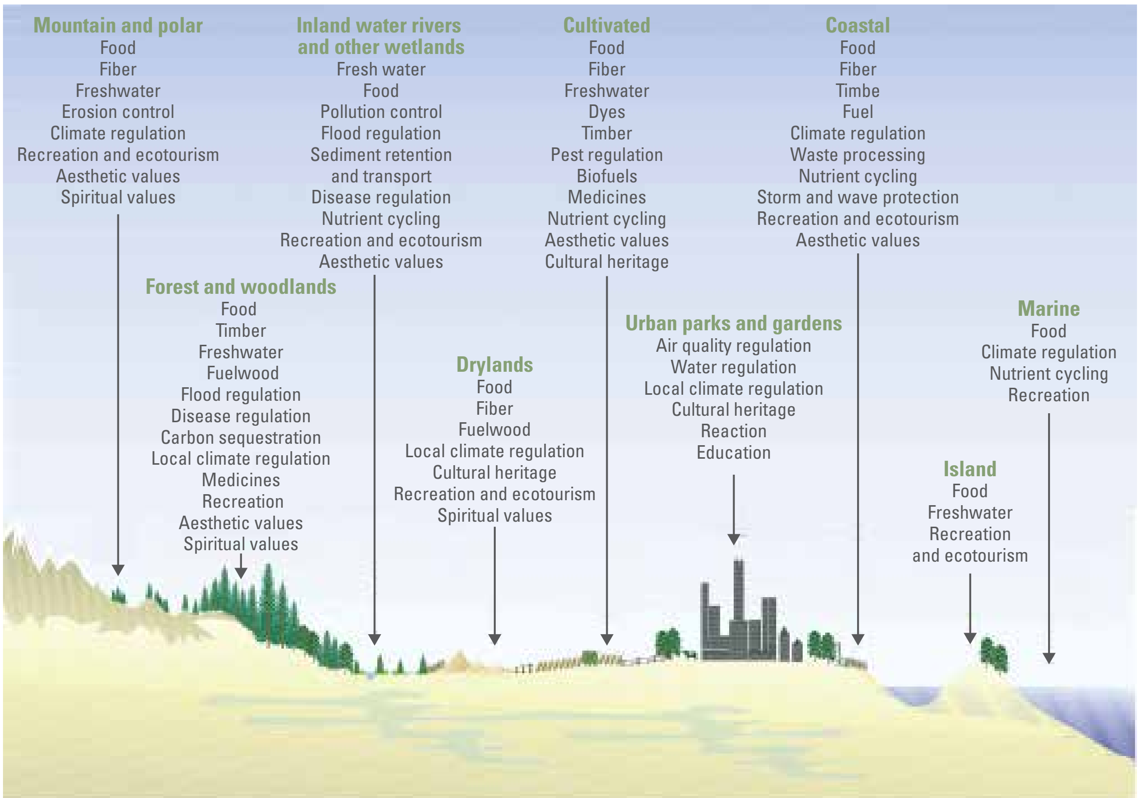
Environment sector background

Natural ecosystems benefit people in many ways, from regulating local climates to providing clean drinking water, with the benefits supplied by natural ecosystems collectively referred to as ecosystem services. While these services provide the basis for the livelihoods of many societies and play an important role in ensuring food, water and energy security, they are also fundamental tools in climate change adaptation. Essentially, ecosystem-based adaptation (EBA) addresses the crucial links between climate change, biodiversity, ecosystem services and sustainable natural resource management. In this respect, the concept of using ecosystems as a basis to adapt to climate change impacts has gained momentum in recent years and has now emerged as an important approach in the adaptation to climate change.

Healthy ecosystems and their services provide opportunities for sustainable economic prosperity in conjunction with the provision of defence against the negative effects of climate change. Conversely, degradation of ecosystems results in increased climate change vulnerability for the communities that live in these ecosystems as well as for the ecosystems themselves. Importantly, decision makers need to be convinced that the 'environmental infrastructure' is capable of meeting their adaptation objectives. This will require a systematic consideration of the applicability, limitations and risks of EBA options as compared to traditional, often 'hard' infrastructure alternatives.

Through its governing council decisions, UN Environment recognized the adverse impacts of climate change, among other drivers, on ecosystems and on their ability to meet the needs for local food production and national food security and, inter alia, water resources. UN Environment also acknowledged the dependence of all countries, particularly developing countries, on ecosystems for livelihoods, food production and well-being, including adaptation to the impacts of climate change. Furthermore, UN Environment emphasized the heightened vulnerability of developing countries, particularly the least-developed countries and the small island developing States, to the impacts of climate change and reaffirmed that adaptation and mitigation actions generate multiple co-benefits, and that the resilience of many ecosystems is already being exceeded by an unprecedented combination of climate change, associated disturbances and other drivers. UN Environment reaffirmed its support to ecosystem-based adaption through the United Nations Environment Assembly (UNEA- 1, resolution 1/8; UN Environment, 2014) and considered that climate change is one of the greatest challenges of our time, expressing deep concern that all countries, particularly developing countries, are vulnerable to the adverse impacts of climate change and are already experiencing increased impacts, including persistent drought and extreme weather events, sea-level rise, coastal

Figure 1. Ecosystems and their representative ecosystem services



Source: Millennium Ecosystem Assessment.

erosion and ocean acidification, further threatening food security. Additionally, in paragraph 190 of the outcome document of the United Nations Conference on Sustainable Development entitled "The future we want", heads of states and governments expressed concern that all countries are already experiencing the adverse impacts of climate change, which is threatening efforts to achieve sustainable development, eradicate poverty and achieve food security, and emphasized that adaptation to climate change is an immediate and urgent priority.

Decision X/33 of the 10th Conference of the Parties to the Convention on Biological Diversity (CBD), parties and other governments were invited, in accordance with national capacities and circumstances, to integrate ecosystem-based approaches for adaptation into relevant strategies, including adaptation strategies and plans, national action plans to combat desertification, national biodiversity strategies and action plans, poverty reduction strategies, disaster risk reduction strategies and sustainable land management strategies on biodiversity and climate change and the role of ecosystem-based adaptation highlighted therein.

The Intergovernmental Panel on Climate Change (IPCC) has identified IWRM as an important climate-adaptation strategy and that well managed water and other natural resources provide high levels of ecosystem services (ES). In 2003, the Millennium Ecosystem Assessment made a strong case for using an ecosystem services approach for effective IWRM. This requires watershed managers, policymakers, and communities to better understand, communicate, and disseminate the use of ES mechanisms for effective basin management (i.e. IWRM) and the realization of multiple benefits (including climate change adaptation, building resilience in basin riparian communities and conflict resolution).

While the rationale for such synergistic use of IWRM and ES paradigms is conceptually clear, most watershed managers focus on an IWRM framework that looks at traditional water resources such as water quantity, navigation and hydropower.

In essence, ES valuation and management are a practical way of achieving IWRM goals as well as other tangential socio-economic and environmental benefits. In principle, most managers recognize the need to adopt ecosystem-based approaches to watershed management, acknowledging that watersheds provide important ecological services such as waste assimilation, floodwater storage, erosion control etc. There is also an increasing acceptance of the role of ecosystem management in providing additional social and economic benefits, including local livelihoods and alleviating poverty within catchments.

Training objectives and methodology

This training is designed to bring together, in a facilitated and highly interactive setting, a group of 25-30 professionals (see below for targeted stakeholders), in order to develop the capacities of the Arab countries in the area of climate change adaptation with a specific focus on the water sector to protect the environment.

The expectation is that participants taking part in the training have an acceptable understanding of IWRM. The material is designed to support a facilitated, multi-day workshop that will empower participants to understand the tools and concepts needed to build programmes, direct staff and allocate resources as they develop and integrate IWRM as a concept for adaptation to climate change in the water sector in the Arab region. In addition, participants in the training will have a comprehensive exposure on impacts of climate change in the water sector on the environment in the Arab region.

The training material presents basic facts on the inter-relationship between the water sector and biodiversity, IWRM tools and other modern tools needed to adapt to future conditions, how to prioritize adaptation measures and implementation considerations. Case studies and exercises from the Arab region are incorporated to learn from experiences of 'real world' projects and programmes. Specific objectives of this environment module are:

- Increase understanding of government officials and regional stakeholders of the impact of climate change on water resources;
- Framing the linkages between climate change, water sector and biodiversity;
- Review the vulnerability assessment protocols and indicators in the water sector;
- Enhance government capacity to incorporate IWRM tools into strategies, policies, plans and programmes of water management in order to be better prepared for future climatic conditions (i.e. CCA);
- Present tools for adaptation in the water sector in order to protect the environment;
- Review the governance framework and implementation mechanisms towards identifying the needed adaptation interventions for the sector.

The exercises included in the annex to this module are:

Exercise 1. Ecosystem services
Exercise 2. Catchment ecosystem state and indicators
Exercise 3. Ecosystem services in management
Exercise 4. Ecosystem issue and indicators
Exercise 5. Trade-offs in ecosystem management
Exercise 6. Catchment stakeholder analysis
Exercise 7. Monitoring and evaluation
Exercise 8. Catchment incentives, tools and objectives
Exercise 9. The Maward dam

Targeted stakeholders

With water resources intersecting numerous sectors, and given the myriad forms of governmental institutions dealing with policymaking, planning and implementation, this training module benefits a wide variety of officials from the public sector, academia, non-governmental organisations, and the private sector. The module will also benefit those interested to learn about the different aspects of climate change impacts on water resources, the associated linkages to the environment and the use of IWRM as a tool for climate change adaptation in these two sectors. The following target groups should find this module of particular interest:

- Decision makers and technical staff in the water and environment sectors who are concerned with the environment dimensions of climate change and with developing and implementing policies, programmes or projects;
- Decision makers and technical staff in other government sectors concerned with water and environment dimensions of climate change (such as spatial planning, environment, agriculture, food, disaster risk reduction, transport, industry, labour, education, etc.);
- Stakeholders involved in the development and implementation of national adaptation plans (NAPs), national adaptation programmes of action (NAPAs), nationally appropriate mitigation actions (NAMAs) and national communications;
- Representatives involved in the global United Nations Framework Convention on Climate Change (UNFCCC) process, such as negotiators and UNFCCC focal points;

- General environment and water sectors staff and other professionals providing water and environmental services;
- Women and other vulnerable categories;
- Civil society and, to a lesser extent, local community representatives;
- Non-governmental organization (NGO) experts active in the area of climate change and/or water and environment;
- Academics, scientists and researchers working on climate change adaptation in the water and environment sectors.

Module content

In addition to this introductory chapter, the module consists of the following chapters:

- **Chapter 2.** This chapter frames the impacts of climate change on water and ecosystems and biodiversity, and the linkages between these.
- **Chapter 3.** The ecosystem management approach and IWRM and the role of both in identifying adaptation measures are the focus of chapter 3, setting the stage for the next chapter's focus on adaptation.
- **Chapter 4.** This chapter, through ecosystem adaptation and IWRM, takes up the stocktaking of adaptation measures targeting environmental and water impacts, as well as the means to evaluate and prioritize which adaptation measures should actually be considered.
- **Chapter 5.** Governance, legislative context, stakeholders, barriers and other issues pertaining to implementation of adaptation measures are the focus of chapter 5.
- **Chapter 6.** Lastly, a look at follow up on adaptation programmes development at the local level make up the chapter on areas for action.
- **References and Further Readings.** A listing of the references that supported the preparation of this module.
- **Annex.** A set of exercises providing an opportunity for practitioners to extend their understanding of the various concepts underlying ecosystem management approach and IWRM.

CH. 2

Projections of the Impacts of RICCAR Findings on Ecosystems and Biodiversity in the Arab Region

Projections of the Impacts of RICCAR Findings on Ecosystems and Biodiversity in the Arab Region

"Although integral to the immediate well-being of people, ecosystems and biodiversity are under threat globally and under exceptional threat in the Arab region due to rapid economic development, population growth, and climate change. Ecosystems in the region, and specifically those in the Fertile Crescent and the Nile, are of universal significance to the historical culture of civilization, and the various modes through which agricultural cultivation has evolved. Further significance stems from the region being the centre of genetic species of over 70 per cent of food crops consumed globally today. The genetic adaptability of the various cultivated plants of the region may hold the key for research and development towards enhancing food security. The region also boasts varying endemic species of great global significance. The status of biodiversity and ecosystems is dependent upon individual and global action with the increase in demand for food coupled with the economic policies of the region leading to the spread of intensive agricultural systems and cultivation of marginal lands to meet population needs. The region through a combination of unique natural circumstances, human related practices and global trends is in need of strong policies and immediate action to combat degradation and protect these vast resources."

Source: UNEP, 2015a.

In this chapter, an attempt to develop predictions for the impacts of RICCAR findings on ecosystems and biodiversity in the Arab region is elaborated based on best available data and information. It should be emphasized that there is no sufficiently reliable and comprehensive characterization of ecosystems and biodiversity in the region, and the predictions were based on specific watershed sites in West Asia and North Africa. It aims to provide suggestions that may be of use to trainers as they go through a process to predict impacts on specific sites in their countries.

The Arab region, with support from UN Environment in Bahrain, joined the global biodiversity discussions and signed the Biodiversity Compact alongside 194 countries to comply with the Aichi Biodiversity Targets framework and Strategic Plan for Biodiversity 2011-2020. The Compact aims to curb the loss of biodiversity (which today reached 1000 times the rate of loss of 50 years ago) and conserve biodiversity components and their sustainable use for human well-being. The countries were empowered to comply with the Convention on Biological Diversity (CBD) guidelines by preparing their Fifth National Reports to the CBD and update their National Biodiversity Strategy and Action Plans (NBSAP).
The year 2015 witnessed the release of most of the national reports and NBSAPs which assess biodiversity threats, indicators and policies and defines national targets and actions to be undertaken until the year 2020 (CBD COP 10 Decision X/2 2010). This also included mainstreaming biodiversity into national development plans, climate change strategies and SDGs as well as integrating other Multilateral Environmental Agreements (MEAs) related to biodiversity such as the International Wetlands Convention (Ramsar), the Convention on Migratory Species (CMS), the International Trade in Endangered Species of Wild Fauna and Flora Convention (CITES) and the World Heritage Convention. As a result, the most recent data related to biodiversity and ecosystems in the Arab countries was published in

the Fifth National Reports. Nevertheless, the reports do not show data of impacts of climate change on ecosystems and biodiversity per se but do provide some description of potential impacts on ecosystem services such as water resources. The Global Biodiversity Outlook (fourth edition), a United Nations biodiversity flagship report presented some impacts of biodiversity in 100 years, in a business as usual scenario. The report predicted the overall status of biodiversity in 2020, which showed unfavourable signs on water-food ecosystem services thus threatening humans and environmental and socio-economic sustainability. The impacts on inland water resources and wetlands were also assessed and demonstrated devastating degradation and loss of wetland biodiversity and ecosystem services (Aichi Targets 6,7 and 14) (https://www.cbd.int/nr5).

Temperature

General predictions of the impacts of temperature changes on ecosystem and biodiversity are as follows:

- Changes in growth, reproduction, and distribution of lake and stream biodiversity;
- Temperature increases could influence the quality of surface water in terms of dissolved oxygen, stratification, mixing ratio, self-purification and biological content and growth ofespecially algal bloom, bacterial content and fungal levels;
- Rapid warming, and higher organic inputs affect marine and lake productivity, while combined impacts of wildfire and insect outbreaks decrease water ecosystems productivity;
- Accelerated losses of nutrients from terrestrial ecosystems to receiving waters (Hershkovitz, 2013);
- For lakes, higher temperature is likely to lead to higher primary productivity with more intense algal blooms, stronger and longer periods of summer stratification with greater oxygen depletion in the hypolimnion and increased release of phosphorus from sediments (Hershkovitz, 2013);
- An increasing number of ecosystems, including areas of high biodiversity, are likely to be further disrupted by a temperature rise of 2°C or more above pre-industrial levels;
- Introduction of invasive alien species is another threat to biodiversity and native fauna and flora. Alien species are species or sub-species occurring outside of their natural range and have high dispersal potential;
- Under warmer seasons, freshwater phytoplankton and zooplankton blooms are also appearing earlier. Other terrestrial animals and plants are moving uphill as their habitats warm. Since the migration rate of many species is insufficient to keep pace with the speed of climate change, they could be pushed towards extinction in the future (Hershkovitz, 2013);
- Roughly, 10 per cent of species will face an increasingly high risk of extinction for every 1°C rise in global mean surface temperature (up to an increase of about 5°C);
- In regions where climatic change may lead to warmer and drier conditions, mountain vegetation could suffer more because of increased evapotranspiration. This is most likely to occur in mountain climates under the influence of continental and Mediterranean regimes. Below 2400 m, the juniper trees are either dead or in very poor condition and regeneration is virtually absent;
- Shifts in species ranges are so extensive that by 2100 they may alter biome composition of watershed areas. Both winter warming and intensification of the hydrologic cycle cause accelerated losses of nutrients from terrestrial ecosystems to receiving waters. Ecosystem feedbacks, especially those associated with release of carbon dioxide and methane release from wetlands and thawing permafrost soils, magnify the rate of climate change.

Examples of hot spots in the Arab region:

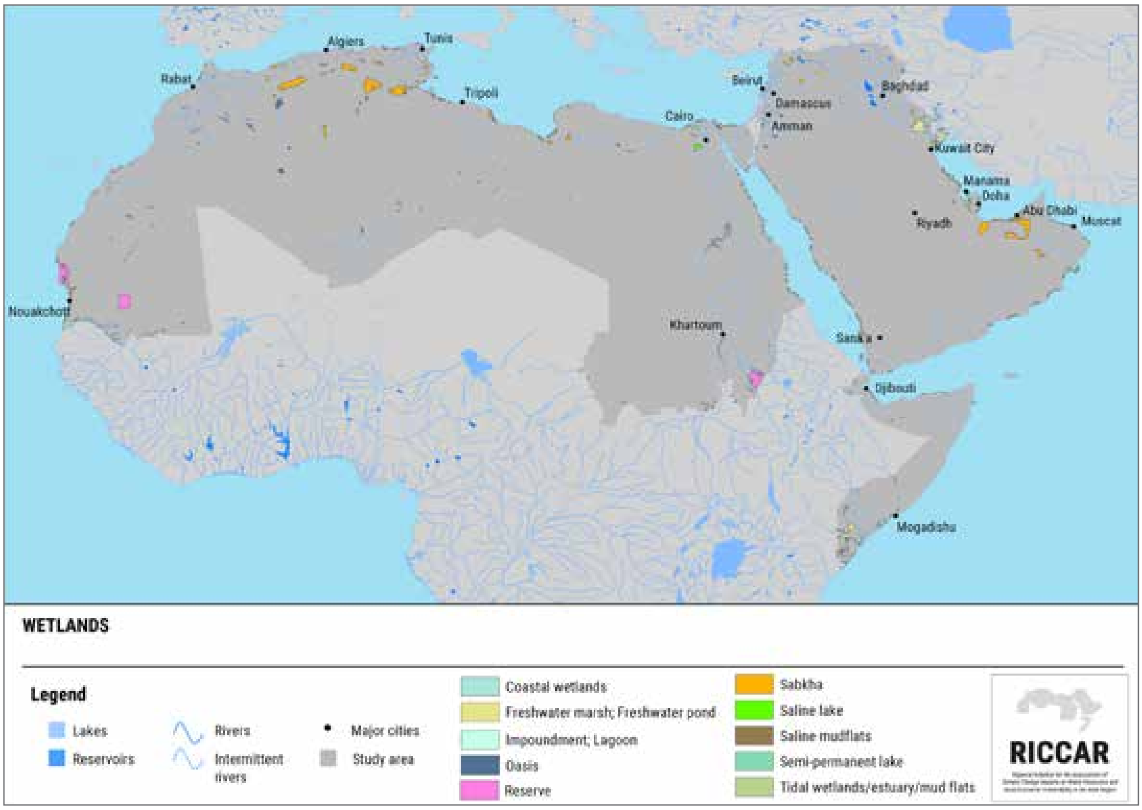
- Those impacts, which are most significant for biodiversity, include loss of coastal zones due to sea level rise, sea water temperature rise, droughts and desertification, increased water scarcity and ground water salinity (UNEP, 2010b). Some projections of climate change impacts suggest reduced rainfall (0-20 per cent) coupled with higher temperatures, which would decrease water flows in the Euphrates and Jordan rivers, affecting agriculture in Fertile Crescent lands (Iraq, Jordan, Lebanon, State of Palestine and the Syrian Arab Republic);
- The major climate change impacts on wetlands in the region are the decrease of the level of waters and drying of several wetlands, which are already under drought stress (such as Ammik site in Lebanon, Jabboule site in the Syrian Arab Republic), the reduction of

Table 1. Wetlands of international importance in selected countries

Country	No. of sites	Total area
Algeria	42	2,959,615
Egypt	2	105,700
Iraq	1	137,700
Mauritania	4	1,240,600
Sudan	4	8,189,600
Tunisia	20	726,541
Algeria	42	2,959,615
Egypt	2	105,700
Iraq	1	137,700
Mauritania	4	1,240,600
Sudan	4	8,189,600
Tunisia	20	726,541

Source: Ramsar Convention. Available from www.ramsar.org.

Figure 2. Designated wetlands



Source: RICCAR, 2017.

Source: Qahtan Abid, Iraqi Marshlands.

the freshwater biodiversity in such sites, the elimination of migratory species and the reduction in income of people that are dependent on wetlands;

- Natural ecosystems especially at risk include the coastal mountain ranges of the Red Sea, the cedar forests of Lebanon and the Syrian Arab Republic, mangroves along certain coastal areas of the Arabian Peninsula, reed marshes in Iraq, the mountain ranges in Oman and Yemen and all the major river systems (AFED, 2009);
- *Juniperusexcelsa, subsp, polycarpos* in open woodland in the central range of the Western Hajar Mountains. This species is present from 2100 m to the summit at 3000 m. Juniper would be one of the most threatened species if temperature increased (El-Keblawy, 2014), noting that the juniper woodlands of Oman are unique to the Arabian Peninsula;
- Invasive alien species (IAS) are widely known as a major threat to biological diversity, food and water security and human and animal health. Terrestrial and freshwater ecosystems, estuarine and marine systems are impacted by the spread of IAS and more problems can be expected in the future. In the Arab region, IUCN has classified 551 species of invasive species ranging from plankton to red palm weevil, cacti species, water hyacinth and numerous fish (UNEP, 2010b). Among these species, 36 per cent are classified as aliens, whereas 51 per cent are native and the bio-status of 75 species is yet to be determined. Global warming is expected to exacerbate the introduction and spread of IAS;
- Increased temperatures and the associated sea-level rise will result in seawater intrusion into some coastal areas in the Arab region. This will lead to a number of socio-economic impacts in the Nile Delta region in Egypt, and the inundation of some parts of the Bahraini coast. The archipelago of Bahrain has a limited area of about 745 km2, and with sea-level rise it is estimated that an area of 36-70 km2, the equivalent of 5-10 per cent of the total area of the Kingdom, will be covered with seawater (UNEP, 2010).

Dry spells

General predictions of the impacts of dry spells on ecosystem and biodiversity are as follows:

- Land degradation and desertification will exacerbate habitat loss, including degradation and fragmentation, and are the most important cause of biodiversity loss globally. Natural habitats in most parts of the world continue to decline in extent and integrity, although there has been significant progress to reduce this trend in some regions and habitats. Reducing the rate of habitat loss, and eventually halting it, is essential to protect biodiversity and to maintain the ecosystem services vital to human well-being;
- Changes in the reproduction of migratory birds that depend on lakes and streams for their breeding cycle.

Examples of hot spots in the Arab region:

- Forest areas in the West Asian region is less than one per cent of total land cover, the region being a largely arid area with sparse vegetation. However, recent analysis based on remote sensed data shows that forest loss in West Asia has increased over the recent decade, with a jump in the deforestation rate from 2011 to 2012. From 2001 to 2013, cumulative tree cover loss increased from 0.44 per cent to 5.71 per cent compared to forest cover in 2000. High rates of forest loss were seen in 2012 (2.14 per cent) and 2007 (0.7 per cent), while 2003 and 2004 had the lowest proportion of deforestation (0.1 per cent each). As an attempt to redress some of these losses, countries like Lebanon have embarked on tree planting programmes (UNEP, 2010b). The largest deforestation rates in the Eastern Mediterranean occur in the Beqaa and Hermel and inner slopes of the Mount-Lebanon and Anti-Lebanon range;
- Natural ecosystems especially at risk include the coastal mountain ranges of the Red Sea, the cedar forests of Lebanon and the Syrian Arab Republic, reed marshes in Iraq, the mountain ranges in Oman and Yemen and all the major river systems;
- Wadi Wurayah National Park in Fujairah covers an area of 200 km^2 of the Al-Hajjar mountain range, which shelters a rich diversity of rare and endangered habitats and species. One of the most striking features of the national park is its freshwater wetland area. This freshwater wetland is one of few remaining in the region, which qualified it to be registered on the Ramsar list of internationally important wetlands. The Wadi Wurayah National Park protects natural and cultural values, and it contributes to the sustainable development of the country. The park hosts a number of rare and endangered species, such as the Arabian Tahr, Arabitragus jayakari, which is listed as endangered in the IUCN Red List of Threatened Species. Less than 2,000 of these magnificent wild goats survive and are all found only in the Hajar Mountains in Oman and Wadi Wurayah in the United Arab Emirates. The wetlands also shelter the Garra barreimiae, which is a regionally endemic fish, listed as vulnerable by IUCN. In addition, 455 species of insects, ten species of spiders, one species of pseudo-scorpion and one species of woodlice have been recorded. Furthermore, the park has a number of archaeological sites that have an intrinsic cultural value, making it a great venue for ecotourism. The establishment of Wadi Wurayah national park was part of the Fujairah emirate 2040 development vision, and the park continues to involve the local community through a wide range of educational activities;
- The protected area of Wadi Al-Ghaf is located south of the West Bank in the State of Palestine along the Taweel valley near Al-Khalil city, and covers around 1,000 hectares. Wadi Al-Ghaf protects many species including species of bats that resides in the Safa caves and attracts many visitors. The area is also rich in freshwater and local communities rely on it for agriculture. The site hosts a wealth of wildlife including wolf, hyena, deer, porcupine, fox and hedgehog, while the rich vegetation covers and preserves the soil and humidity. There are over 45 kinds of plants and trees in the area, including oak trees, pine trees, maple trees, and sagebrush.

Precipitation

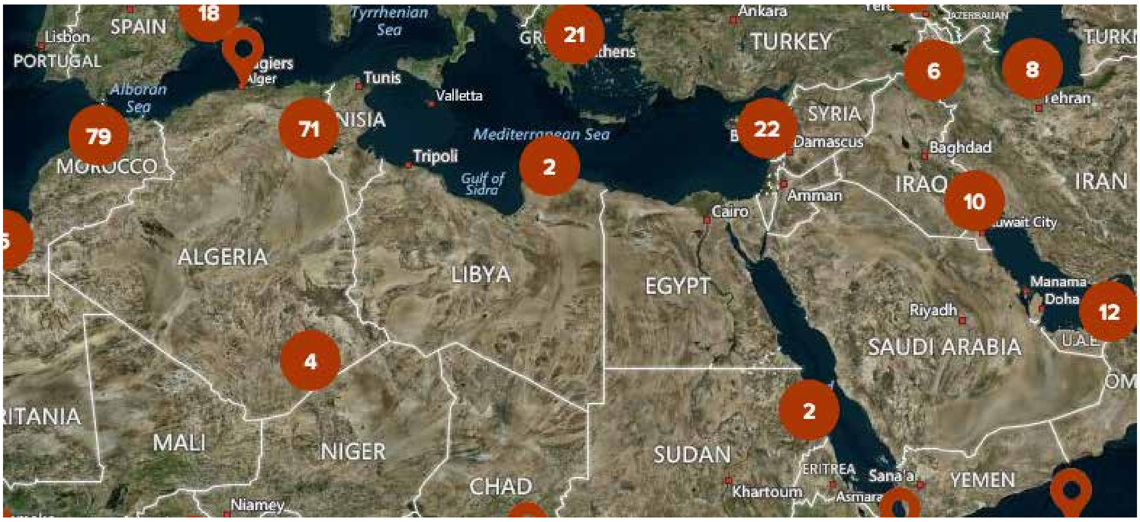
General predictions of the impacts of change in precipitation on ecosystem and biodiversity are as follows:

- Decreased flow in rivers and streams, causing a loss of ecosystem services;
- Changes in growth, reproduction, and distribution of lake and stream biodiversity;
- Changes in community composition and food web structure caused by increased salinity;
- Adverse impacts on submerged aquatic plants caused by changes in underwater light regimes resulting from an increase in water turbidity caused by more intense precipitation and suspended sediment loads in summer;
- Changes in the reproduction of migratory birds that depend on lakes and streams for their breeding cycle;
- At the regional and local scale, drier conditions could induce forest fires and thus changing biomass stocks. This would alter the hydrological cycle with knock-on effects for marine systems such as coral reefs, reduce visibility to near zero, impact plant and animal species functioning and detrimentally impact the health and livelihoods of the human population;
- The major impacts of human-induced, uncontrolled forest fires are on biological diversity and forest ecosystem functioning, and their underlying causes;
- Elimination of migratory species and reduction in income of people that are dependent on wetlands are the major climate change impacts on wetlands in the region;
- Apart from the effect on forest vegetation, fires can have a significant impact on forest vertebrates and invertebrates, with the direct effect on forest fauna being detrimental;
- Indirect effects of fires are far reaching and longer term and include stress, loss of habitat, territories, shelter and food. Fires can also cause the displacement of territorial birds and mammals;
- The destruction of standing cavity trees as well as dead logs on the ground affects smallest mammal species and cavity-nesting birds.

Examples of hot spots in the Arab region:

- In changing precipitation, as for change in temperature, the natural ecosystems especially at risk include the coastal mountain ranges of the Red Sea, the cedar forests of Lebanon and the Syrian Arab Republic, mangroves in the the Regional Organization for the Protection of the Marine Environment (ROPME) Sea Area, reed marshes in Iraq, the mountain ranges in Oman and Yemen and all the major river systems (AFED, 2009);
- Reduced rainfall coupled with higher temperatures would decrease water flows in the Euphrates and Jordan rivers by 30 and 80 per cent, respectively, by the end of this century;
- For both the Euphrates and the Tigris, it is expected that their discharge would decline at a rate of 30–50 per cent (UNEP, 2010);
- Decrease of the level of waters and drying of several areas that are already under drought stress (such as Ammik site in Lebanon, Jabboule site in the Syrian Arab Republic), reduction of the freshwater biodiversity in sites;
- 2-4 ^{0}C increase in average air temperature between 2000 and 2100 might reduce runoff to the Al Wahda Dam (Morocco) by 10 per cent as was shown by RICCAR;
- Reduced rainfall coupled with higher temperatures would decrease water flows in the Euphrates and Jordan rivers by 30 and 80 per cent, respectively, by the end of this century. The Fertile Crescent lands (Iraq, Jordan, Lebanon, State of Palestine and the Syrian Arab Republic), which depend upon these vital surface waters, will lose fertility due to lack of water and soil erosion (AFED, 2009);

Figure 3. Distribution of RAMSAR wetlands in the Arab region



Source: Available from www.ramsar.org.

- Nine lakes in North Africa (Rhaba, Zerga, Bokka in Morocco, Chitan Ichkeul and Korba in Tunisia and Edkhe, Burullas and Manzela in Egypt) are extremely vulnerable to wind variability due to their value as important bird habitats. According to the European Union's Change, Stress, Sustainability, and Aquatic Ecosystem Resilience in North African (CASSARINA) project, nine wetland lakes underwent substantial ecosystem changes during the last 100 years, with an increasing rate over the recent decades (Flower, RJ and Patrick, ST 2000);
- General and continuous drought conditions with increase in water deficits in the Mediterranean region. It is expected that such dry conditions and rainfall decrease will put more pressure on available water resources, especially in the major river basins of the region, which will also be influenced by the increase in water demands in the upstream areas of these rivers because of climate change. These phenomena will trigger more competition over water resources, especially in the case of the Tigris and Euphrates (UNEP, 2010);
- The number of Ramsar protected sites in the Arab region is 109 with a total area of 12 410 436 ha, 66 per cent of which are in North African countries (Ramsar, 2007); the number of world heritage sites totals 65 and covers an area of 1 063 259 ha (8 per cent) in the Arab region. All Ramsar sites in the Arab region will be affected by the impacts of climate change projections;
- Mediterranean coastal forests and bushes in Algeria, Lebanon, Morocco, the Syrian Arab Republic and Tunisia are the most vulnerable to forest fires due to drier conditions. As is the case in other Euro-Mediterranean countries, forest fires have been especially damaging in Lebanon in recent years, representing one of the most important elements that destroy Lebanon's natural resources. Moreover, the absence of a national forest management strategy and the limited human, technical and financial resources contribute to the degradation of Lebanon's forests. The effects of forest destruction have led to fragmentation and loss of the forest ecosystems, which in turn has had a devastating impact on the livelihoods of local communities. The damage from recent fires were so immense that they reduced the forest cover to 13 per cent in a relatively very short period of time and raised concern at the national and international levels that they could lead to total eradication of forests if radical steps were not taken to solve the problem. After the disastrous forest fires in 2007 that burned more than 2000 ha only in few days, a national forest fire management strategy was launched in 2008 (Lebanon, Ministry of Environment, 2008).

Extreme wind

General impacts of extreme wind on ecosystems and biodiversity are as follows:

- Changes in growth, reproduction and stream biodiversity;
- Increase in water turbidity due to dust sedimentation;
- Change in the nutrients load in freshwater systems with high risk of eutrophication due to fertilization of watersheds;
- Destruction of selected terrestrial habitats in watersheds;
- Changes in the reproduction of migratory birds that depend on lakes and streams for their breeding cycle;
- High wind coupled with drier conditions could induce forest fires that have significant adverse impacts on forest fauna and flora with full destruction of forest habitats.

Examples of hot spots in the Arab region:

- Merjas Sidi Bou Rhaba and Zerga in Morocco and Garaet El Ichkeul in Tunisia are highly vulnerable because of their value as bird reserves. They support a high diversity of birds, invertebrates and microphites. Merja Bokka is known locally as a high value site for water birds (Flower, and Patrick, 2000);
- The Tihamah plain is home to the majority of southwest Arabian endemic bird species. The mountain juniper woodlands are vital habitat for these birds, such as the Yemen linet (*Carduelis yemenensis*), Yemen thrush (*Turdus menachensis*) and Yemen warbler (*Parisoma buryi*). As the Arabian Peninsula forms a bridge between the African and Eurasian continents, the Asir Mountains and the western highlands of Yemen provide an important resting spot for migrating birds. The high escarpment and cliffs are especially important to migrating raptors in autumn. For example, in excess of 3,000 birds per season pass through Al Hudayah. Species such as the Gyps fulvus, bearded vulture (*Gypaetus barbatus*), Yemen linnet (*Carduelis yemenensis*), Yemen thrush (*Turdus menachensis*), and African paradise flycatcher (*Terpsiphone viridis*) are all resident in the high escarpments of the Asir Mountains. Wadi Turabah in Saudi Arabia is the last place in the Arabian Peninsula where the hammerkop (*Scopus umbretta*) can be found nesting, and the isolated and distinctive endemic imagpie subspicies *Pica asirensis* is present on Shalla ad-Dhana;
- The nine lakes in North Africa (Rhaba, Zerga, Bokka in Morocco, Chitan Ichkeul and Korba in Tunisia and Edkhe, Burullas and Manzela in Egypt) are extremely vulnerable to wind variability due to their value as important bird habitats. According to the European Union CASSARINA project, all nine lakes have undergone substantial ecosystem changes during the last 100 years and at an increasing rate over the recent decades. Freshwater availability decreased during the latter part of the 20th century in watersheds (Flower, and Patrick 2000);
- The Mediterranean coastal forests and bushes in Algeria, Lebanon, Morocco, the Syrian Arab Republic and Tunisia are the most vulnerable to forest fires due to high winds coupled with drier conditions.

CH. 3

Ecosystem Approach and Integrated Water Resources Management as Tools for Climate Change Adaptation

Ecosystem Approach and Integrated Water Resources Management as Tools for Climate Change Adaptation

> The ecosystem approach "focuses on the broader goal of balancing and sustaining ecosystem services, complementing IWRM as a strategy for the integrated management of water, land and living resources in a way that maintains ecosystem health and productivity in balance with sustainable water use…it links ecosystem service delivery and human needs."
>
> **Source:** UNEP-IISD, 2011.

The ecosystem approach has emerged as a promising incremental process to dealing with integration and sustainability of water management, with IWRM being a notable example. This is because it provides a number of benefits for both people and nature in terms of integrating environment in decision-making, strengthening investment in ecosystems and social inclusion, and catalysing good governance. Moreover, the ecosystem approach is well adapted to the use of a wider variety of management tools and options. In particular, it deploys alternative non-structural measures to cope with floods and droughts as well as emissions of pollutants into surface and ground waters.

It comes as no surprise that the need for such an approach has increasingly been recognized among water professionals as it caters to a number of critical connections. An ecosystem approach takes into account the role of environmental goods and services, incorporates knowledge about the functioning of the entire catchment ecosystem into planning and management, and focuses on managing water and land resources within catchments and river basins. An ecosystem approach explicitly recognizes the need to maintain watershed ecosystem health. In other words, an ecosystem approach incorporates ecosystem services as a way of expressing value and a way to influence behaviour to address water security.

The evolution of the IWRM framework to encompass ecosystem services would enable the realization of a broader cluster of benefits from well managed water and related resources. These would include flood and drought mitigation, biodiversity and wildlife habitat conservation, food production, etc.

RICCAR indicators and outputs

RICCAR undertook high-resolution regional climate modelling for the Arab region with results for temperature, precipitation and climate extreme events, as discussed in greater detail in the introduction module. The results of modelling were fed into a vulnerability assessment based on the methodology of the IPCC, where vulnerability is understood to be the function of a system's climate change exposure, sensitivity and adaptive capacity to cope with climate change effects.

Figure 4. Sectors and impacts selected for the Arab region vulnerability assessment

Sectors	Impacts
Water	Change in water availability
Biodiversity and ecosystems	Change in area covered by forests
	Change in area covered by of wetlands/marshes
Agriculture	Change in water available for crops
	Change in water available for livestock
Infrastructure and human settlements	Change in inland flooding area
People	Change in water available for drinking
	Change in health due to heat stress
	Change of employment rate in the agricultural sector

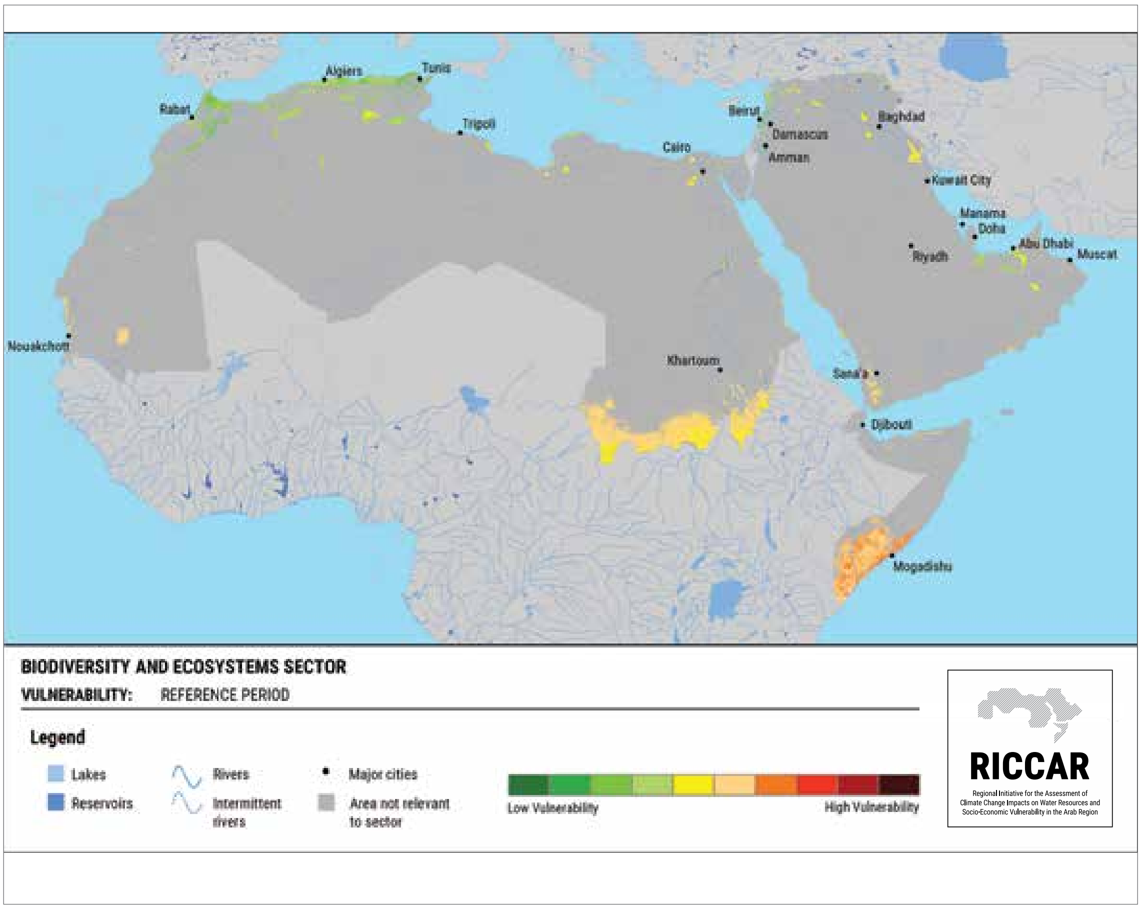
Source: ESCWA, 2015.

The integrated vulnerability assessment conducted under RICCAR combined a series of single vulnerability assessments for several water-related climate change impacts on key sectors and climate change impacts, as presented in figure 4.

The overall vulnerability for the biodiversity and ecosystems sector done by RICCAR is the aggregation of overall vulnerability of both the forest and wetland subsectors. Although both subsectors contribute equally towards the sector vulnerability assessment, the forests subsector has a stronger correlation. The result generally indicates a low to high gradient from north to south. Areas of high vulnerability are located in the Horn of Africa (see figure 5).

Ecosystems are at risk of terrestrial change or extinction due to climate change impacts. For all future periods and scenarios, vulnerability projections are low to moderate (see figures 6 and 7). Most of the Arab region has only slight increase in vulnerability from mid- to end-century under both moderate and extreme case scenarios. Like the reference period, the future scenarios represent a strong correlation with the forests subsector. Improvements in reforestation/afforestation efforts are expected to increase biodiversity and ecosystems in the region as a whole. Up to 3 per cent of identified biodiversity areas are classified as hotspots. Areas include forests in the southern Sarawat Mountains, northern Horn of Africa, and the southeastern Sahel near Dinder National Park as well as wetlands near the Shabelle, Senegal, and Blue Nile Rivers.

Figure 5. Biodiversity and ecosystems – Reference period – Overall vulnerability



Source: RICCAR, 2017.

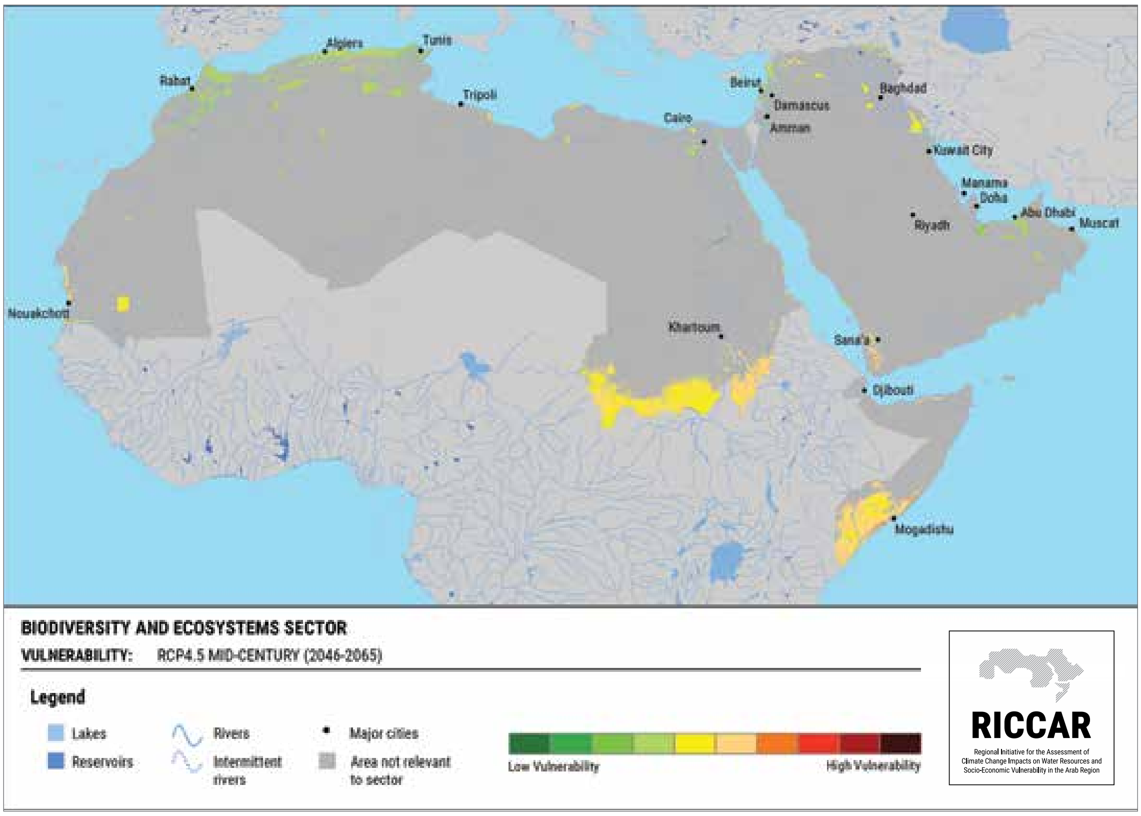
Complementarities between integrated water resources management and ecosystem management

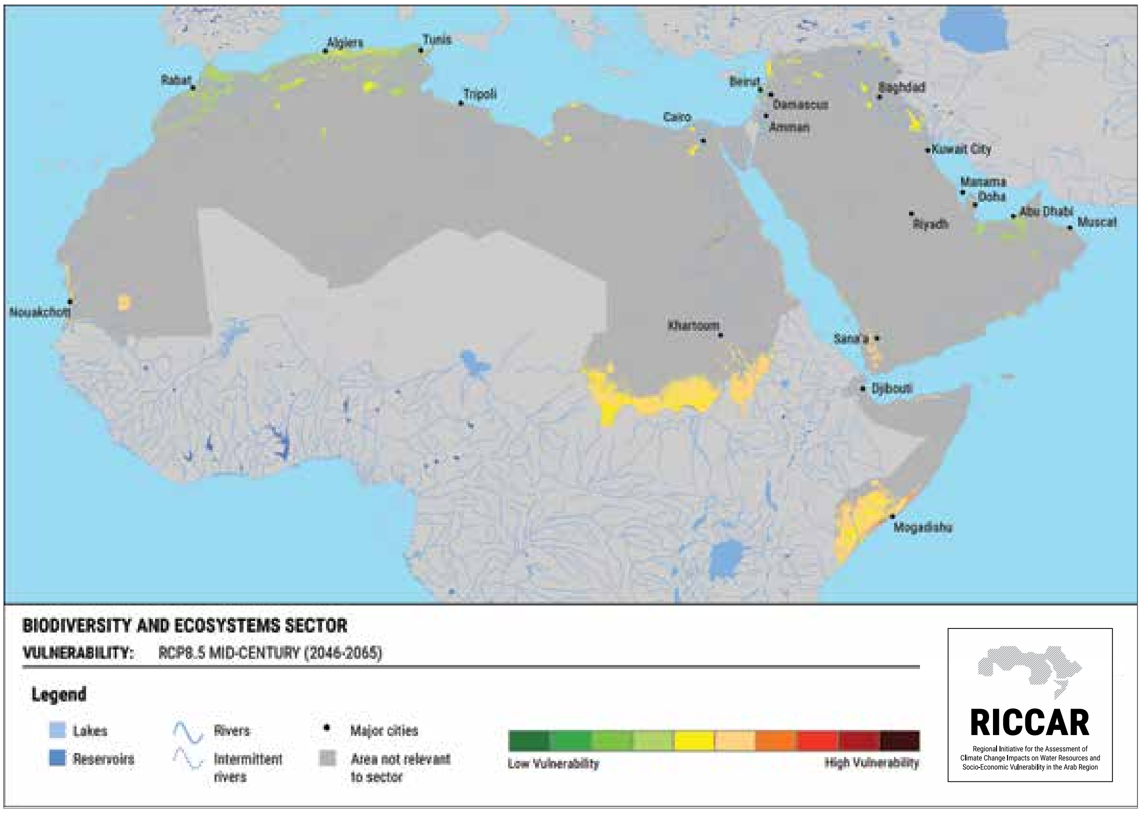
The IWRM framework and ecosystem approach recognize that complementary elements of an effective water resources management system must be developed and strengthened concurrently, as illustrated in figure 8.

A number of questions are presented below in the form of a short exercise that can help frame complementarities between IWRN and ecosystem management.

- How is – or how could – IWRM being implemented in your catchment now?
- How does IWRM structure the ways you evaluate management options?
- What do you feel should be added to your current IWRM toolkit to meet the objective of increasing benefits from water resources?
- What are complementarities between IWRM and EM? Can both be implemented in the same place?
- Identify two societal goals that would be better served by IWRM than EM;
- Identify two societal goals that would be better served by EM than IWRM.

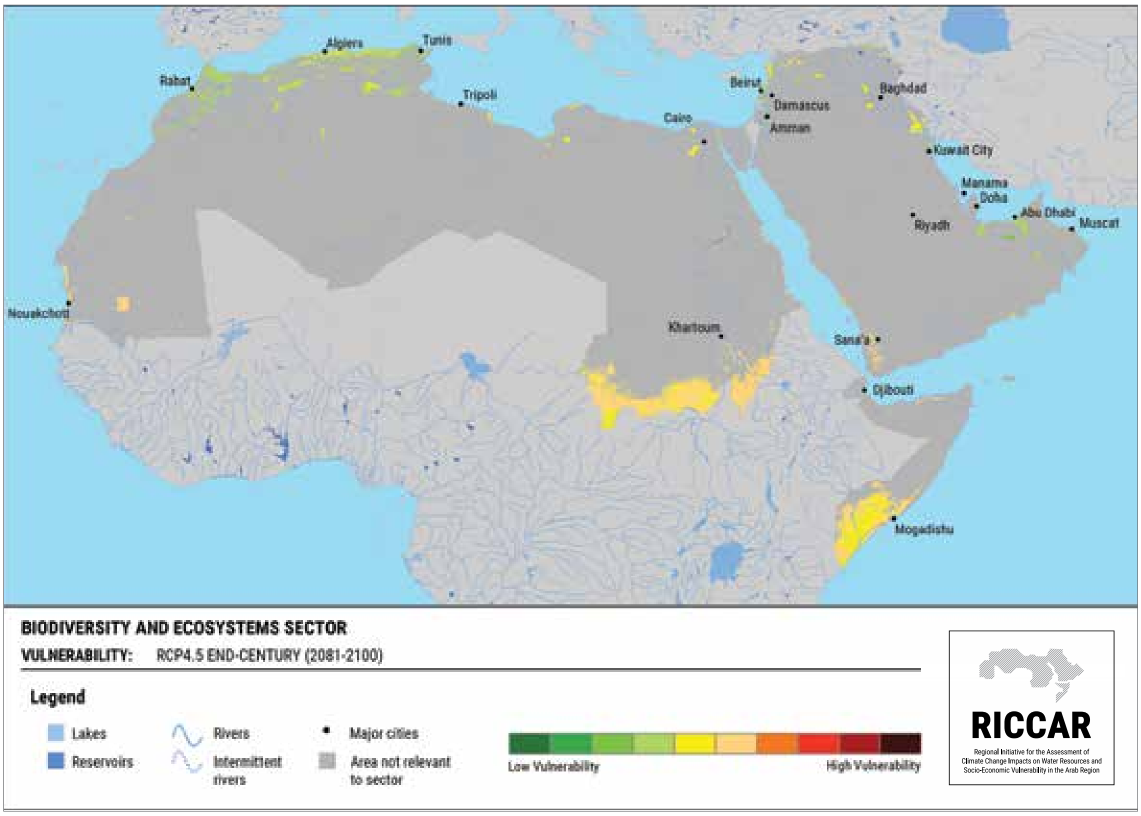
Figure 6. Biodiversity and ecosystems – RCP 4.5/8.5 Mid-century – Overall vulnerability

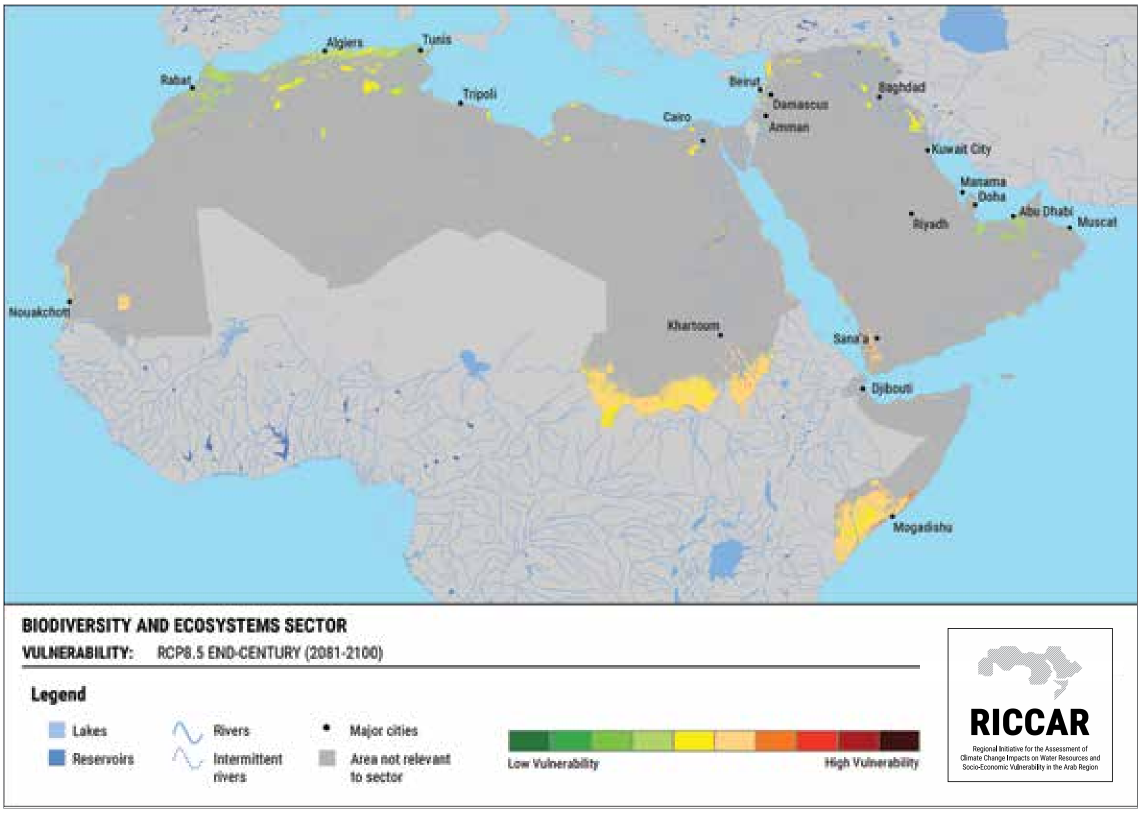




Source: RICCAR, 2017.

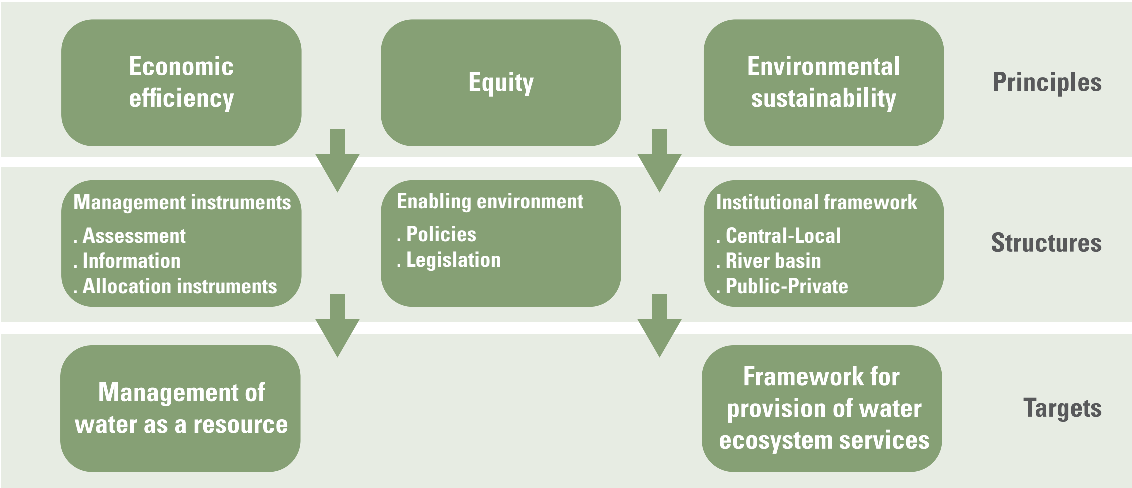
Figure 7. Biodiversity and ecosystems – RCP 4.5/8.5 End-century – Overall vulnerability





Source: RICCAR, 2017.

Figure 8. Linkages among principles, structures and targets



Source: Adapted from UNEP-IISD-DHI, 2011. Ecosystem Approaches in Integrated Water Resources Management, p.17.

Analysis of differences and similarities between integrated water resources management and ecosystem management

Clearly, IWRM and EM have elements in common (table 2); water is an ecosystem service required from nearly all catchments. Water security controls the lives of millions of people and depends on the characteristics of the ecosystems surrounding the waters. An analysis of water security and ecosystem services offers more depth on that relationship and may be an additional useful resource. This analysis of differences and similarities deals with three selected aspects: scope, content and specificity.

Global experiences reveal that successful IWRM implementation is limited in achieving its potential due to inadequate resourcing and fractured governance structures that continue to manage ES as distinct, department or sector-specific objectives (such as agriculture, natural resources, energy, etc.). Actively pursuing an ES agenda would help integrate these sectoral goals through watershed management, while economic instruments, such as payment for ES, would help provide incentives and resources for such initiatives. Thus, both limitations could be potentially overcome by moving from a more traditional form of IWRM to one that incorporates ecosystem management principles, and encourages incentives and markets for managing and providing healthy and sustainable ES, and addressing drivers of ecosystem change more systematically.

Indicators for ecosystem-based adaptation

Indicators facilitate performance assessment with a number of guidance manuals supporting the selection of indicators to facilitate assessment of EBA. When selecting indicators, the following questions should be considered:

- How will data availability change during the period of implementing the intervention and beyond?
- What existing metrics are available and what data, collected for other purposes, could be applied in the assessment?
- Can local ecological knowledge inform the selection of indicators?

Table 2. The complementarity between IWRM and EM

IWRM	EM
• Both water quality and water quantity • Provide part of the basis for sustainable livelihoods • Protection and conservation of water resources to sustain functions and characteristics	• Targeted toward human well-being • Supply defined ecosystem services like provisioning services (such as food, fibre), regulating services and cultural services • Watershed services
Typical geographic scope	
• Transboundary • National • River basin • Sub-basin • IWRM is typically applied at an aggregate level	• Ecosystem macro-units (such as biomes, eco-regions), meso-units (forests, wetlands, lakes, islands) and micro-units such as farm level • Ecosystems cross river basins or other hydrologic lines • There is always a mosaic of ecosystems in a landscape • Ecosystem management is typically applied at a disaggregated level
Typical thematic content	
• Water cycling • Mineral cycling and biological growth to the degree they have a significant influence on changes in water quality and quantity • Human systems in terms of water use, wastewater production, cross-sectorial water requirements and stakeholder involvement • Natural systems in terms of land and water interaction and upstream-downstream linkages • Interaction between human and natural systems	• Water cycling • Mineral cycling • Solar energy flow • Biological growth • Carbon cycling • Land use (such as grazing, fire) • Humans as part of the biosphere • Food web • Vegetation layers • Soil coverage • Water bodies • Spatial configuration of species
Typical value statements	
• Economic efficiency • Environmental and ecological sustainability • Social equity and equity in access • Gender plays a strong role	• Values usually are defined on a case by case basis • Human well-being as influenced by ecosystem integrity and ecosystem stability

Source: UNEP-IISD, 2011.

A framework for indicators selection

EBA interventions aim to enhance the delivery of ecosystem services. Monitoring indicators (table 3) across each element will provide a greater understanding of performance and facilitate adaptive management, with actions focused on the identified areas of concern.

Table 3. Sample of EBA indicators aligned to ecosystem services addressed and different adaptation technologies, specifically for water resources

Adaptation technology	Description	Ecosystem services addressed	Example of EBA indicators
Rainwater collection from ground surfaces	This practice consists of collecting rainfall from ground surfaces using micro-catchments to divert or slow runoff so that it can be stored before it can evaporate.	• Freshwater • Water cycling • Soil formation and retention	• Number of people with access to clean water • Water quality
Small reservoirs and micro-catchments	Collecting flows from a river, storm or other natural watercourse (sometimes called floodwater harvesting) which can be stored and used to improve soil moisture for agriculture.	• Freshwater • Water for irrigation • Food and fibre	• Soil infiltration • Annual per capita water availability • Catchment area
Catchment thinning	Catchment thinning involves the planned removal of vegetation (trees) in densely forested areas that are suffering from drought to increase the amount of surface water runoff and increase stream flows. The technique is currently in its infancy.	• Food, fibre and fuel • Water cycling	• Stream flow • Number of people with access to clean water • Water quality • Groundwater level • Catchment area • Soil infiltration
Bores/tube wells for domestic water supply during droughts	Increasing access to groundwater through the installation and/ or improvement of boreholes to ensure a source of potable water during periods of drought.	• Freshwater	• Soil salinity • Water quality • Water balance • Number of people with access to clean water • Estimated costs of developing groundwater sources for rural domestic supply

Adaptation technology	Description	Ecosystem services addressed	Example of EBA indicators
Desalination	Desalination is the process of removing sodium chloride (salt) from brackish water as well as seawater. Desalination can be achieved through either thermal processes (evaporation) or membrane processes.	• Freshwater	• Number of people with access to clean water • Water quality • Incidence of water borne disease
Improving the resilience of wells to flooding	This technology consists of constructing containment structures (bunds) around wells and bores to prevent contamination from floodwaters. The structures are generally a concrete apron with a clay (bentonite)/grout or concrete seal.	• Freshwater • Human disease regulation	• Water quality • Occurrence of well inundation • Number of people with access to clean water
Rainwater harvesting from rooftops	This basic technology involves the collection of rainwater from rooftops and diversion to a storage reservoir (tank) for later use.	• Freshwater	• Number of people with access to clean water • Water quality and quantity • Water storage capacity

Source: UNEP, 2011.

Box 1. The Jordan Valley area in the West Bank - State of Palestine

Pressure on the water and environment sectors

The direct causes for the changes in plant and animal species composition, distribution and density and thus the loss of such valuable heritage is basically linked to the present prevailing political status issues including the division of Palestinian accessible areas, land confiscation, and expansion of the Israeli segregation wall that are all affecting biodiversity in the State of Palestine. Other pressure sources threatening its biodiversity include:

1. Unplanned urban expansion.
2. Unorganized establishment of industrial factories.
3. Overgrazing.
4. Overexpansion.
5. Overfragmentation.
6. Deforestation and unplanned forestry activities.
7. Desertification and drought.
8. Invasive allied species.
9. Pollution and contaminations.
10. Excessive use of pesticides and chemicals.
11. Hunting.
12. Climate and environmental changes.

As a result, common floral and faunal species are under threat of becoming rare or very rare species and disappearing altogether. Over the last 40 years, up to 636 species were found to be endangered out of the 2076 recorded plant species growing in the State of Palestine. The present mechanisms to climate change adaptation include:

1. Expansion of the use of rainwater harvesting, and water conservation technique such as cisterns for domestic and agricultural use.
2. Monitoring and controlling the number of grazing animals, and introducing drought resistance species and soil improvement.
3. Improving water efficiency by introducing water saving irrigation technological solutions such as drip irrigation.
4. Treatment and reuse of wastewater in irrigating fodder crops and fruit trees.
5. Small to medium scale desalination of brackish and sea water.

Procedures needed to respond and adapt to climate change should include:

1. Comprehensive review and development of Palestinian policy and legislation concerning biodiversity sector.
2. Cross sectoral national policy coordination that would support enforcing of conservation and management laws in a comprehensive manner that ensures responsible acts from all stakeholders.
3. Enhancement of the level of cooperation and coordination among academic and research centres in the field of biodiversity.
4. Harmonization of national actions with international and regional conventions, activities and plans for better management.
5. Introduction of standards and regulations on natural heritage site conservation and management into legislation.

Source: Case study presented by B. Bashir, AWARENET member, in the Workshop on Climate Change Adaptation in the Environment Sector Using Integrated Water Resources Management (IWRM) and Ecosystem-based Management Tools, 22-24 March 2016, Beirut – Lebanon.

CH. 4

Ecosystem Adaptation Measures

Ecosystem Adaptation Measures

Ecosystem-based adaptation measures to climate change in the water sector are related to the ecosystem structure, how it functions, its current state, the ecosystem services provided, adopted management tools and monitoring and evaluation.

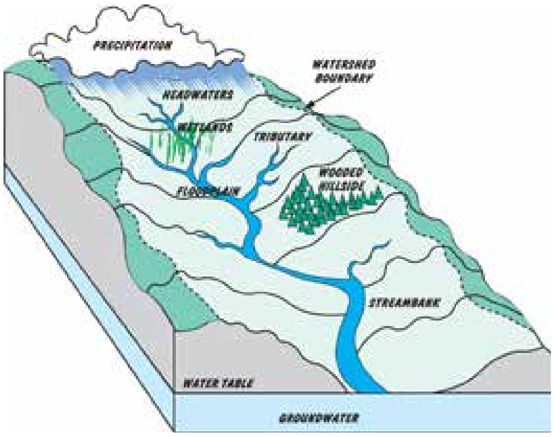
This can be facilitated by analytical frameworks such as the Driving Force Pressure State Impact Response (DPSIR), which is a causal framework for describing the interactions between society and the environment. According to the European Environment Agency (EEA, 1999, p.6), "social and economic developments exert Pressure on the environment and, as a consequence, the State of the environment changes, such as the provision of adequate conditions for health, resources availability and biodiversity. Finally, this leads to Impacts on human health, ecosystems and materials that may elicit a societal Response that feeds back on the driving forces, or on the state or impacts directly, through adaptation or curative action."

Before developing the concept of ecosystem-based adaptation, it is important to have a common understanding of the terms used in the framework of EBM (UNEP–IETC, 2004).

What is a Watershed?

Rivers can be seen as veins of a leaf, extending all over a drainage basin up to their divides. When rain falls on a watershed, it finally ends up in a river system. A river channel is the lowest point in the surrounding landscape. Its purpose is to convey excess water from a drainage basin, which will include the products of weathering and additional loads of solutes produced by man. This property makes a drainage basin an integrator and its operation is reflected in the quantity and quality of the river run-off. Drainage basin (catchment area) is the area that supplies a river system, lake or reservoir with water. The whole area consists of smaller sub-catchments supplying tributaries of the main river and direct catchments, which drain straight into a lake or main river. The purpose of the river system is to drain catchment areas. Surplus water in the drainage area forms river run-off, which is conveyed by a river system. Products of weathering (sediments and solutes) as well as man-generated pollutants, are transported with the water.

Figure 9. Watershed schematic



Source: Available from http://www.accdpa.org/conservation-solution-center/watershed/.

Where are the boundaries of a Watershed?

The boundary line separating catchments is called a drainage divide or watershed divide, which in turn is delineated on a topographic map according to the relief of the landscape. This method helps to determine the surface catchment. In many catchments, the area that supplies a river system with groundwater is not coincident with the surface catchment, as ground water may flow from a distant area. In such a case, a groundwater catchment should be delineated based on an analysis of the groundwater contour lines or piezometric surface.

What is a Landscape?

A landscape is the total human environment including the geosphere, biosphere and hydrosphere. From an ecological point of view, it should be considered as a group of biotopes, which are the smallest spatial units of homogenous abiotic conditions (physiotope) with a related natural combination of biota. This imposes the approach for landscape analysis, which requires a holistic and integrative approach focused on the entirety of biogeochemical processes, such as proposed in the concept of ecohydrology.

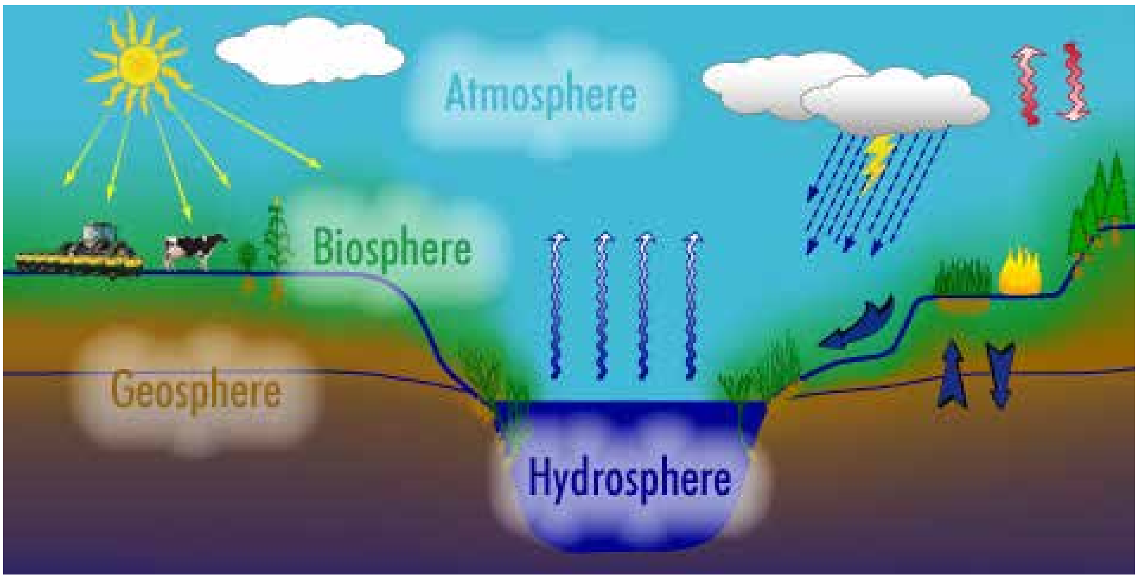
What are the differences and similarities between Lakes, Man-made reservoirs and Reservoirs?

A lake is a natural, standing, freshwater or saline body of water usually found on the Earth's continental landmasses. Man-made reservoirs, also called 'artificial lakes', are water bodies with different shapes and sizes that have been constructed by humans by damming a river or other source. Reservoirs that have been formed by diverting water from a river to an artificial basin are called impoundments.

What are Estuaries and Coastal Areas?

Estuaries are commonly defined as areas where rivers discharge into the sea. They are considered "'as a partially enclosed coastal body of water which is either permanently or periodically open to the sea, and within which there is a measurable variation of salinity due to the mixture of sea water with freshwater derived from land drainage'. However, this hydrological definition must include a biological approach, that also considers estuaries as being responsible for 'sustaining euryhaline biological species for either part or the whole of their life cycle'" (UNEP-IETC, 2004, p.40). According to water circulation patterns, estuaries can be classified as salt wedge estuaries,

Figure 10. Elements of a landscape



Source: Illinois State Water Survey. Available from http://www.isws.illinois.edu/nitro/biggraph.asp.

partially mixed estuaries, well-mixed estuaries, and fjord-type estuaries. Salt wedge estuaries occur when circulation is controlled by a river that pushes back the seawater. Partially mixed estuaries, usually deeper estuaries, have a tidal flow: salt water is mixed upward and freshwater is mixed downward. Well mixed estuaries are frequently shallow, have strong tidal mixing and reduced river flow resulting in vertical homogeneous salinity. Fjord-type estuaries are deep and have moderately high river input and little tidal mixing. Estuaries are commonly subdivided into upper, middle and lower areas. The upper estuary includes most of the freshwater section, although the effects of tides are still observable. It is an area where riparian vegetation is abundant. This vegetation constitutes a buffer zone, controlling nutrient inputs into an estuary, thus representing a particularly important target for application of phytotechnology. The middle estuary is a transition area in terms of salinity (mainly brackish water) and vegetation. The lower estuary is characterized by a marine influence, while the coast is where land meets the sea. However, as in estuaries, land and ocean processes change this line over time and space, affecting the area considered as coastal.

The structure and function of ecosystems

What is ecosystem management?

Ecosystem management can be defined as working with ecosystem functioning to supply defined ecosystem services. The functioning of ecosystems depends on the interactions between core ecosystem processes and the structure of the ecosystem. This section explains what an ecosystem is, what ecosystem services are, and how thinking in terms of ecosystem structure and processes can help management.

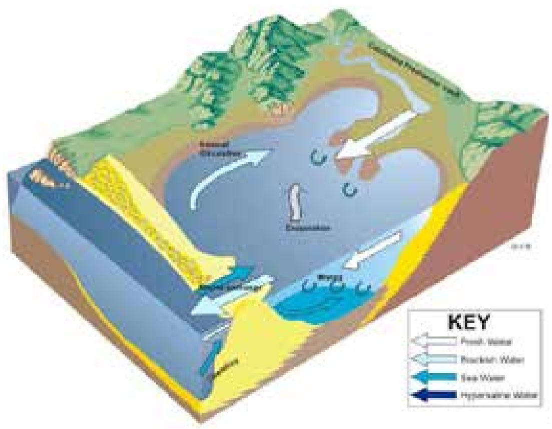
In many ways, ecosystem management is a small but significant redirection of management goals and energies. In other ways, ecosystem management is a new perspective or way of thinking about existing management of land and water resources (such as farming, forestry, supply of water resources, recreation and tourism, or biodiversity conservation). An ecosystem management perspective helps to achieve these objectives for using land and water resources by including an understanding of how the natural environment 'works' or operates as an ecosystem. Understanding the natural world as an ecosystem helps to design management activities that are more likely to produce intended results on a sustainable basis.

Ecosystem management also sees people as not only dependent on ecosystems but also as part of ecosystems. Humans both depend on ecosystems for services, such as food and freshwater, and influence them through harvesting products, alter them through farming and other land uses, and emitting waste into the natural world.

What is an ecosystem?

The concept of an ecosystem comes from the science of ecology, which is the study of the underlying principles and interactions of organisms and their environment. While the science of ecology can be very detailed, this section introduces a few core principles that can be easily understood to help practical management.

Figure 11. Estuary schematic



Source: UC Davis. Available from http://geowiki.ucdavis.edu/Core/Oceanography/09%3A_Coastal_Processes/9.1_Estuaries.

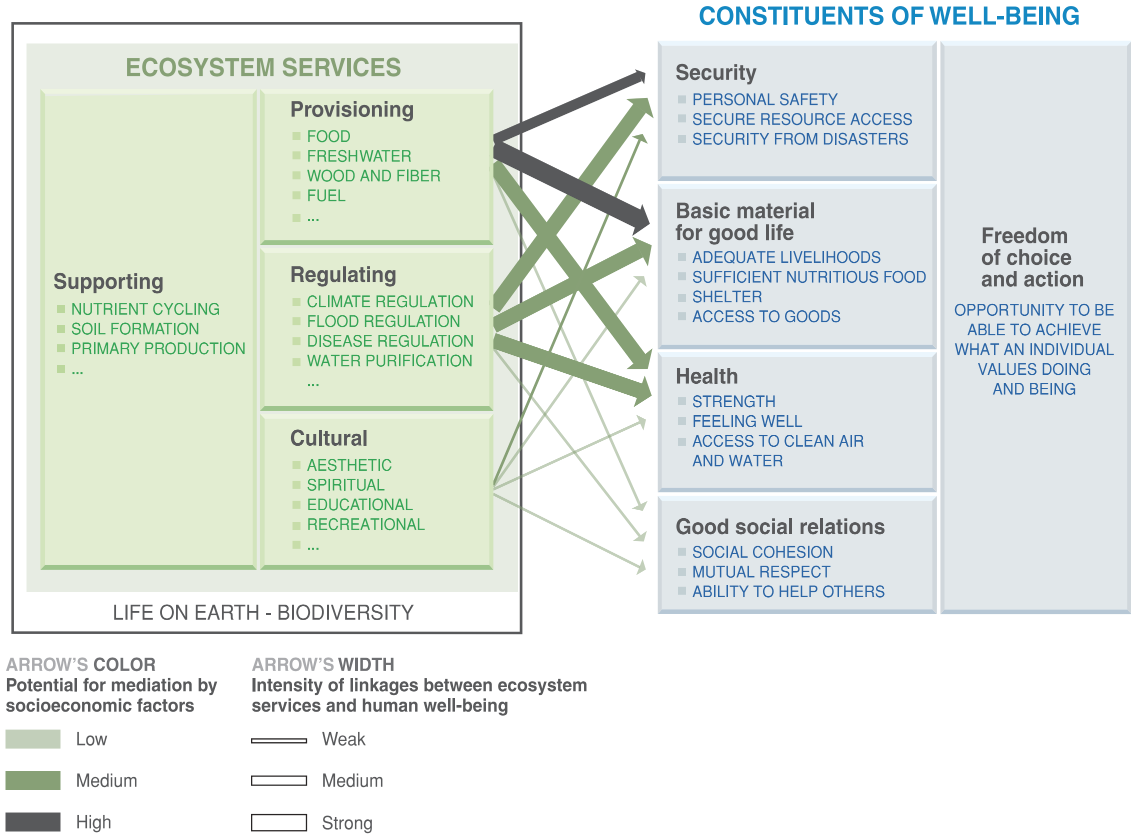
What are ecosystem services?

The simplest and most widespread definition of ecosystem services is the benefits people obtain directly and indirectly from ecosystems. A similar definition is that ecosystem services are the benefits provided by ecosystems that contribute to making human life both possible and worth living. Examples of ecosystem services include products (such as food, fuel, and water), regulation of floods, prevention of soil erosion, buffering against disease outbreaks, and non-material benefits, such as the recreational and spiritual benefits of natural areas.

The Millennium Ecosystem Assessment grouped ecosystem services into four broad categories:

- Provisioning services are products obtained from ecosystems, including food, fibre, fuel, genetic resources, ornamental resources, freshwater, biochemical, natural medicines and pharmaceuticals;
- Regulating services are benefits obtained from the regulation of ecosystem processes including air quality regulation, climate regulation, water regulation, erosion regulation, water purification, waste treatment, disease regulation, pest regulation, pollination and natural hazard regulation;
- Cultural services are non-material benefits people obtain from ecosystems through spiritual enrichment, cognitive development, reflection, recreation and aesthetic experiences, including cultural diversity, spiritual and religious values, knowledge systems, educational values, inspiration, aesthetic values, social relations, sense of place, cultural heritage values, recreation and ecotourism;

Figure 12. Linkages between ecosystem services and human well-being



Source: Millennium Ecosystem Assessment.

- Supporting services are necessary for sustaining the production of all other ecosystem services. Examples are primary production (plant growth) and nutrient cycling for soil formation and water quality regulation. Because ecosystem services are defined in terms of their benefits to people, we should recognize that the value assigned to any ecosystem service is context dependent.
- An exercise on prioritizing ecosystem services for different types of stakeholders is provided in the annex (exercise 1: Ecosystem services).

Table 4. Ecosystem services provided by or derived from the Iraqi marshlands

Service	Sub-category	Definition	Examples
Provisioning services – the goods or products obtained from marshland ecosystems			
Food	Crops	Cultivated plants or agricultural produce which are harvested by people for human or animal consumption.	• Paddy rice • Great millet • Dates • Vegetables and fruits
	Livestock	Animals raised for domestic or commercial consumption or use.	• Asian water buffalo • Cattle • Sheep • Water buffalo milk and yogurt
	Capture fisheries	Wild fish captured through trawling and other non-farming methods.	• Shrimp • Yellow fin sea bream • Khishni
	Aquaculture	Fish, shellfish, and/or plants that are bred and reared in ponds, enclosures, and other forms of fresh- or salt-water confinement for purposes of harvesting.	• Cyprinids • Grass carp • Shellfish
	Wild foods	Edible plant and animal species gathered or captured in the wild.	• Wild boar • Waterfowl (coot, teal) • Desert monitor
Freshwater		Inland bodies of water, groundwater, rainwater and surface waters for household, industrial and agricultural uses.	• Freshwater for drinking, cleaning, cooling, and transportation (canoeing and boating)
Fibre and fuel	Fibre	Wood and non-wood based fibres for a variety of uses.	• Reeds for housing and mats • Date palm wood
	Fuels	Fossil fuel and biomass fuel.	• Reeds • Crude oil • Cattle dung

Service	Sub-category	Definition	Examples
Biochemical		Extracted medicines and other materials from biota.	• Potential use of marsh flora extracts, native herbs for pharmaceuticals and pest control
Genetic materials		Genes and genetic information used for animal breeding, plant improvement and biotechnology.	• Resistance and breeding of native plant and animal species
Regulating services – the benefits obtained from the control of natural processes in marshland ecosystems			
Climate regulation		Source and sink for greenhouse gases; influence local and regional temperature, precipitation, and other climatic processes.	• Help moderate the national rainfall patterns and control desertification and dust storms
Water regulation	Hydrological flows	Water storage, timing and magnitude of water flow and recharge of aquifers.	• Storage and retention of water flowing from Euphrates-Tigris system upstream and tidal flow downstream • Permeable clay and silt facilitates recharge of the recent alluvium aquifer
	Water purification and waste treatment	Retention, recovery and removal of excess nutrients and other pollutants.	• Marsh wetlands remove harmful pollutants from water by trapping metals and organic materials • Soil microbes degrade organic waste rendering it less harmful
Erosion regulation		Role of vegetative cover in soil retention.	• Reeds, grasses and estuarine vegetation retain soils and sediments
Natural hazard regulation		Capacity of the marshland area to reduce the damage caused by natural hazards.	• Marsh areas naturally absorb seasonal floods and tidal surges • Moderation of drought at a local scale
Pollination		Animal-assisted pollen transfer between plants, without which many plants cannot reproduce.	• Habitat for bees and birds, the key pollinators of economically important crops

Service	Sub-category	Definition	Examples
Cultural services – the non-material benefits that Iraqis obtain from marshland ecosystems			
Ethical values		Spiritual, religious, aesthetic, intrinsic or other values that Iraqis attach to the ecosystems, landscapes or species of the marshlands.	• Customs, oral traditions, knowledge and rituals attached to the use of the land and rivers • Iraqi tangible and intangible cultural heritage • An area of global importance
Recreation and tourism		Recreational activities that people derive from the marshland ecosystems.	• Canoeing, bird and wild-life watching, recreational fishing, archaeological site visitation, marsh communities
Aesthetic		The value that Iraqis and the international community place on knowing that the marshlands exist, even if they never use the area.	• Globally significant natural beauty
Educational		Opportunities for formal and informal education and training.	• Science, cultural awareness, specialized vocational training, public awareness of national, regional and global importance
Supporting services – the underlying processes that are necessary for the production of all other ecosystem services			
Soil formation		Process by which organic material is decomposed to form soil.	• Retaining sediment, recycling and supporting the health of the ecosystem
Nutrient cycling		Storing, recycling, processing and acquisition of nutrients.	• Returning phosphorus, sulphur and nitrogen to Iraq's atmosphere, water and soils

Using the concept of ecosystem services in management

When using the concept of ecosystem services in the management of an area, it is easiest to start with identification of the desired provisioning services, also called 'goods' in economic terms, because they are the physical things that can be harvested and consumed or sold.

Under conventional land and water resource management approaches, management objectives have often been to maximize production of these physical goods. One way of viewing ecosystem management is to expand the definition of production beyond provisioning ecosystem services to include maintenance of the regulating and supporting services that underpin the provisioning services, and to include as consideration the desired cultural services.

Ecosystem functioning: Core processes and structure for the supply of services

Ecosystem processes

The functioning of ecosystems, that is, how they 'work' or 'operate' as an ecological system, can be understood in terms of four core ecosystem processes and how these interact with the structure of the ecosystem and landscape. Management of desired ecosystem services needs to consider both the necessary ecosystem structure and the functioning of ecosystem processes to supply the services. While each of the four cores ecosystem processes can be considered individually they are completely inter-linked, and so change in the functioning of any one of them automatically means change in the functioning of the others, as they are simply different aspects of the same system.

Thinking of and seeing the natural world in this way are central to an ecosystem approach to management. The four core ecosystem processes that are part of the functioning of ecosystems at all scales are:

- Water cycling
- Mineral cycling
- Solar energy flow
- Biological growth

When managing land and water resources for particular ecosystem services, being able to think in terms of solar energy flow is important for several reasons. All provisioning ecosystem services, except freshwater supply, are the product of living organisms. The production (biomass) of these organisms depends directly on the amount of solar energy they can obtain.

Ecosystem structure

For the purposes of ecosystem management, especially in freshwater systems, the most useful types of ecosystem structure that can be considered for management are:

- Structure of the food web
- Physical structure of vegetation layers
- Soil coverage
- Water bodies
- Decomposition of organic matter
- Spatial configuration of species

In addition, climate, topography and soil types are also major determinants of ecosystem structure and processes, but these are obviously less amenable to management actions.

Box 2. Baraka watershed in the Sudan

The Baraka is an international river, flowing from the Eritrean Highlands to the Sudan. Total area of the catchment is approximately 65,000 km². In the Sudan, the catchment covers an area of approximately 21,350 km². The main tributaries Barka and Anseba originate from Eritrea, while Langab originates from the hilly regions in the Kassala State in the Sudan. In the lower catchment, the river channels have created three distinct "deltas" – all part of the same alluvial fan – the so called Tokar delta, and in the summer months the delta is inundated by intense floods. The floods occur as a series of flashes, and the variation in number of flashes per year is considerable. The hydrological pattern is characterized by its highly ephemeral conditions with almost all the run-off concentrated in the months of June, July and August. The maximum monthly runoff that reaches the delta varies between 25 mm³ and 135 mm³. The water related vulnerability of the catchment population is mainly related to floods, the difficulty of controlling available water for productive use, and groundwater pollution as well as saline intrusion. The flooding threat imposes such a serious problem that relocation of the Tokar town is seen by the Red Sea authorities as the only long-term solution. Other issues of concern are the continued spreading of mesquite and change in land cover. The carrying capacity of natural resources in the semi-arid areas of the Sudan is vulnerable.

The mesquite problem is a major threat to socio-economic development in the catchment. The mesquites removal programmes have not met their targets, due to many reasons. One reason is the difficulty to limit animals spreading the tree seeds when entering the delta for land grazing.

Priority infrastructure actions:

Baraka/Langab dam: It aims to help mitigate flood risks for the city of Tokar and to optimize irrigation of the delta. Upstream regulation of the flash floods is necessary not only for better control of the water for irrigation in Tokar delta, but even more importantly, it is a necessity to be able to protect Tokar town against the risk of a devastating flood.

Tokar town flood protection and management: The risk of flooding of Tokar town is high and increasing year by year due to the increasing sedimentation in the delta. With the construction of the Baraka/Langab dam, flood control will be much improved in the delta of Tokar. The flood management components include: detailed design and construction of Tokar town flood protection, early preparedness plan and flood early warning system.

Tokar irrigation rehabilitation project: There is a potential to efficiently irrigate an average of 36,000 ha of land with mixed cropping pattern of millet and cotton. The size of the irrigated land can be much larger in a year with high floods.

Tokar delta ground water development: The Tokar delta is also an aquifer; its groundwater resources are presently being exploited for Tokar town water supply and to some extent for relatively small-scale winter crop irrigation. Tokar delta aquifer systems have potential for further exploitation and the groundwater development projects are seen as viable projects on condition that the flood regulation projects materialize.

Source: Case study presented by A. Mohamed Hussein, Workshop on Climate Change Adaptation in the Environment Sector Using Integrated Water Resources Management (IWRM) and Ecosystem-based Management Tools, 22-24 March 2016, Beirut – Lebanon.

Ecosystem resilience and transformation risk

Another valuable result of thinking of the natural world as an ecological system is that systems can have properties or behaviour that only occurs because of the combination of all the components of the system. One such emergent property is the degree of resilience of the system to absorb pressures or stresses on it without significantly altering its structure and functioning. The resilience of an ecosystem can be measured in terms of the risk of its transformation to an undesirable state. The transformation risk for each ecosystem process can be assessed under current management practices and the practices necessary to deliver the desired ecosystem services.

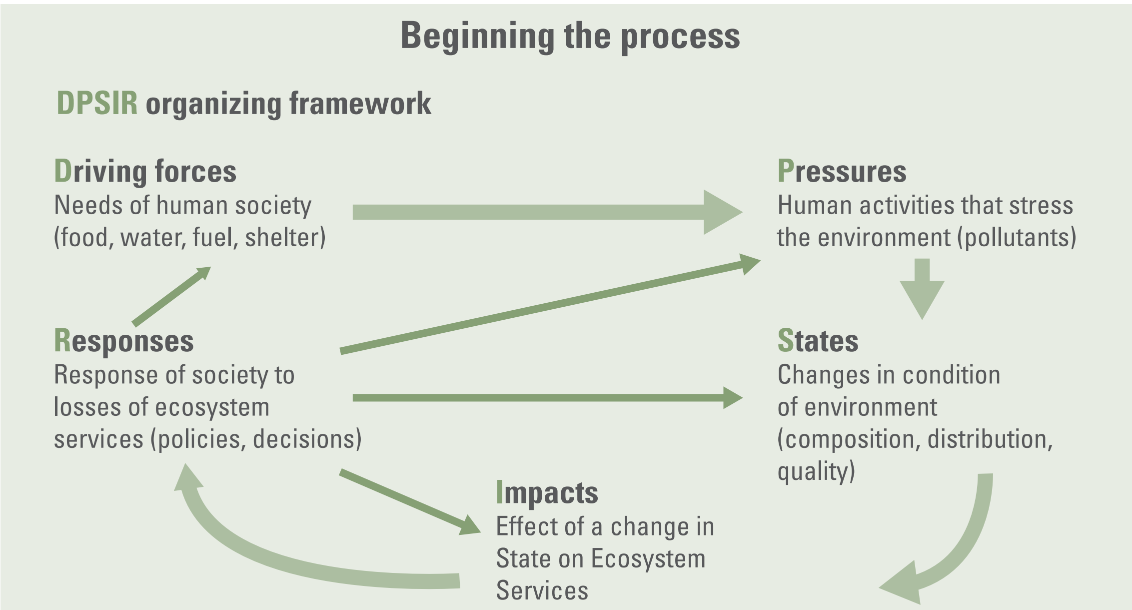
A conceptual framework for understanding ecosystem state and impact

Overview of the DPSIR framework

An understanding of the ecosystem state and trends, what forces affect them, and the impacts of ecosystem change are necessary to intervene in ecosystems in the interest of achieving certain management goals and objectives. Because no two ecosystems are the same, the specifics of an analysis will differ on a case-by-case basis, although similarities among ecosystem structure, function and dynamics do allow general frameworks to guide such analysis.

The DPSIR (figure 13) framework has been developed over thirty years to analyse the dynamic interaction of human society and the environment. The underlying concept of the DPSIR framework is that the state of the environment or of ecosystems is a combined result of broad natural and anthropogenic forces of change, collectively called Pressures (Pinter and others, 2008).

Figure 13. Simple representation of the DPSIR components of the framework and their connections



Source: The United States Environmental Protection Agency (EPA). Tutorials on Systems Thinking using the DPSIR Framework.

Table 5. Example of DPSIR indicators

	Driving force (economy and social indicators)	Pressure (human activity)	State (current status and environmental change)	Impact (ultimate impact of environmental change)	Response (actions taken of legal, technical, economic and environmental nature)
Social	• Population density • Population growth rate • Education level • Average age of citizens • Number of houses	• Urbanization rate • Change of forest area by industrialization • Increase of mining area • Number of production factories • Emission load of waste water • Fertilizer use • Impervious area rate • Available seawater resource • Maximum daily rainfall • Total available water resource • Altitude and watershed slope • SOx, NOx emission rate • Water demand for agriculture • Industrial rate	• Household water use per day • Water resource supply rate • Achievement rate of environmental flow in river • Irrigation rate • Water resource use per people • Water resource per agricultural land • BOD goal achievement rate • River water quality • Groundwater quality • Floods frequency • Drought rate • Change rate of temperature • Change rate of water quality • Change rate of ecosystem	• Days under water quality goal • Number of environmental accident • Death rate of below age of 5 years • Population and damage area due to the limited water supply • Drought damaged property density • Decrease of river water resource • Disease problem caused by water quality	• Involvement of stakeholders • Empowerment of population in decision-making process • Water users associations • Documenting and communicating local knowledge
Economic	• GDP per capita • Unemployment rate • Asset value • Number of cars per people • Investment of environment part • Development rate				• Incentives provided • Subsidies approved • Economic legislation and regulations • Microcredit • Marketing
Environmental	• Water bodies • Forest • Agriculture production rate • Number of dams • Protection area				• Reforestation • Shift in crop land • Hydropower generation • Sustainable forestry and agriculture • Environmental legislations and regulations

These connections are anything but simple. Environmental state and trends are usually the net result of multiple, interacting forces of change. In any given ecosystem, there are also many different subsystems and associated variables (such as the hydrological regime, soil, biodiversity) that define overall ecosystem conditions. It is also clear that changes in one ecosystem condition can result in cascading sets of impacts. For example, changes in the hydrologic cycle can have implications for agriculture, hydropower production, public health, municipal infrastructure, and others.

While recognizing simple cause-effect relationships is important, ecosystem management must take into account the full complexity of these relationships as they play out on the landscape over time. A DPSIR analysis focused on a given ecosystem will identify different relationships.

Table 6. Examples of priority environmental issues from the Arab region

Freshwater Water scarcity due to climate change might reduce the available renewable water resources by 15-20 per cent in the next 50 years. This could lead to decreases in the flow of major rivers and groundwater recharge rates, a higher frequency of flash floods and droughts, and a loss of productivity in rain-fed agriculture.	**Soil, land use, land degradation and desertification** Land degradation and desertification are one of the main environmental problems facing West Asia. Developments such as the intensification of crop and livestock production and pastoral activities, war, overuse of agrochemicals, overstocking of livestock, and a lack of integrated water-land-use planning and management have resulted in reduced ecosystem services, including biodiversity loss.
Oceans and seas The coastal and marine environments in the Arab region are facing threats due to pressures from the urbanization of coastal zones, tourism, maritime and oil traffic, rapid industrialization and overfishing. This has contributed to the depletion of living resources, coastal zone degradation and marine pollution. Many West Asian countries are involved in land reclamation activities with adverse impacts on coastal and marine ecosystems.	
Priority environmental concerns	
1. Declining water quality in rivers and coastal waters. 2. Increasing environmental risks from hazardous materials and wastes. 3. Inadequate or unsatisfactory water supplies. 4. Loss of critical habitats and biodiversity. 5. Declining coastal and marine resources.	6. Increasing land degradation. 7. Disturbed or unpredictable hydrological regimes. 8. Climate change. 9. Air pollution. 10. Noise pollution.

Source: UNEP, GEO5.

What is happening to the ecosystem and why?

Successful management requires an understanding of the current state and dynamics of the ecosystem and the conditions that led to the present situation. Answering these questions is the starting point of the DPSIR analysis and should involve addressing the following sub-questions:

- What are the priority issues and concerns in the ecosystem?
- What are the specific states or conditions beyond the priority ecosystem condition identified and how have those states and conditions changed over time?
- What are the key pressures and drivers that contributed to the specific changes identified?
- What are the priority issues and concerns in the ecosystem?

Given the complexity of ecosystems, at any given time, there is a very large number of issues that require the oversight of an ecosystem manager. However, without losing a whole-ecosystem perspective, it helps to identify priorities and establish focus that can guide both analysis and management. Because of the large differences among ecosystems depending on their location, size, socio-economic context and other surrounding factors, the mix of priority issues tends to differ from one place to another. Priorities may also change over time, because of new ecosystem dynamics, new social priorities or new scientific insights, thus making periodic review essential.

Exercise 2: Catchment ecosystem state and indicators (see the annex) is a multi-part exercise that asks groups to identify the issues that concern the state of their catchment ecosystem, describe indicators, measures and timeframes for a number of services, and an analysis of drivers and pressures.

What are the specific states or conditions beyond the priority ecosystem issues identified and how did these states and conditions change over time?

To understand how these ecosystem states change over space and time, it is necessary to identify specific indicators. Indicators represent a quantitative description of a specific

Table 7. Example drivers and pressures

Drivers	
• Consumption and production patterns • Demographics • Science and technological innovation • Economic demand, markets and trade • Institutional and socio-political frameworks • Distribution patterns	
Sectors	**Human influence**
• Agriculture, fisheries and forestry • Transport and housing • Finance and trade • Energy and industry • Security and defence • Science and education • Culture	• Pollution • Land use • Resource extraction • Modification and movement of organisms

Source: UNEP, GEO4.

ecosystem condition and they can serve as instruments to diagnose problems or measure the effects of management action.

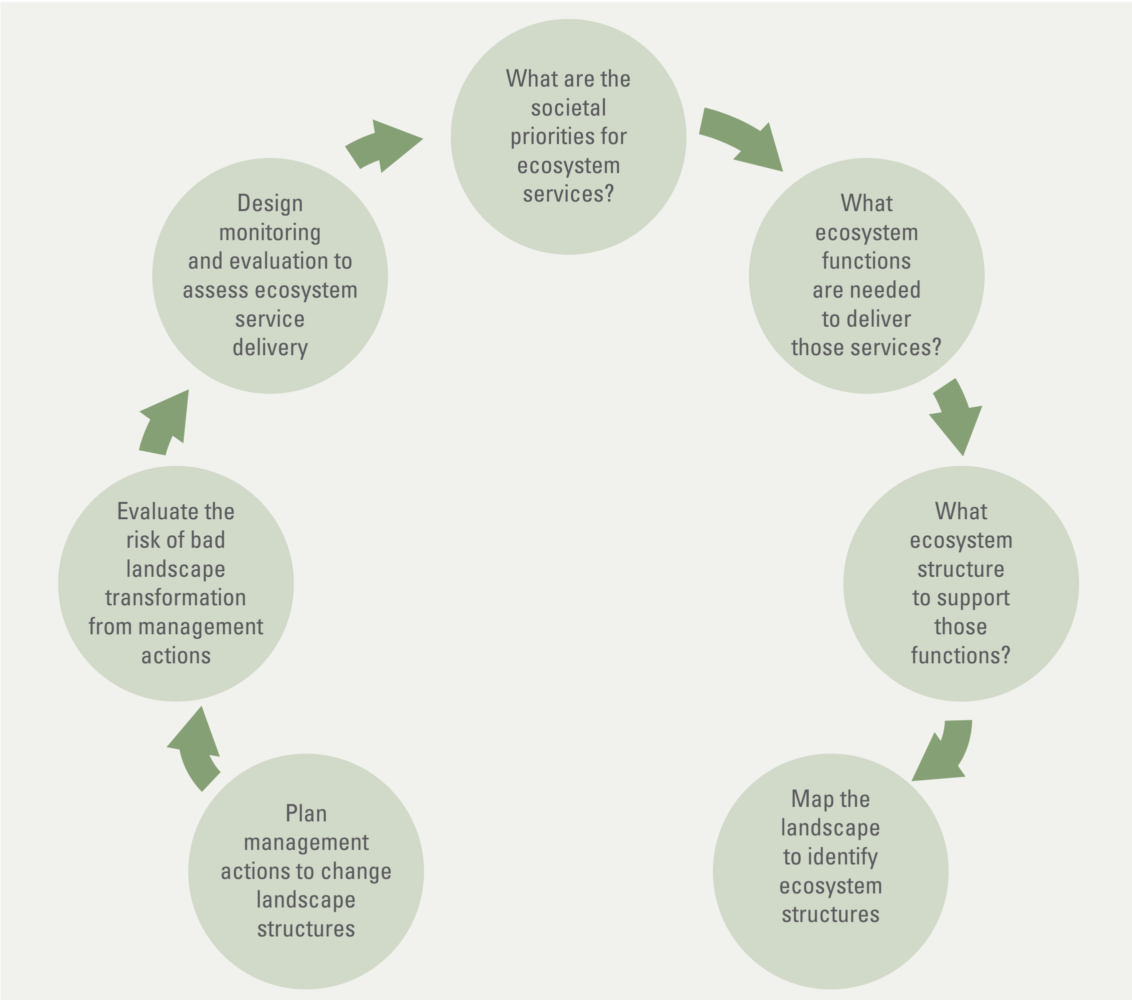
Indicator selection is usually a separate sub-process involving or at least consulting technical experts or literature on how relevant environmental variables can be quantitatively measured. Indicators often rely on data that already exists or can be gathered given existing technical, scientific and capacity constraints. Typically, indicator selection is guided by indicator criteria.

State of ecosystem services and functioning

Determining management objectives in terms of ecosystem services, processes and structure

Ecosystem management is defined as working with ecosystem functioning to supply defined ecosystem services. This module explains the seven steps for setting management objectives

Figure 14. Flow diagram of a pathway for using ecosystem services to identify management objectives



Source: Reconstituted from UNEP-IISD-DHI, 2011. Ecosystem Approaches in Integrated Water Resources Management, p. 48.

with this perspective (figure 14). An emerging way to encourage good practices and to share costs and benefits among the stakeholders in the catchment involves harnessing the value and specifying the rewards of ecosystem services. Figure 14 illustrates the process of identifying and evaluating ecosystem services in management.

Step 1. What are societal priorities for ecosystem services?

Step 1 determines which ecosystem services are necessary to give the quality of life and income for the users, managers of the land or water area, and 'off-site' or downstream beneficiaries. The identification of ecosystem services is made in relation to each of the four core ecosystem processes. For each process, first identify the necessary provisioning and cultural services and then identify the regulating services that help to maintain them. Ideally, for each service the desired value and a minimum and maximum acceptable value are determined. It is critical in this step to carefully and explicitly bring in local

Table 8. Priority adaptation project in Nile Basin countries

Priority adaptation Project focus	Congo	Egypt	Ethiopia	Kenya	Tanzania	Uganda	Rwanda	Burundi	Sudan
Water resource management		X		X	X	X	X	X	X
Promotion of drought-tolerant crops		X	X	X	X	X	X	X	X
Sustainable agriculture and land management	X	X		X	X	X	X	X	X
Environmental conservation and biodiversity/land restoration	X		X		X	X		X	X
Early warning systems			X			X	X	X	X
Diversification of energy sources				X	X		X	X	X
Malaria control	X		X	X	X		X	X	X
Integrated coastal zone /flood plain management	X	X		X				X	X
Strengthening community awareness	X	X	X	X	X		X	X	X
Livelihood diversification	X		X	X			X		X
Water and sanitation						X	X		
Indigenous knowledge						X			
Disaster risk reduction/risk transfer			X	X					

Source: UNEP Review of Adaptation Best Practice in the Nile River Basin Region.

ecological knowledge, as well as the views of any indigenous and native people who are stakeholders in the catchment. Table 8 presents the priority adaptation projects undertaken in the Nile Basin countries, two of which (Egypt and the Sudan) are part of the Arab region.

An important element in this step is to understand local hydrology as catchments are hydrologically defined. Understanding where and how water is delivered (such as rainfall), how hydrology changes along the axis of the stream channel and with land use, and how different ecosystem services require different water quantities and qualities are critical to sustaining those services. In that regard, it is important to recognize that ecosystem itself is a stakeholder here. Environmental flows are those that maintain the functions of the ecosystem (such as fish habitat, water for wildlife). Those minimum base flows must be identified and either quantified or at least estimated to ensure sustainability.

Table 9. Examples of ecosystem services related to the four core ecosystem processes

Examples of ecosystem services related to the water cycling ecosystem process	Examples of ecosystem services related to the mineral cycling ecosystem process
Provisioning ecosystem services	
Water for crop irrigation: m^3 per day for x days.	Mineral levels in the soil necessary for food crops, forage for livestock, or tree growth – soil pH, mineral parts per million, % organic matter.
Soil water moisture levels for agricultural crop or tree growth: x % humidity for x days.	River or lake water turbidity and quality for aquaculture.
Water flow from springs or pumped from groundwater for livestock and wildlife drinking: x litres per day for x days.	Drinking water quality for x number of people daily, or yearly.
River water flow or volume in lake for aquaculture or transport: x m^3 per day.	Downstream water quality for other users (such as industry, domestic, agriculture, HEP).
Drinking water for x number of people daily, or yearly: x litres.	
Downstream water flow and quality for other users (such as industry, domestic, agriculture, HEP).	
Supporting services	
Levels of photosynthesis by food crops, forage for livestock and wildlife, tree growth, biomass increase: kg/ha.	Growth rates and production of food crops forage for livestock and wildlife, trees, medicinal plants, fish, game species, biomass increase: kg/ha.
Levels of sugars and protein in forage for livestock and wildlife: % protein.	Availability of prey for wild predators hunted commercially or for recreation.
Availability of prey for wild predators valued for hunting, tourism or regulation of prey species.	Availability of organisms to ensure the decomposition process.

Cultural ecosystem services	
Presence and population size of species and ecological communities valued for spiritual, recreational or educational reasons.	Individual and group cultural practices and well-being based on farming, hunting, management and contact with land and water ecosystems and species. Presence and population size of species and ecological communities valued for spiritual, recreational or educational purposes.
Regulating ecosystem services	
Availability of food for animals that pollinate and disperse the seeds of crops and wild plants.	Availability of food and habitat for animals that pollinate and disperse the seeds of crops and wild plants.
Availability of food for predators that reduce populations of agricultural pests and human disease agents.	Availability of food and habitats for predators that reduce populations of agricultural pests and human disease agents.
Production of plant matter to support soil formation: kg/ha.	Production of plant matter and animal wastes to support soil formation: kg/ha.
Global climate regulation through the sequestration of carbon dioxide by vegetation and soils: tons of carbon/ha.	Global climate regulation through the sequestration of carbon dioxide by vegetation and soils: tons of carbon/ha.

Source: Millennium Ecosystem Assessment, 2003.

Step 2. What ecosystem functions are needed to deliver those services?

Step 2 determines the necessary functioning of each of the four ecosystem processes to deliver the desired ecosystem services, noting that there will be considerable overlap in the results because the processes are different aspects of the same system. The necessary functioning of each ecosystem process may be different for different ecosystem services. Catchment-specific consideration will also be required to account for variation in climate, topography and soil types. This means that some prioritization and trade-offs between the desired ecosystem services from an area may be necessary. As a result, there may be a compromise in the level of functioning of the ecosystem processes to satisfy a range of ecosystem services. The identification, in step 1, of desired ecosystem services in relation to the ecosystem processes helps to determine the main features of the processes that are required for each land unit or water body being managed.

Step 3. What ecosystem structure is needed to support those functions?

This step introduces ways to describe and measure ecosystem structure to influence the desired functioning of ecosystem processes. This process should begin by building a description of the food web in terms of the requirements of the decomposers, then the predators, and finally herbivores and plants. Descriptions of the soil structure and vegetation layers should follow.

The descriptions of the functioning of the ecosystem processes in step 2 will already have produced useful information on the desired ecosystem structure, because the processes are often measured using indicators of physical aspects or structure of the system.

Step 4. Map the landscape to identify ecosystem structures

Step 4 considers the spatial distribution or configuration of vegetation and crops, water bodies, livestock, wildlife, recreation and cultural values, etc. as part of the necessary ecosystem structure for the desired services. The overall principle that needs to be kept in mind with this step is to be guided by the likely effects of landscape and waterscape structure on the desired functioning of the ecosystem processes. This will obviously require local knowledge. In addition, the potential for actually changing the spatial configuration of landscape and waterscape structures will depend greatly on local topography and the resources available. This step may well involve a long-term plan and periodic steps.

Step 5. Plan management actions to change landscape structures

Step 5 is the stage of planning actions to move toward the desired structures of the ecosystem and landscape. It is not possible to know fully what actions will be required for the variety of circumstances and desired ecosystem services, but local and scientific knowledge can help. As stated earlier, in some ways ecosystem management is a new perspective or way of thinking for land and water resource managers, such as for farming, forestry, supply of water resources, recreation and tourism, cultural or spiritual values, or biodiversity conservation.

Step 6. Evaluate the risk of bad landscape transformations from a management action

The concept of ecosystem resilience and transformation risk as one way of measuring resilience has been already introduced. Before any planned management actions are implemented, they should be assessed to see if they could increase the risk of transformation of ecosystem functioning to an undesirable state. This first requires identifying possible thresholds for undesirable changes in ecosystem structure and processes. This should be done for each of the ecosystem processes.

Step 7. Design monitoring and evaluation to assess ecosystem service delivery

This chapter describes the adaptive management cycle, an essential part of which is monitoring. When practicing management of ecosystem functioning, it must not be assumed that the understanding of ecosystems and of their response to management is sufficient to make fixed plans. The complexity and variability of the natural world mean that it is frequently necessary to measure progress towards stated goals, and then make needed adjustments. In some cases, this may require a complete re-planning if initial assumptions and plans do not produce the intended results.

The annex delivers an exercise guiding groups through ecosystem services and different aspects of the seven-step process of setting management objectives discussed above (see exercise 3: Ecosystem services in management).

Understanding current conditions

Information base for managing ecosystems

The development of an information base forms a key element to supporting the establishment of legal, economic or outreach instruments for managing ecosystems. Whereas knowledge lies at the centre of any learning process, learning is broader than information. It combines

Box 3. Vulnerability assessment of Marj Sanour watershed

The study provides insight into the social, environmental, and agricultural vulnerability of Marj Sanour watershed in Jenin Governorate in the State of Palestine, prepared as part of the Social, Ecological and Agricultural Resilience in the Face of Climate Change (SEARCH) project. The project evaluated the different natural conditions and human resources of the watershed and to what extent they are vulnerable to climate change and shed light on the causes, problems and implications of climate change and the methods locally adopted to adapt to it. The study defined the vision of Marj Sanour local citizens, assessed the various scenarios and identified strategies and plans necessary to achieve this vision, ensuring stakeholders' participation in all stages.

The results included:

- Increasing the capacity and knowledge of stakeholders and local communities in the use of tools to adapt to climate change, and planning and strategizing through learning and exchange of information in regional networks;
- Strengthening local action planning for adaptation to climate change, which increases the institutional capacity and coordination and is reflected by using practical and participatory approaches in building livelihoods and ecosystem / biodiversity flexibility;
- Reducing the climate vulnerabilities and risks in watershed through the implementation of pilot projects at the local level;
- Developing practical tools / guides in partnership with the political decision makers to contribute to the development of national strategies and sectoral plans for adaptation to climate change, poverty reduction and economic development.

Source: IUCN; 2013.

traditional and innovative strategies such as teaching, testing of new ideas or staff exchanges to assist practitioner networks and support professional updating.

Gender disaggregated data at national and local levels is essential for designing policies and setting programmes, in order to take gender issues into consideration in service provision and increase women's participation in enhancing ecosystems and prevent their decline.

Similarly, monitoring systems also need to distinguish gender concerns and to periodically address the progress in women's status related to development and integrated water management systems.

For further reading on this topic:

- Flow: the essentials of environmental flows.
  http://iucn.org/about/work/programmes/water/resources/toolkits/flow/;
- Methods for evaluating environmental flows (Arthingon and Zalucki, 1998).

Improved water governance underpins action (Rule)

Effective water governance capacity is the foundation of efficient management of water resources. Water governance reform processes must work towards building capacity in a cohesive and articulated approach that links national policies, laws and institutions within an enabling environment that allows for their implementation. Reforming water governance shows how national water reform processes can deliver good water governance by focusing on the principles and practice of reform.

Box 4. Integrated assessment of wetland ecosystem in Mauritania: Lake Aleg (2008)

Lake Aleg is located south-west of Mauritania, at the eastern end of the Senegalese-Mauritanian basin. It is part of Moughataa Aleg, itself located in the Wilaya of Brakna. Due to its water and floristic richness, the lake is a very strong attraction area in this region characterized by a climate of Saharan-Sahelian type, with low precipitation (less than 300 mm/year), a dry season that lasts around 8 months from November to June, and a rainy season known as wintering that lasts 4 months.

Temperatures are usually high during most of the year with peaks in May and June, which can exceed 40°C. The lowest temperatures are recorded in the months of December and January with a minimum average ranging between 15 and 16°C. Evapotranspiration is 6.24 mm per day on average over the year.

The lake is in a great depression, bounded by sand dunes northwest and small trays of forty meters to the east. Its size depends essentially on intermittent hydrological inflows of Wadi Ketchi, itself formed by three other wadis, the Agoueinita, the Erdy and Aska Naroua. At its optimum depth of 31m, it can reach an area that is 20 km long and 5 km wide, with a volume of water estimated at 66.44 million m3. The lake is very flat, and it frequently overflows onto the road from Aleg to Boutilimit.

The major bed of the lake is composed of sandy clay and houses the crops in the dry season to progressively receding floods of the river. Non-flooded areas are the sandy area of pastures and crops under rain.

Historically, pastures adjacent to the lake were used by small sedentary family farmers and nomads for transhumance, and by those who always use the lake as a passing zone. Today, the lake remains a vital source of income and food for the surrounding populations through agriculture, forage resources, firewood and other wood and non-wood products it provides. It contributes to the water supply of non-connected households to the drinking water system, provides water for the animals, and recharges the main aquifer of Brakna. In addition, the immediate belt of the lake includes many tamourts that are temporary pools.

Wildlife (small mammals) and flora (grasses and aquatic species, wood) of the lake area are quite diverse, despite the combined effects of drought and adverse actions of man on natural resources (including excessive cutting of trees), which have resulted in the disappearance of several forest formations, disappearance or regression of several woody species, and the eradication of several wild animal species.

Ornithologically, Lake Aleg plays an undeniable role because it serves as passage and wintering area for migratory birds: Palearctic-African tropical, teals, geese, ducks, storks, moorhens and spatulas. However, their diversity is threatened because they experience many attacks (hunting, trampling of plants that serve as their habitat and provide them with food).

In summary, the major issues of the ecosystem of Lake Aleg are at two levels:

Environmental:
- Decrease in the amount of water available
- Degradation of the water quality (pollution and salinization)
- Overexploitation of plant and animal resources
- Silting of the drainage system
- Degradation of arable land
- The lack of sanitation (liquid and solid waste in the receiving environment)

Socio-economic:

- Lower level of well-being
- Proliferation of human and veterinary infectious diseases and water quality degradation
- The absence of an integrated ecosystem management
- The decline in production and productivity (food security)

Source: Case study presented by M. Yahya Afdal at the Workshop on Climate Change Adaptation in the Environment Sector Using Integrated Water Resources Management (IWRM) and Ecosystem-based Management Tools, 22-24 March 2016, Beirut – Lebanon.

Women should be integrated into the governance of water resources at all levels in order to ensure that they have an equal share to the power and influence of this vital resource. Gender mainstreaming is an essential part of governance, including:

- Enabling the environment for women's full participation and allowing the country to leverage their potential and contribution, including valuing the unrecognised work in both households and family businesses;
- Building women's capacity including for leadership and for adaptive programmes;
- Developing women's social organisations;
- Providing social services, rural advisory services and soft skills.

Developing water policies is the first step in the implementation of an ecosystem approach. Policies set goals for water use, protection and conservation. Specific knowledge will however be required on how to prepare national water resources policy as well as to identify policies with relation to water resources. As part of the same enabling environment, lessons learned and tools for use in the development of water law will be valuable background for improved regulatory capacity whether they address water rights, legislation for water quality or reform of existing legislation.

Lack of transboundary coordination impairs action (Share)

A useful toolkit to support learning around this topic is "SHARE: Managing waters across boundaries". This document provides an overview of the world's shared water resources and insights for managing these resources. Using case studies from around the world, it describes the benefits to be gained from cooperation and the challenges of constructing legal frameworks, institutions, management processes, financing, and partnership strategies to govern transboundary waters equitably and sustainably.

Financial incentives support implementation of an ecosystem approach (Pay)

Payments for watershed services are an emerging innovation in water management. Establishing payments for watershed services offers a hands-on explanation of the issues that need to be addressed when establishing these payment schemes. It explains the services and the values of watershed services. It then highlights the technical, financial, legal and social aspects of establishing payments schemes for maintaining or restoring watershed services critical for downstream water security.

Empowerment enables participation in action (Negotiate)

Water practitioners are increasingly called upon to negotiate workable agreements about how to best use, manage and care for water resources. Reaching agreements over water makes the case for constructive engagement and cooperative forms of negotiation in dealing with complex water issues. In this regard, women can play a crucial role in negotiation and conflict resolution, both nationally and regionally.

At the local level, villagers also have the opportunity to use indigenous knowledge to conduct participatory research for informing decision-making on fish stocks. Other case studies about empowerment and enabled participation can be useful in this regard (http://iucn.org/about/work/programmes/water/resources/toolkits/negotiate/). One important resource that marginalized people and their allies can use to have a greater positive influence on natural resources policy is IIEED's PowerTools. This toolkit is comprised of 26 "how-to" ideas based on experience from around the world, discussion of power tools in theory and practice, related research on policy tools in action, and a directory of the many other websites that contain policy tool resources.

Box 5. Oil from ancient Argan trees managed by women's cooperatives supports local economy and protects against deforestation (Morocco)

Today dry periods and occasional extreme rainfall, growing usage pressure and unsustainable resource use already pose a threat to Morocco's natural resources. For instance, the populations of Argan trees – a native plant that provides not only firewood and building timber, but also livestock feed and fruits for human consumption and cosmetic application, are threatened by overexploitation and deforestation (600 hectares are lost each year). In addition, the loss of these trees will not only have an environmental impact (loss of root systems and biodiversity) but also a socioeconomic one, since 3 million Moroccans depend on Argan oil production as a primary source of income. The degradation of Argan trees has made it increasingly difficult for women's cooperatives to survive as they are the ones traditionally in charge of caring for trees and for the production of oil.

The Mohammed VI Foundation for Research and Preservation of the Argan Tree takes an integrated approach by promoting women's education and capacity building to improve the management of women cooperatives, as well as getting legal protection through the establishment of a Protected Geographical Indication (PGI) for Moroccan Argan oil and all products specific to Morocco, which helps protecting traditional knowledge and promoting producers' collective rights. Reforestation of Argan trees contributes both to protection of the natural balance and biodiversity (Women's Rio +20 Good Practice Award, 2012).

Another project (GIZ) supported women's cooperatives in this manner. At the end of 2008, only 60 women were benefiting from the productive measures initiated by the project but, at the end of 2009, their number grew to 546 in the whole operational area. In addition, 282 women are benefiting from small-scale projects in the context of combating desertification (in 2008, they were only 137), as well as the approximately 1000 women who are organized in the union for women's cooperatives in the Argan-region and are earning a higher income due to the better quality and marketing options (Krauss, 2011).

In the end, these two projects, through their large social and gender dimension, benefit women cooperatives, promote local production and save women's jobs.

Source: Women's Rio +20 Good Practice Award. (2012). Women's contributions to Sustainable and Equitable Economies. Rio de Janeiro. Krauss, J. (2011). Gender and Climate Change. Gender Experiences from Climate-Related GIZ Projects. Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH.

Building consensus legitimatizes action by actors (Negotiate)

Reaching agreements over water is particularly targeted at water practitioners interested in designing, leading or participating in processes enhancing water resources management and resolving water resource conflicts or disputes. In so doing, the toolkit gives an overview of the skills that water professionals will need to build meaningful stakeholder participation in decision-making on water.

The way forward

Integration of ecosystem-based management into IWRM as tools for ecosystem-based adaptation

As mentioned earlier in this training manual, EBA involves a wide range of ecosystem management activities to increase resilience and reduce the vulnerability of people and the environment to climate change. The adaptation is linked to the security of access to basic human needs, such as water and food etc., which are services provided by the ecosystems. Therefore, human beings or water ecosystem users should have the ability to integrate efforts to sustain and restore ecosystem functions and promote human rights under changing climate conditions. This concept is valid to all water ecosystems with special emphasis on regions, such as the Arab region, which are under high water stress due to scarce water resources, long drought periods, conflicts destroying the terrestrial ecosystems, overexploitation of ground water, pollution, inadequate land use and very low human involvement in decision-making processes.

Experience indicates that EBA can be applied in different landscapes, may be more cost-effective than engineering and technological options and often provides multiple benefits. In addition, EBA could be combined with engineering approaches (so called “grey-green” infrastructure) and finally help decision makers recognize where building resilience is the best adaptation response.

The critical question remains why and how watershed managers should integrate EBM to increase the effectiveness of IWRM tools for climate change adaptation in the Arab region.

The implementation of IWRM in Arab countries reveals that after the initial progress made in initiating IWRM planning and establishing an enabling institutional environment for IWRM in many countries, progress slowed down due to a resistance to change mindset, low level of stakeholder’s integration, weak operational approaches, as well as institutional and social changes. While the status of IWRM implementation might have improved in certain countries (Bahrain, Egypt, Iraq, Jordan, Kuwait, Lebanon, Oman, State of Palestine, Qatar, Saudi Arabia, the Syrian Arab Republic, the United Arab Emirates and Yemen) since the report publication (UN-WATER/WWAP/2006/5) 10 years ago, the report noted that 31 per cent of the countries made progress in the implementation of IWRM, 38 per cent made some progress and 31 per cent of the countries were still in early stages of the implementation. The report mentioned the following key areas for improvement:

- Capacity enhancement
- Civil society involvement
- Adaptive management
- Monitoring and indicator development
- Environmental sustainability

Taking into consideration the uneven status of IWRM implementation, new developments, commitments of Arab countries related to MEAs in the management of water resources, and

Table 10. Selected adaptation measures in the River Nile Basin and in Egypt

Project name or focus	Description
Fisheries project for Lake Albert and Lake Edward (Congo, Egypt, the Sudan and Uganda)	The objective of the project is to establish a sustainable framework for the joint management of fisheries in Lake Albert and Lake Edward to improve the living conditions of people living around lakes and wetlands and to protect the environment.
Water Hyacinth abatement in the Kagera river basin (Burundi, Egypt, Rwanda, the Sudan, Tanzania and Uganda)	The objective of the project is to eliminate adverse effects on environment, health and socioeconomic activities that are caused by water hyacinth infestation, by reducing to manageable levels the infestation of water hyacinth in the Kagera River basin.
Adaptation to climate change in the Nile Delta through integrated coastal zone management	The objective of the project is to integrate the management of sea level rise risks into the development of Egypt's low elevation coastal zone (LECZ) in the Nile Delta.
To align Egypt's climate risk management and human development efforts in pursuing the achievement of MDGs in the face of climate change and the predicted serious threats to the country	The objective of the project is to combine mitigation and adaptation under one integrated climate risk management (CRM) banner with a special attention given to the vulnerable poorest populations of Egypt through two complementary approaches: mainstreaming GHG mitigation into national policy and investment frameworks, including increased clean development mechanism (CDM) financing opportunities; and enhancing the country's capacity to adapt to climate change.
Alexandria coastal zone management project (ACZM)	The objective of the project is to improve the institutional mechanisms for sustainable coastal zone management in Alexandria and, in particular, reduce land-based pollution to the Mediterranean Sea.
Climate change enabling activity (additional financing for capacity building in priority areas) (Egypt)	The proposed activities under this project will allow for improvement of activities undertaken in an earlier phase, hence the continuity and complementarity of climate change enabling activities in Egypt.
Bioenergy for sustainable rural development (Egypt)	The primary objective of the proposed project is to advance the use of renewable biomass as an energy resource, for the purpose of promoting sustainable rural development in Egypt and reducing greenhouse gas (GHG) emissions resulting from conventional energy resources. The biomass options that will be advanced under this project include: anaerobic biomass digesters for dung, household sewage and related high-moisture feedstock; anaerobic biomass digesters for leafy feedstock including agricultural residues and biomass densification (briquetting, pelletization) for rural enterprise and household applications; efficient biomass stoves, furnaces and dryers for rural enterprise and household applications; and biomass gasification for production of fuel gas for process heat, shaft power, pumping and electricity.

Source: UNEP, 2010. Stock Taking of Adaptation Activities in the Nile River Basin.

the ecosystems conservation scientific findings, there is a strong case to be made for the use of EBM to assist watershed managers. EBA will allow for more effective management of catchment by combining EBM and IWRM tools for an effective preparedness to adapt watersheds and associated human communities to climate change impacts in the Arab region.

Practically, there are twelve principles for the implementation of ecosystem-based watershed management. Watershed managers in the Arab region could make use of their own experiences to assess the compatibility and complementarity of their IWRM measures with these principles and would consider additional necessary measures for a successful integration of EBM in IWRM towards EBA.

Principle 1

The objectives of management of land, water and living resources are a matter of societal choice.

Rationale

Different sectors of society view ecosystems in terms of their own economic, cultural and societal needs. Indigenous peoples and other local communities living on the land are important stakeholders and their rights and interests should be recognized. Both cultural and biological diversity are central components of the EBM and management should take this into account. Societal choices should be expressed as clearly as possible. Ecosystems should be managed for their intrinsic values and for the tangible or intangible benefits for humans, in a fair and equitable way.

Box 6. Management of low elevation coastal zones, Nile Delta, Egypt

The dominant feature of Egypt's coastal zone is the low-lying delta of the River Nile, with its large cities, industry, flourishing agriculture and tourism. The Nile Delta and Mediterranean coast account for 30-40 per cent of Egypt's agricultural production and half of Egypt's industrial output. Based on projections on relative sea level rise (RSLR), Egypt's Mediterranean coast and the Nile Delta are highly vulnerable to abrupt sea level rise due to climate change.

Egypt has implemented a coherent set of policies, regulations and actions to reduce disaster risk in the low elevation coastal zone (LECZ) areas. Risk reduction strategies, policies and practices (measures) have been integrated into land use and national development plans following the adoption of the national climate change action plan. Environmental impact assessment that accounts for climate risk is a requirement for approval as well as regulating the setback distance of all coastal infrastructure.

The "living shorelines" approach has been adopted for protection against the effects of sea level rise (SLR) on low-lying coastal areas. This "soft" approach focuses on an innovative set of bank stabilization and habitat restoration techniques to reinforce the coastline, minimize coastal erosion, protect natural habitats and maintain coastal processes. Pilots of the "living shoreline" measures in the Nile Delta are focused on specific stretches of coastline that have already been identified as areas of sand accretion due to the installation of hard coastal protection structures. These areas offer a strategic opportunity to monitor the adoption of innovative shoreline protection techniques and to evaluate the potential benefits of expanding the measures to other shoreline areas along the Nile Delta.

The living shoreline approach involves local communities in the actual design of on-the-ground measures, hence ensuring community ownership and buy-in. Communities are also involved in the monitoring and evaluation schemes to gauge the actual effectiveness and viability of the 'soft' coastal stabilization measures.

Source: UNEP, 2015. Review of Adaptation Best Practice in the Nile River Basin Region.

Principle 2
Management should be decentralized to the lowest appropriate level.

Rationale
Decentralized systems may lead to greater efficiency, effectiveness and equity. Management should involve all stakeholders and balance local interests with the wider public interest. The closer management is to the ecosystem, the greater the responsibility, ownership, accountability, participation and use of local knowledge.

Principle 3
Ecosystem managers should consider the effects (actual or potential) of their activities on adjacent and other ecosystems.

Rationale
Management interventions in ecosystems often have unknown or unpredictable effects on other ecosystems; therefore, possible impacts need careful consideration and analysis. This may require new arrangements or ways of organization for institutions involved in decision-making to make, and if necessary, appropriate compromises.

Principle 4
Recognizing potential gains from management, there is usually a need to understand and manage the ecosystem in an economic context. Any such ecosystem-management programme should:

a. Reduce those market distortions that adversely affect biological diversity;
b. Align incentives to promote biodiversity conservation and sustainable use;
c. Internalize costs and benefits in the given ecosystem to the extent feasible.

Rationale
The greatest threat to biological diversity lies in its replacement by alternative systems of land use. This often arises through market distortions, which undervalue natural systems and populations and provide perverse incentives and subsidies to favour the conversion of land to less diverse systems. Often those who benefit from conservation do not pay the costs associated with conservation and, similarly, those who generate environmental costs (such as pollution) escape responsibility. Alignment of incentives allows those who control resources to benefit and ensures that those who generate environmental costs will pay.

Principle 5
Conservation of ecosystem structure and functioning, in order to maintain ecosystem services, should be a priority target of the ecosystem approach.

Rationale
Ecosystem functioning and resilience depend on a dynamic relationship within species, among species and between species and their abiotic environment, as well as the physical and chemical interactions within the environment. The conservation and, where appropriate, restoration of these interactions and processes are of greater significance for the long-term maintenance of biological diversity than simply protection of species.

Principle 6
Ecosystems must be managed within the limits of their functioning.

Rationale
In considering the likelihood or ease of attaining the management objectives, attention should be given to the environmental conditions that limit natural productivity, ecosystem structure,

Box 7. Integrated water resources management, Egypt

Egypt went through an unprecedented period of prolonged drought between 1978 and 1987. The fact that Egypt was very close to a major water shortage because of the drought led to a set of responses and anticipatory planning to cope with such events in the future. As research on the implications of climate change on the Nile Basin began to appear in the early 1990s, the focus was on drought and its implications for Nile water management.

Egypt has made emergency plans to counter future drought conditions, including reduction in the annual releases from the Aswan High Dam through more efficient regulation, extension of the winter closure period of the irrigation system, reduction of the area under rice and improvement of the Nile's navigable channel to maintain supply to irrigation outtakes.

In 1988, the Ministry of Water Resources and Irrigation (MWRI) developed a simulation model to review several options for reservoir operation under different Nile flow and downstream release scenarios. Currently, the MWRI's Nile Forecast Centre (NFC) operates a modelling system designed to predict inflows to Lake Nasser with as much lead time as possible.

In 1999, Lake Nasser reached the highest point since its completion. Egypt was forced to use the Toshka overspill canal to avoid overtopping the Aswan High Dam owing to limited capacity to handle increased releases downstream of the dam. Hence, in 2002, Lake Nasser flood and drought control project was established. The purpose of the project was to analyse the impacts of climate variability, especially flooding, on the operation of the Aswan High Dam reservoir.

The decadal variability in the Nile flows has prompted a series of adaptive responses by the MWRI to improve early warning of Nile flows and build capacity to handle the impacts of multi-year episodes of high and low flows more effectively.

Equal measures to deal with prolonged high flows must be considered. Changes in supply due to climate change should be considered alongside the certainty of demographic trends, and potential abstractions by upstream riparian countries. Egypt's water vision for the 21st century includes focus on policies to shift supply approaches to an integrated manner, which includes both supply and demand management. The MWRI has strong technical expertise and capacity in water management – supply side options – but less capacity in terms of socio-economic and institutional management options to regulate demand.

Source: UNEP, 2015. Review of Adaptation Best Practice in the Nile River Basin Region.

functioning and diversity. The limits to ecosystem functioning may be affected to different degrees by temporary, unpredictable or artificially maintained conditions and, accordingly, management should be appropriately cautious.

Principle 7
The EBM should be undertaken at the appropriate spatial and temporal scales.

Rationale
The approach should be bounded by spatial and temporal scales that are appropriate to the objectives. Boundaries for management will be defined operationally by users, managers, scientists and indigenous and local peoples. Connectivity between areas should be promoted, where necessary. The ecosystem approach is based upon the hierarchical nature of biological diversity characterized by the interaction and integration of genes, species and ecosystems.

Principle 8
Recognizing the varying temporal scales and lag-effects that characterize ecosystem processes, objectives for ecosystem management should be set for the long term.

Rationale
Ecosystem processes are characterized by varying temporal scales and lag-effects. This inherently conflicts with the tendency to favour short-term gains and benefits over future ones.

Principle 9
Management must recognize that change is inevitable.

Rationale
Ecosystems, including species composition and population abundance, change and hence, management should adapt to the changes. Apart from their inherent dynamics of change, ecosystems are beset by a complex set of uncertainties and potential "surprises" in the human, biological and environmental realms. Traditional disturbance regimes may be important for ecosystem structure and functioning, and may need to be maintained or restored. The ecosystem approach must utilize adaptive management in order to anticipate and cater for such changes and events and should be cautious in making any decision that may foreclose options, but at the same time, consider mitigating actions to cope with long-term changes, such as climate change.

Principle 10
The EBM should seek the appropriate balance between, and integration of, conservation and use of biological diversity.

Rationale
Biological diversity is critical both for its intrinsic value and because of the key role it plays in providing the ecosystem and other services, upon which we all ultimately depend. There has been a tendency in the past to manage components of biological diversity either as protected or non-protected. There is a need for a shift to more flexible situations, where conservation and use are seen in context and the full range of measures is applied in a continuum from strictly protected to human-made ecosystems.

Principle 11
The EBM should consider all forms of relevant information, including scientific, indigenous and local knowledge, innovations and practices.

Rationale
Information from all sources is critical to reach effective ecosystem management strategies. A much better knowledge of ecosystem functioning and the impact of human use is desirable. All relevant information from any concerned area should be shared with all stakeholders and actors. Assumptions behind proposed management decisions should be made explicit and checked against available knowledge and views of stakeholders.

Principle 12
The EBM should involve all relevant sectors of society and scientific disciplines.

Rationale
Most problems of biological diversity management are complex, with interactions, side effects and implications, and therefore should involve the necessary expertise and stakeholders at the local, national, regional and international level, as appropriate. Table 11 includes an example exhibiting a methodology that could be used by watershed managers to assess the compatibility and complementarity of IWRM and EBM measures and identify gaps and measures that should be tracked to ensure a better integration between EBM and IWRM tools.

Table 11. Gap analysis for integration of EBM in IWRM tools for CC adaptation

EBM principle	Rationale	IWRM measures already tackled	Gaps in the implementation of IWRM measures	Measures that should be taken to ensure complementarity	Unit responsible for complementarity	Monitoring process
Principle 1 (societal choice)	Public participation in the production, review and update of the river basin management plans.	Introduction of public participation procedures.	Provision of information to selected stakeholders without active and comprehensive participation of stakeholders.	Institutionalization of active participation of stakeholders in the decision-making process; better comprehensiveness of stakeholders.	Catchment manager office.	Report of the catchment manager to stakeholders.
Principle 2 (decentralization)						
Principle 3 (adjacent and other ecosystems)						
. . … …						

Thinking like a manager: Beginning the cycle of strategic adaptive management

The cycle of strategic and adaptive ecosystem management

Implementing an ecosystem approach in a place-based context necessitates a plan-do-check process that is strategic, analytic, deliberative and adaptive. Such an approach is necessary because limited resources curtail the extent of interventions, the inherent complexity demands a synthetic view that is both quantitative and rooted in the multiple perspectives, and because the inherent uncertainty and dynamics require continuous review, learning and adjustment.

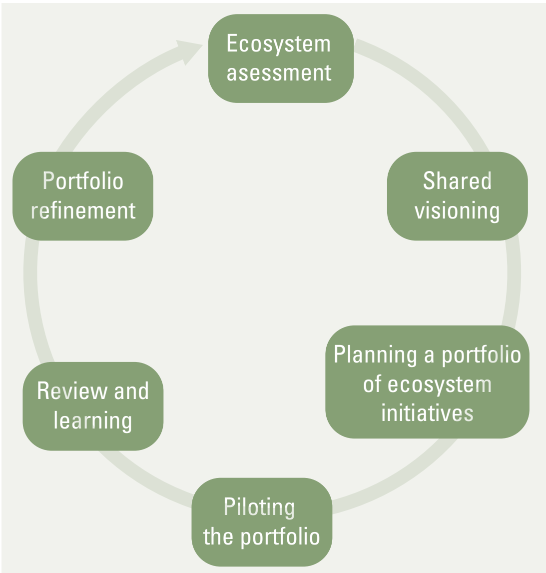
The interaction of human, natural and socio-economic systems is increasingly viewed as a complex adaptive system. Successful intervention in such a system therefore requires a process that embraces unpredictability, continuous learning and adjustment. Swanson and others (2009) provide a summary of principles for intervening in complex adaptive systems as compiled from literature across many sectors including natural resource management, healthcare, information technology and business management.

Another set of principles for intervening in complex adaptive systems point to the importance of understanding local conditions, strengths and assets and the interactions with the natural, built and social environment. This is the rationale for beginning any ecosystem management effort with assessment. The key to assessment is obtaining an understanding of current conditions and trends both by respecting history – as complex adaptive systems are shaped by their past (Glouberman and others, 2003; Holling, 1978), and through a prospective mind – to help make societies more resilient to external shocks and more flexible in response to rapid change.

These principles are reflected in several steps, as shown in figure 15: The strategic and adaptive cycle of ecosystem management, namely:

- Ecosystem assessment: using a conceptual framework of ecosystem goods and services to understand the system – past, present, and future, and to identify advantage points for intervention;
- Shared visioning: deliberating with stakeholders to identify a shared vision of the ultimate outcome of management interventions;
- Portfolio planning: deliberating with stakeholders and experts to identify and agree on implementation of a variety of ecosystem initiatives that have potential to achieve the ultimate outcome;
- Portfolio piloting: implementing a portfolio of ecosystem initiatives and monitoring key performance indicators are at the heart of adaptive management. This stage is referred to as piloting to emphasize that in a complex adaptive system; any ecosystem initiative must always be treated as a hypothesis in need of testing;
- Monitoring and assessment: the spirit of a pilot test is review and learning; this underlines that in complex adaptive systems, it will be the system that determines what works and what does not. The ecosystem manager must first and foremost be a learner;
- Portfolio refinement: as a result of refining the portfolio, the manager has a better understanding of what works and what does not toward achieving the ultimate outcomes.

Figure 15. The strategic and adaptive cycle of ecosystem management



Source: Reconstituted from UNEP-IISD-DHI, 2011. Ecosystem Approaches in Integrated Water Resources Management, p. 67.

Ecosystem assessment

The intent of this first stage of strategic and adaptive ecosystem management is to gain an understanding of the current state and trends of the ecosystem from both a socio-economic and ecologic perspective. A good guiding motto for the ecosystem manager at this stage is: respect the past, understand the present, and explore the future.

Ecosystem assessment requires more than a conceptual model; it also requires a simplified system map to help the ecosystem manager see the integrated story behind particular issues.

Box 8. The Iraqi marshlands of Mesopotamia *(al-ahwar)*

Located around the confluence of the Tigris and Euphrates rivers in Southern Iraq, the Iraqi marshlands were once home to several hundred thousand inhabitants, the Ma'dan, a people whose unique way of life had been preserved for over 5,000 years. Due to the impacts of climate change and human activities, 90 per cent of the marshland disappeared impacting human life and ecosystems. With a steady water flow, limited interference from human activities, dam construction, pollution and oil industry in addition to a robust management plan, these natural wetlands may continue to provide a sustainable environment to their inhabitants, supplying them with enough food, water, fibre and health materials for generations to come.

The UN Environment Regional Office for West Asia embarked on a project in 2014-2016 entitled, "World Heritage Inscription Process as a Tool to enhance the Cultural and Natural Resources Management of the Iraqi Marshlands", to support the Government of Iraq to nominate the Iraqi marshlands as a world heritage site at the UNESCO World Heritage Convention in Paris. The inscription process, which is based on the outstanding universal values (OUVs) of the Iraqi marshlands (biodiversity and cultural values), is used as a vehicle to enhance the natural and cultural resources and strengthen institutional and technical capacity of local communities to manage the marshlands, conserve their biodiversity, sustain their ecosystem services of food, water and fibre, build resilience to climate change and protect their prehistoric relics. A management planning exercise, integrating the cultural and natural components of the world heritage file was undertaken in close consultation with marshland stakeholders, relevant local authorities and ministries: environment, tourism and antiquities, water resources, agriculture and oil and gas taking into consideration threats from extreme drought, climate change, mining, water dams, and sand and dust storms. A consolidated management plan was finalized in June 2015 in collaboration with the International Union For Conservation of Nature - Regional Office for West Asia, the Arab Regional Center for World heritage (ARCWH), UNESCO, the Ministry of Environment and the Ministry of Tourism and Antiquities.

The project also aims to mobilize global and regional support through mainstreaming and promoting international cooperation and building synergy with MEAs (CBD, Ramsar Convention, World Heritage Convention (WHC), the United Nations Convention to Combat Diversification (UNCCD) and others). The consultative process among conflicting stakeholders was challenging but necessary to determine the management objectives and actions as well as roles within an institutional framework for implementation. The project included Iraq as a State arty to the 1972 WHC and nominated "The Ahwar of Southern Iraq and Relict Landscape of the Mesopotamian Cities", a mixed serial property, for inscription on the world heritage list in January 2014.

Source: Iraq, the Ministry of Environment (2014). The Ahwar of Southern Iraq: Refuge of Biodiversity and the Relict Landscape of the Mesopotamian Cities. Nomination dossier for inscription of the property on the world heritage list. http://whc.unesco.org/uploads/nominations/1481.pdf.
The Consolidated Management Plan of "The Ahwar of Southern Iraq: Refuge of Biodiversity and Relict Landscape of Mesopotamian Cities" (2015). Khaled Allam Harhash, Geraldine Chatelard, Sami el-Masri and Gaetano Palumbo. International Union for Nature Conservation, Amman – Jordan.
United Nations Environment Programme (UNEP) (2014-2016), "World heritage inscription process as a tool to enhance natural and cultural resources management of the Iraqi marshlands", project AEL 2B24-IRAQ Marshlands, PIMS # 547, Manama – Bahrain.

The Driving -Force-Pressure-State-Impact-Response (DPSIR) framework is one such simplified system map. The DPSIR framework addresses three core questions, including:

- What is happening to the environment and why?
- What are the consequences for the environment and humanity?
- What is being done and how effective is it?

Shared visioning

If the ecosystem assessment is comprehensive in nature, that is not initiated to address a specific issue, an array of pressing ecosystem issues is likely to be identified and in need of attention. How does one proceed given limited financial and human resources? Ecosystem managers need to prioritize which ones to address first and which will need to be addressed later.

Involving stakeholders in the ecosystem assessment process as early as possible makes the shared visioning process easier to initiate and undertake. The ecosystem assessment is the starting point for articulating a shared vision. The identified future states of the environment provide the framework for the shared vision, as these are the ultimate long-term outcomes.

In order to make progress towards ecosystem maintenance or restoration (table 12), ecosystem managers can use many different types of targets. For example, compare benchmark targets against performance in other jurisdictions. Thresholds on the other hand are scientifically based and reflect a critical value for an environmental state indicator; a value that once reached can elicit irreversible change in the behaviour of the system.

Portfolio planning

Ecosystem managers will have a shared space defined by an agreement on the desired future state of the ecosystem variables. This stage of portfolio planning focuses on describing potential pathways to the desired future and underscores the importance of exploring and implementing a variety of ecosystem initiatives that have the potential to achieve the desired future. Variation is a critical part of adaptive management and successful intervention in complex adaptive systems.

Exercise 4: Ecosystem issue and indicators (see the annex) allows groups to focus on one indicator for a selected ecosystem issue, describing its current state, expected future state and desired future state.

Table 12. Examples of types of targets

Type of target	Example
Benchmarks	Highest percentage of households connected to sewage system in a comparable jurisdiction.
Thresholds	Maximum sustainable yield of a fishery.
Principle	The policy should contribute to the increase of environmental literacy.
Standards	Water quality standards for a variety of uses.
Policy-specific targets	Official development assistance shall be 0.4 per cent of national GDP.

Valuing ecosystem services

What is valuation?

In order to make better decisions regarding the use and management of ecosystem services, their importance to human society must be assessed. The importance or "value" of ecosystems are viewed and expressed differently by different disciplines, cultural conceptions, and philosophical views.

Definitions of "value"

The Millennium Ecosystem Assessment (2003) defined value as "the contribution of an action or object to user-specified goals, objectives, or conditions". According to the Oxford English Dictionary, the term "value" is used in three main ways:

- Exchange value: the price of a good or service in the market (i.e. market price);
- Utility: the use value of a good or service, which can be very different from the market price (for example, the market price of water is very low, but its use value is very high; the reverse is true for diamonds or other luxury goods);
- Importance: the appreciation or emotional value we attach to a given good or service (such as the emotional or spiritual experience some people have when viewing wildlife or natural scenery or our ethical considerations regarding the existence value of wildlife).

These three definitions of value roughly coincide with the interpretation of the term value by the three main scientific disciplines involved in ecosystem valuation or its attributes:

- Economics is mainly concerned with measuring the exchange value or price to maintain a system;
- Ecology measures the role (importance) of attributes or functions of a system in maintaining ecosystem resilience and health;
- Sociology tries to find measures for moral assessments.

Why is ecosystem valuation important?

Because of the many services and multiple values of ecosystems, many different stakeholders are involved in ecosystem use (and misuse), often leading to conflicting interests and over-exploitation of some services (such as fisheries or waste disposal) at the expense of others (such as biodiversity conservation and flood control). In addition, there are many structural shortcomings in economic accounting and decision-making procedures leading to incomplete cost-benefit analysis of planned interventions in ecosystems.

When should valuation be undertaken?

It is particularly important to carry out valuation studies in three situations:

- Assessment of total economic value (TEV) (i.e. determining the total contribution of ecosystems to the local or national economy and human well-being). The TEV of ecosystems should be explained and communicated to all stakeholders, creating the boundary conditions for policymaking to stimulate conservation and sustainable use of this "natural capital" and prevent degradation or destruction (Hunter and Gibbs, 2007, p. 75);
- Trade-off analysis (i.e. evaluating costs and benefits of alternative development options for a given ecosystem to make informed decisions about possibilities and impossibilities for sustainable and multi-functional use of ecosystem services);

- Impact assessment (i.e. analysing the effects of proposed wetland drainage or other destructive practices on wetland services). In many cases, there will be good reasons for converting natural ecosystems into another type of land (or water) use. However, in many occasions, loss of ecosystems and services is caused by accidents (such as oil spills) and unintended side effects (externalities) of economic activities.

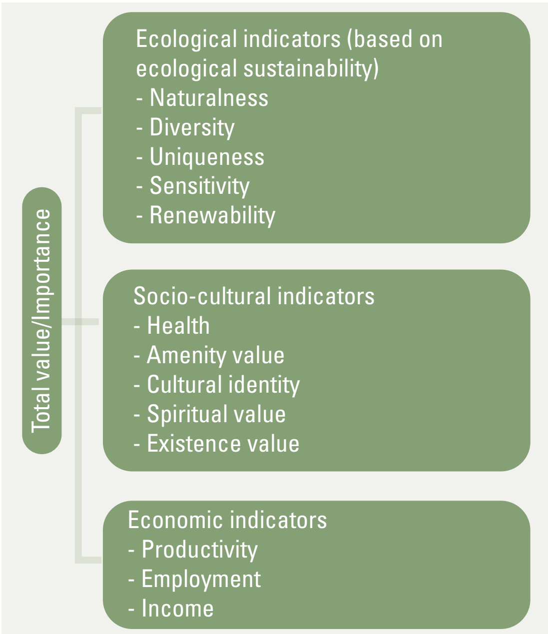
A framework for ecosystem valuation

Five main steps for valuation are explained below. Additional activities needed for a complete assessment include analysis of pressures, trade-offs and management implications.

- Step 1: Analysis of policy processes and management objectives (why should valuation be undertaken?);
- Step 2: Stakeholder analysis and involvement (who should do the valuation, and for whom?);
- Step 3: Function analysis (identification and quantification of services) (what should be valued?). An inventory of ecosystem ecological processes and components is translated into functions that provide specific ecosystem services;
- Step 4: Valuation of services (how to undertake the valuation?). The benefits of ecosystem services identified in step 3 should be expressed in appropriate measurement units (such as ecological, socio-cultural, economic indicators) and monetary units;
- Step 5: Communication of ecosystem values (to whom should the assessment results be provided?). Valuation of ecosystem services: the total value and types of value.

The total ecological value of an ecosystem is based on ecological, socio-cultural and economic values (figure 16). Each type has its own criteria and value units, briefly described below.

Figure 16. Components of the total value of an ecosystem



Source: Reconstituted from UNEP-IISD-DHI, 2011. Ecosystem Approaches in Integrated Water Resources Management, p. 105.

Socio-cultural value (importance) of ecosystem services

For many people, natural systems are a crucial source of non-material well-being through their influence on physical and mental health, and their historical, national, ethical, religious and spiritual values. Particular watersheds may have been the site of an important event in their past, the home or shrine of a deity, the place of a moment of moral transformation, or embodiment of national ideals (see table 5).

Trade-offs and goals for ecosystem management

People are part of ecosystems – typically the major driver of impacts. Transition from hunter-gatherer subsistence to agricultural, urban, and finally megalopolis has masked the connection between people and ecosystem processes. That transition involves increasing modification and transformation of terrestrial ecosystems and increasingly severe downstream impacts on coastal and marine ecosystems. The ranges and levels of ecosystem service benefits change as the context moves from intact ecosystems to increasingly modified ecosystems, but the level of service depends on use and management. It is typically a gradual process but major urban, agricultural, industrial, mining and associated water harvest and storage developments are imposing substantial and far-reaching changes. The following site provides an educational game for trade-offs between ecosystem services: http://www.naturalcapitalproject.org/pubs/ES_Games_Verutes_Rosenthal_2014.pdf.

The annex includes a two-part exercise on trade-offs, covering the relationship between upstream and downstream waters and holistic management (see exercise 5: Trade-offs in ecosystem management).

Box 9. Diagnostic analysis of Tunisian wetlands

Strong pressure on wetlands by human activities:

- Reduction and transformation of wetlands ecosystem
- Desertification
- Land use - agriculture
- Urbanization
- Tourism

Following the drastic cuts in water supplies due to strategic backups of surface water (dams, hilly lakes), these vulnerable lands became susceptible to all the processes of desertification at the centre (such as the Sebkha of El Kelbia in the plain of Kairouan) and south of Tunisia.

Legal and administrative issues

Wetlands are integrated as components in a number of ministries and respectively in their various branches and services. Due to decentralization, their management is under the authority of CRDA (Commissariats Régionaux au Développement Agricole) and regional services (Borough of Forestry, Agricultural Engineering, C.É.S., Water Resources etc.). The decision on the programmes of development work, management, conservation and corresponding budget estimates, therefore, fall under the mandate of the CRDA and the concerned boroughs. In the light of the pressures of tourism, urban development, agricultural uses and lack of funding, wetlands are not a priority. The 1975 law defined the operating rules of wetlands for water management, while the 1988 Forest Code empowers the Ministry of Agriculture conservation and protection against filling and draining. Yet, aspects of the socio-economic environment of wetlands and their sustainable development are not present in any legislation.

Climate-related impacts

a. Elevation of accelerated sea level

The predictions made by climate scientists based on IPCC scenarios indicate that by 2100 a potential temperature increase of 1.3 to 2.5°C will elevate the average sea level by 38 cm to 55 cm. Three scenarios were studied for a forecast on the impact of the sea rise.

b. The great flood / flood / wet years

The last 35 years have been marked by numerous floods, with the most serious being in 1969, 1973, 1982, 1984, 1990, 1995, 2000 and 2003.

The 1969 flood caused the loss of 12 per cent of GDP, 300,000 citizens were affected, including 500 killed and 70,000 homes were destroyed. Wadi Zeroud channelled about 2.5 billion m^3 of water in a few days, transforming the plain of Kairouan into a vast expanse of water and mud (275 million m3 of sediment). Today, its water (and sediment) are retained in the Sidi Saad dam.

In 1973, Wadi Medjerda stored 1 billion m3 in 6 days, equivalent to the average annual contribution. It carted around 100 million tonnes of sediment, 75 per cent were deposited in the lower valley of the Medjerda while 25 per cent were carried down to the sea. This flood was the most disastrous ever recorded on Medjerda with one hundred people killed. The Tunisian Red Crescent estimated 28,000 homeless persons in total and about 5000 ha flooded in the middle and lower valley.

In January and February 2003, heavy rains in the northwest of Tunisia caused four consecutive floods of Wadi Medjerda at Ghardimaou, Jendouba and Bou'Salem upstream of Sidi'Salem dam. The latter received 1200 million m3 of water and evacuated a total of 1100 million m3 downstream, also causing important flooding in the middle and lower valley of the Medjerda (28,000 homeless).

In September of the same year, torrential rains fell on Tunis district. Apart from the very serious damage to the city, both sebkhas west and northeast of the city were completely flooded. The water in the Sebkha of Sejoumi reached its highest level in decades. It does not have a natural flow, and to this day, the sebkha water is discharged by pumping in Wadi Meliane. The flooding of the Sebkha of Ariana, which houses the sewage treatment plant in Tunis, caused an invasive algae growth and led to putrefaction and stench over a large area of the capital. Whole neighbourhoods of houses remained under water for months.

A monitoring committee was created so that it periodically assesses the ecological situation of the Sebkha of Ariana. It has also prepared a preliminary study on its rehabilitation. In early 2005, the construction of a golf course started with the use of wastewater. However, the creation of a residential area on sensitive land at highest risk was not fully adapted to the situation. Mitigation of the effects of heavy rains was not included, therefore increasing the likelihood of new disasters in the future if heavy precipitation events recur.

c. Dry years

Concrete impacts on wetlands due to extremely dry years have not yet been identified. However, major droughts on wetland ecosystems do cause attenuation in terms of their operation. The periods between freshwater inflows are extended, crop production is reduced and the process of desertification is ongoing. Sebkhas in nearby cities risk becoming pools of sewage and landfills as reported for the Sebkha of Sejoumi west of Tunis, while a strong disturbance has been reported in Lake Ichkeul in 1988-1993 and 2002 (a lack of freshwater has increased the salinity of the lake more than 80 g l-1).

Recommendations – Proposals

Despite considerable efforts, the Medjerda valley is the most sensitive and vulnerable point of Tunisia and is the vital centre of the country. The two components of climate change, accelerated levels of sea rise and increased heavy rains, cause major flooding and threaten the flooded Medjerda valley. It should be noted that 84 per cent (about 10,000 ha) of wetlands losses in Tunisia are in the Medjerda valley. Its banks are transformed into farmland, while many dams on Medjerda itself and its tributaries control its waterways. Management is mainly for agricultural purposes with the objective of retaining large floods. These floods are regular and well monitored, however their impact on ecosystems is unknown. The planned dam on Wadi Tessa should bring new changes on the side of the valley basin. The Mediterranean climate, particularly for aggressive rivers and their adjacent environments (riparian forests and farmland), makes these ecosystems extremely vulnerable.

Source: Tunisia, Ministry of Environment (2005). Changements Climatiques: Effets sur l'Economie Tunisienne et Strategie d'Adaptation pour le Secteur Agricole et les Resources Naturelles.

Terrestrial ecosystems

Once humans arrive at an untouched landscape, their decisions become part of local ecosystem dynamics. The initial humans may move on, leaving all natural processes relatively intact, but at a later point, others may arrive and use the area and its resources in ways that range from undetectable impact to gross alienation and transformation of soils, water flows and pre-existing plant and animal communities.

At the lowest levels of impact, the demands for food, water, shelter and resources may be so slight that there is no detectable change in the natural diversity and ecosystem processes of the area. In this situation, human needs and demands are met within the resilience of self-maintenance capacity of the ecosystem.

Water pricing provides one opportunity to use resource allocation to cause changes in the ways in which water is used. There are several ways in which to construct a water-pricing scheme (Easter and Perry, 2011). Examples include a fixed charge per unit of time, a constant, per-cubic meter rate, a rate that decreases as use increases (supporting large volume users such as industry), a rate that increases as use increases (advantaging small users such as households), a staggered rate (a particular price per cubic meter for the first volume and a second price for the remaining volume), a constant price for the physical service and an additional cost per unit of water used, and peak-load or seasonally adjusted pricing.

Example of watershed ecosystem valuation

At a global level, there are indicators and average estimates of the value of annual ecosystem services, as shown in table 13.

Another example of valuation of wetlands is based on ecosystem benefit indicators. Indicators include:

- The number of farms that would benefit from an increase in summer water flows, as a result of conservation that improves retention of upstream precipitation;
- The number and/or value of buildings, farms and roads in floodplains protected by wetlands;
- The number of persons who will benefit from recreational use of increased open space and species populations.

Table 13. Average global value of annual ecosystem services

Ecosystem	Typical cost of restoration	Estimated annual benefits from restoration	Net present value of benefits over 40 years	Internal rate of return	Benefit/cost ratio
	US$/ha	US$/ha	US$/ha	%	Ratio
Marshlands	33,000	14,200	171,300	12%	5.4
Lakes and rivers	4,000	3,800	69,700	27%	15.5
Coastal	232,700	73,900	935,400	11%	4.4

Box 10. El-Heswa protected area wetland - Yemen

- Implementation of a UNDP sustainable natural resources management programme (2004); Project succeeded to establish the wetland as a protected area in Yemen;
- Detailed strategies and action plans were developed, including awareness and capacity building and an environmental campaign (UNDP);
- The Government developed a management plan for wetlands (2011);
- The analysis of the management plan and strategies (2011) was done in compliance with the Strategic Plan – Aichi 20 Targets (2011-2020).

Source: Paper presented by M. Safadi, AWARENET at Climate Change Adaptation in the Economic Development Sector using IWRM Tools, Amman – Jordan, 2016.

Other economically relevant and measurable indicators include:

- The scarcity, at the scale of the neighbourhood, watershed, region, wetlands, open space, habitat or other ecological features (in general, the scarcer the feature, the more valuable);
- The presence of ecological or social features that complement the resource, such as streams or lakes that add to the experience of forest recreation or trails and docks that provide access to natural resources for visitors.

All of these indicators and others are relatively easy to measure using existing social and environmental datasets, particularly geo-referenced data (such as census and land-cover data).

An example from Bahrain is related to the valuation of ecosystems services provided by a world marine heritage site. Based on global estimates and values of similar habitat types and the extent/area of the habitat in the pearling site, the total combined potential value for the pearling site is between $3.4 billion and $227.1 billion. The different zones of the site are valued differently depending on the habitat type, amount, and services provided.

- Ecosystem services:
  - Tourism, recreation and research between $7.5 million and $287 million;
  - Fisheries between $147.1 million and $5,607.5 million;
  - Coastal protection $3,104.4 million;
  - Biodiversity $109 million;
  - Water quality between $48.6 million and $235.7 million.
- Zones:
  - Hayr Shattayyah is valued between $2,398.9 million and $220,329.9 million;
  - Hayr Bu Am' amah is valued between $456.8 million and $482.7 million;
  - Hayr Bul Thamah is valued between $532.3 million and $562.5 million;
  - Reef Bul Thamah is valued between $28.6 million and $5,768.5 million.

CH. 5

Adaptation Measures Implementation Matrix

Adaptation Measures Implementation Matrix

Stakeholder analysis

Stakeholders are the people and institutions who have an interest, have something to gain or lose from the ways a catchment is managed. A stakeholder analysis is a technique used to identify the key people who have to be won over, to be convinced that efforts will benefit their definition of successful catchment management. Communicating early and often with stakeholders helps ensure that stakeholders understand the nature of mitigation and adaptation and their benefits. This, in turn, increases their active support, when necessary.

Four steps are needed for this exercise. The first step in stakeholder analysis is to identify stakeholders. One can use brainstorming and consider all people that are affected by one's work, who has influence or power over it, or has an interest in its successful or unsuccessful conclusion. Although stakeholders may be both organizations and people, ultimately one can only communicate with individual people. It is important to identify the correct individual stakeholders within a stakeholder organization. It is possible to use an onion diagram (figure 17), asking each stakeholder to tick the position where he/she thinks he/she stands. An important activity is to disaggregate these stakeholders by gender, age and position to enable as inclusive a representation as possible. In this regard, consideration of influence held by each individual should be included.

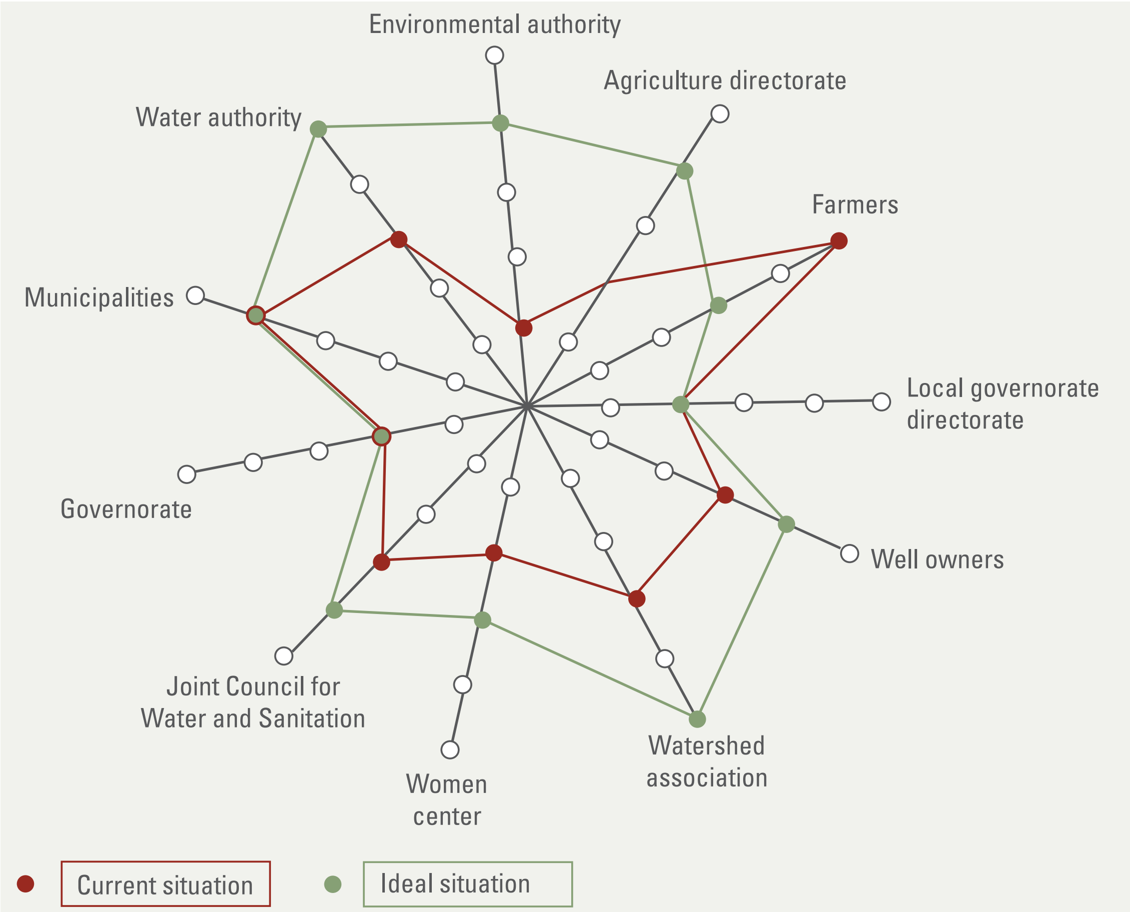
The next step is to develop a good understanding of the most important stakeholders in order to consider ways to win their support. This analysis can be recorded on a stakeholder map. It is important to understand key stakeholders, including assessing how they are likely to feel about and react to each project, how best to engage them in each project, and how best to communicate with them. The power/interest grid is a useful tool for such an analysis, in which the location of each principal stakeholder is identified on a grid.

The third step in the analysis is to work out power, influence and interest, in order to clarify upon whom the most attention should be paid, as a means of prioritising the stakeholders. After the stakeholder map has been created, the fourth step is planning how to communicate with each stakeholder with the aid of the stakeholder planning tool.

Figure 17. The onion diagram for stakeholder analysis

Source: Reconstituted from UNEP-IISD-DHI, 2011. Ecosystem Approaches in Integrated Water Resources Management, p. 78.

Figure 18. Stakeholder analysis in the Marj Sanour watershed



Source: IUCN, 2013. Vulnerability Assessment of Marj Sanour Watershed.

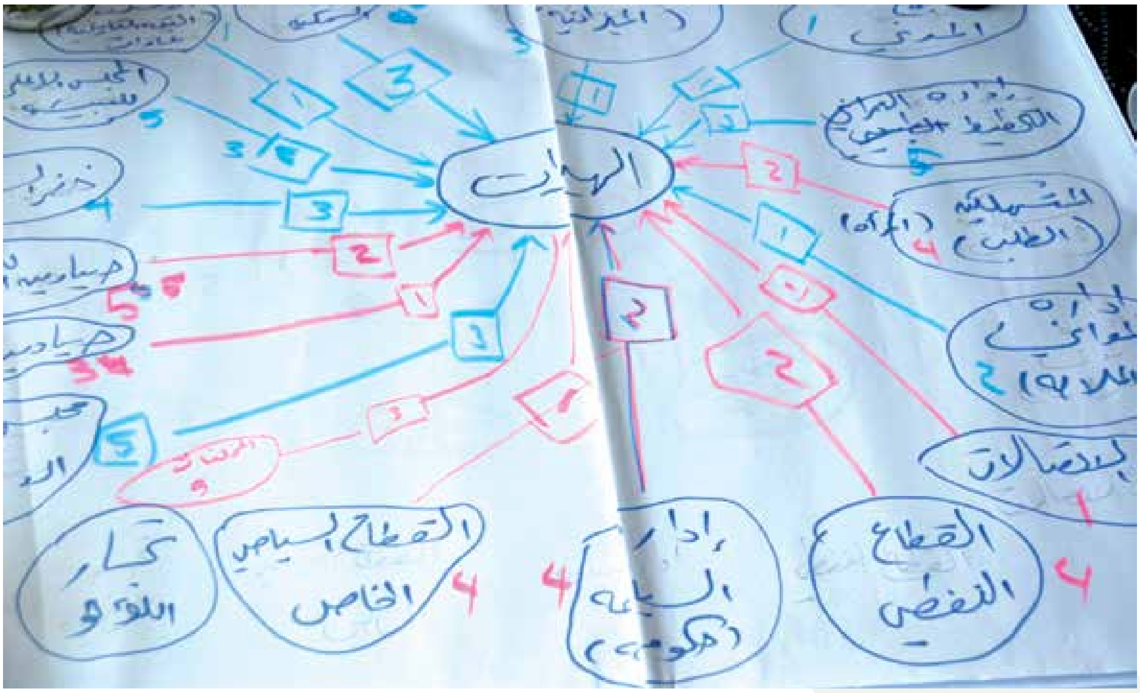
Example of fuzzy cognitive methodology for stakeholders mapping

A set of quantitative or qualitative variables are given values representing their current state. Then a causal relationship between the variables is identified as well as the direction of the causality and the type of relationship (positive or negative). The strength of the relationship is indicated by a weight. A positive weight indicates an excitatory relationship and a negative weight indicates and inhibitory relationship. This mapping system is used to map the importance, as well as the impact of stakeholders on an environmental component, such as water catchment. This tool is also used at a later stage to provide roles to stakeholders in the EBM plan.

In the fuzzy cognitive mapping system, the name of the relevant stakeholders is indicated in the circles with a value from 1 to 5. These values designate the importance of the stakeholder to the pearling zones. Red arrows (negative importance) and blue arrows (positive importance) are drawn between the satellite circles and the central one. A positive value (from 1 to 3) indicates positive impacts on the pearling zones, while negative values (from 1 to 3) indicate negative impacts on the pearling zones.

The annex presents an exercise on stakeholder analysis, looking at the position of each stakeholder relative to proposed adaptation measures, and what strategies to be used when dealing with the stakeholders (see exercise 6: Catchment stakeholder analysis).

Figure 19. Example of fuzzy cognitive stakeholders mapping



Source: Fouad Abousamra.

Monitoring and evaluation

Monitoring is a planned, systematic process of observation that closely follows a course of activities, and compares what is happening with what is expected to happen. Monitoring the implementation of an EM plan makes sure the delivery of ecosystem services meets societal goals, while working within the scope of allocated resources (i.e. time, financial, human, informational, technical). Evaluation is a process that assesses achievement against pre-set criteria.

Foundation of effective monitoring and evaluation

Monitoring and evaluation are approached through three steps. The first is to review different purposes of evaluation and then decide on one or more purposes for evaluation of the EM plan. The second is to identify the primary users of the evaluation, i.e. the persons whose perception will control whether or not the evaluation gets used in guiding the evolution of the EM plan. The third and last is to decide whether external or internal evaluators serve best the purpose for a given EM plan.

There are three fundamental types of evaluation; they can render judgment, encourage improvement, or generate new knowledge (Patton, 1997). Summative evaluation, accreditation, quality control and audits are examples of judgment-intended evaluations. They follow a deductive method by setting clear criteria and standards against which to judge performance, and often they are quantitative in nature. Formative evaluation (Fettermann, 1996) is improvement oriented. The intent of this type of evaluation is making things better during the implementation of a course of behaviour.

The annex provides a group exercise (see exercise 7: Monitoring and evaluation) dealing with monitoring and evaluation, composed of three parts covering general aspects, constraints, stakeholders and piloting initiatives.

CH. 6

Areas for Action: Selecting Tools for a Local Application

CH. 6

Areas for Action: Selecting Tools for a Local Application

The intention of this training manual is to assist local water and land managers to apply EM and to strengthen IWRM as an EBA to climate change in their water catchment. It is a bottom-up approach securing successful and improved watershed management. While governments play a significant role in managing resources, enacting some tools and influencing a catchment manager, such tools cannot readily be selected by the manager.

To implement any of the tools in the toolkit of a resource manager, some resource accounting is needed. Especially where only advocacy and extension resources are available, the manager must understand the balance between the demand for ecosystem goods and services and supply from the untransformed and transformed land. The resource manager also has to keep in mind that men and women play different roles in catchment management and have different needs and constraints, which should be addressed.

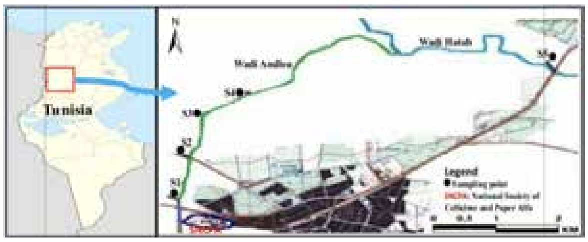
When the catchment manager considers tools to improve management in the area under his/her jurisdiction, these issues of governance need to be considered. The major tools that could be considered by catchment manager include:

Advocacy and extension

Such programmes are long-term interventions and, in general, could take a decade or longer to obtain visible/tangible output. They could start at school and be carried through to adult education and advocacy programmes. In comparison to other tools, they could have a wide impact with limited resources.

Very little institutional arrangements and governance are needed for successful implementation. Non-governmental organizations, such as agricultural unions, cooperatives or other land user associations will enhance and broaden the impact of the programme. Catchment management/agricultural study groups dramatically improve the impact of such programmes. The private sector, through their corporate social responsibility programme, may boost the success of the programmes. Advocacy and extension could tackle issues, such as water wise food production, rainwater harvesting, crop selection, sustainable consumptive utilization of resources, fire management and water for transportation. Possible outcomes are a general improvement in resource use and measurable changes in land management, but achievable only in the long term. The site http://mediaimpactfunders.org/game-on-new-tools-for-learning-and-advocacy/ provides educative games for learning and advocacy.

Box 11. Oued Andalous-Kasserine for ecosystem management (Tunisia) (Future plan ecosystem project)



Kasserine is a city with over 80,000 inhabitants located in a mountainous area in west-central

Tunisia. It is crossed by several wadis, among which Wadi Eddarb, Wadi Andlou and Wadi El Hatab are the most populated. In the vicinity of the city, sheep and cattle graze and irrigated agriculture is practiced (see figure below).

Water has economical value and has to be managed as an economic good. In Kasserine, the rate of access to potable water for the majority of agglomerations throughout the governorate is less than the national average, a fact which exacerbates the plight of vulnerable and poor segments of the population with limited access to potable water at best, and nothing more than contaminated drinking water at worst. The city also witnessed a considerable industrial development marked by the establishment of a large paper pulp mill using esparto grass (S. tenacissima). The mill is run by the National Society of Cellulose and Paper Alfa (SNCPA) and discharges its wastewater continuously, without prior treatment, in the nearby Wadi Andlou.

This project aimed to apply the two combined principles of IWRM and EM, in order to increase the benefits from water resources and limit pollution through the creation of a new ecosystem by installing a macrophytes-based treatment plant that would be able to receive, treat and recycle the water for industry and farmers.

1. Stakeholders
- Community (industrial, farmers)
- Local government (municipality)
- Central government (Ministry of Agriculture, ANPE agency)

2. Priorities for management
- Environment
- Health
- Agriculture
- Food
- Culture

3. Technical characteristics
- The choice of site will take into account landslides;
- The choice of the macrophyte will consider its high growth power and ability to absorb pollutants;
- Water flow must be gravity-based in order to avoid energy consumption.

4. Ecosystem services
- Creation of new jobs;
- Microphites plants will reduce the erosion, retention of pollutants from the soil and water via the roots, production of organic macrophyte matter that may be exploited in compost, reduction of CO_2 and production of O_2;
- New ecosystem will include birds that may attract tourists;
- Source of water for industry or for farming;
- Fish aquaculture will reduce nitrogen and phosphates and limit eutrophication, and will serve as a source of food.

5. Ecosystems monitoring
- Physico-chemical parameters of the water, soil or air;
- Diversity of microbial community;
- Diversity of macrophyte and interaction with chlorine and heavy metals;
- Cycle of composting under aerobic or anaerobic conditions.

6. Adaptive strategy for management of the ecosystem cycle
- Ecosystem assessment: structures, functions, services and risks;
- Portfolio initiatives: review and learning;
- Planning for the portfolio: ultimate outcome, intermediate outcomes, output and activities;
- Consider DPSIR (driver pressure state): classifying the stakeholder types into 'passive' (to be informed) or 'active' (to be consulted at each step).

7. Incentives and tools for local scale management
- Societal instruments (policies, laws, traditions etc.);
- Building the toolbox advocacy extension, government initiatives, legislation and market for the ecosystem.

8. Contribution to economic and social development in Tunisia
- The welfare of citizens;
- Decrease of rural exodus;
- Attraction of tourists (internal and external tourism) and investors.

9. Availability of equipment operators

The pilot plants will be operated by local rural engineering technicians, ONAS technicians and laboratory technicians for measurements.

Source: Case study presented by N. Saidi at the Workshop on Climate Change Adaptation in the Environment Sector Using Integrated Water Resources Management (IWRM) and Ecosystem-based Management Tools, 22-24 March 2016, Beirut – Lebanon.

Incentives

Both resource and tax incentives have short-term impacts; the impact will stay intact as long as the incentive is in place. Outputs are generally measurable and auditable, and normally lead to mainstreaming the programme/intervention into the economy. To be successful, the regional or national government must have access to adequate resources to support the programme; this condition generally is met only in developed countries. Sustainable catchment management sometimes conflicts with economic development goals of a region or country. A strong sub-national, regional or national government and collaboration among land users and natural resource managers are needed for successful implementation. The outcomes are that catchment management can be mainstreamed into the economy, making the implementation more sustainable and with appropriate governance structures in place, the system can be monitored and the probability of success increased.

Legislation and regulation

If well implemented and resourced, this is the most effective way of ensuring sustainable catchment management. Once on the statute books, it is difficult to change as it has a long-term effect. There could be legislation that negatively affects sustainable catchment management, thus undermining the work of natural resource managers. It takes long and extensive consultation to get legislation and regulations on the statute books and it is thus difficult for local catchment managers to impact legislation and regulations. Improper law enforcement will hamper the success of existing legislation and regulation. The institutional and governance needed for successful implementation are a strong sub-national, regional or national government, adequate catchment management capacity to implement and police natural resource management activities.

Box 12. Decentralization of the water sector in Yemen

Since decentralization of the water sector in Yemen, performance of the urban water sector has considerably improved. In particular, smaller towns that have had external support and coastal towns where there is no pressing water constraint have achieved excellent service standards. By contrast, some large towns in the highlands are encountering problems in providing even limited services, especially where the population has been growing fast, systems are old and costly, and water resources are in increasingly short supply.

Source: World Bank, 2009.

While legislation in an effective and necessary component of IWRM, it may not be sufficient or satisfactory from a social point of view. It is essential to create or mobilize the community that not only supports and fights for legislation but also assists in its drafting. Women and other disadvantaged communities have a vital role to play in legislation.

Markets for ecosystem services

Resource-poor regions can access international funding for catchment management. As long as both suppliers and buyers of services adhere to the agreement and security of the resource is nearly guaranteed, it can be implemented through debt-swap mechanisms. Major challenges include that any payment for watershed services must be greater than potential income from other sources, the transaction costs to access markets for ecosystem services are very high and largely unaffordable to resource-poor countries unless they receive international support.

A payments-for-ecosystem-services project has to fit into a regional or national legislative framework; otherwise, it has little chance of success. Because of high transactions costs, payments for ecosystem services programmes are dependent on a collective approach to natural resource management. Buyers of ecosystem services are generally not willing to commit to long-term agreements. The market is therefore aimed at short to medium term

Box 13. Payment for environmental services (Jordan)

Several economic valuation studies have been undertaken for the Jordan rangeland ecosystems. They indicate that there is good potential for developing the rangeland resources in an economically viable way while ensuring that environmental objectives are met and the resource basis is not degraded.

An economic valuation study conducted by IUCN and ELD in Jordan estimated that well managed rangelands will avoid an economic cost to the country of at least 10 to 12 million JD/year.

Direct investments in local activities in the rangelands, such as in "Hima" grazing management, medicinal and aromatic plant production and ecological livestock production need to be, and probably are, economically feasible even for local community organizations (such as herder and women cooperatives). The economic rationale to invest in biodiversity conservation and to develop such financial flows through payment for ecosystem services is the fact that rangelands biodiversity conservation can provide important benefits to society.

Source: Case study presented by B. Bachir at the Workshop on Climate Change Adaptation in the Environment Sector Using Integrated Water Resources Management (IWRM) and Ecosystem-based Management Tools, 22-24 March 2016, Beirut – Lebanon.

agreements. The payments for watershed services are normally aimed at the local water sector. Unless the sector has access to adequate resources, it will not work, which means that it will largely be applicable to more developed regions. Corporate social investment is generally aimed at short-term interventions. The most appropriate party, such as local community, does not always receive the financial incentives.

Stewardship

Stewardship programmes are generally auditable as they are not generally as resource-intensive as payments for ecosystem services. Formal stewardship agreements could enhance access to corporate and international funding of natural resource management. Stewardship has very little potential in resource poor regions, unless it goes hand-in-hand with payments for ecosystem services. It will, therefore, only work in developed regions. If the stewardship programme is linked to a regional or national government, local communities tend not to trust its motives. A strong secretariat is needed to manage the system and an extensive advocacy and extension programme has to be linked to any stewardship programme. Stewardship would ensure that ecosystem services could be secured through biodiversity and forestry stewardship agreements.

Community-based natural resource management (CBNRM)

They are generally pro-poor and there are successful CBNRM programmes, especially in Africa that can be used as examples. Financial implications could become so important that

Box 14. Community-based environmental action planning (CEAP), North Darfur, the Sudan

Summary
- CEAP subcommittees have been established and now oversee activities, such as dam construction, irrigation, rangeland improvement and provision of access to water;
- The project has stimulated a remarkable improvement in peoples' relationships to such committees, which has resulted in coordinated efforts to manage dam construction and maintenance, and farming and grazing;
- Economic ties have improved relationships between communities, for example, through farm labour, crop sharing, land rental and even providing (to friends and relatives at no charge) farmland for cultivation;
- CBNRM networking is needed;
- Objective: To improve the ability of nomadic pastoralists and resident communities to manage their environment and natural resources in a more sustainable manner, and to cope effectively with environmental challenges, such as climate variability and intensified land use.

Specific objectives are as follows:
- Engage nomadic pastoralist communities and resident communities utilizing the same landscapes in natural resource management;
- Build the capacity of local nomadic pastoralist networks to enable them to lead CEAP processes and promote more sustainable environmental activities;
- Adjust CEAP approaches to the specific needs of nomadic pastoralist communities.

This project is undertaken in collaboration with the North Darfur State Ministry of Agriculture, Rangelands and Forestry, and two community-based organisations (CBOs), the North Darfur Nomadic Organisation Network and the Voluntary Rural Development Network. Additional technical support is provided by the Water and Environmental Sanitation (WES) project and the Ministry of Physical Planning and Public Utilities.

Source: UNEP, 2014. Putting it into practice. Selected case studies on CBNRM projects in Sudan.

they undermine sustainable watershed management and availability of supported national and sub-national regulation/legislation. Institutional arrangements and governance needed for successful implementation include strong government support without interference in the internal affairs of community-based organizations, buy-in of tribal authorities into the system in communal areas, strong community-based organizations and strong technical support teams. CBNRM could ensure better community control of natural resource management with the objective of restoring and protecting natural resources.

Eco-labelling and marketing

Because international markets are increasingly aware of the need for sustainable catchment management, the market is growing fast. Challenges only apply to sophisticated markets and are, therefore, largely limited to developed countries. A strong secretariat is needed to manage the system, the production standards are generally high for eco-labelling, and compatibility between international standards and national regulation/legislation is challenging. Institutional arrangements and governance needed for successful implementation include good marketing infrastructure, a strong secretariat to manage the system, and an extensive advocacy and extension programme linked to any eco-labelling programme. Long-term markets for sustainable products are considered as the major outcome of this tool.

Micro-credit schemes

They have very localized impact and are very much pro-poor with links to nature-based enterprise finance mechanism. Some of the challenges of such schemes are that they are not always linked to natural resource conservation, have limited access to formal markets, their objectives can sometimes be in conflict with sustainable natural resource management, and are often available to women only. Institutional arrangements and governance needed for successful implementation include strong, community-based organizational structures and strong finance/natural resources conservation linking mechanism. Collective resource management is the major outcome.

Box 15. Ecosystems in the Jordan River Basin

The most critical ecosystem services in the Jordan River Basin (JRB) are related to water supply. Problems of water scarcity and competition for the resource mean that the needs of ecosystems and their services are often overlooked. Water availability depends on the integrity of the entire hydrological cycle and the water regime. IWRM, however, has not been an active part of the many political arrangements to ease conflict over water among the countries that share the JRB.

In a politically insecure climate, there is a need for an overarching water management plan, equitable water sharing, and ongoing competition for available water among the riparian nations and between economic sectors to avoid potential conflict over shared water resources. Maintaining the functioning of ecosystem services dependent on water has been ignored by the formal efforts to share water in the JRB. The introduction of an ecosystem approach that would foster innovations and identify existing local rights-based approaches to reduce water use in agriculture and through land-use modification could help to enhance ecosystem services for local livelihoods throughout the Jordan Basin. Given the rising demand for water and the potential impacts of climate change, it is increasingly important to create economic incentives to protect and restore water availability and quality in the JRB, in addition to planning how to share the resource among the riparian countries. The value of ecosystem services needs to be incorporated into water planning and decision-making.

Source: UNEP-IISD-DHI, 2011.

Natural resource accounting

It allows the catchment manager to assess the impact of his/her intervention, and ensures that expectations are not unrealistic. There are high levels of expertise needed. Institutional arrangements and governance needed for successful implementation are strong scientific support for measuring, monitoring and reporting. The major outcome of this tool is a realistic picture of the natural resource potential of an area.

In addition to the above tools to protect and manage these services, the watershed manager needs the requisite knowledge, skill and the tools to convince stakeholders.

The repeated value of water

Water is one of few resources that is repeatedly used and re-used as it passes through a landscape. Water falls as precipitation, interacts with the landscape, and provides benefits to human and nonhuman communities. Those benefits include things such as plant growth, drinking water, fish and wildlife habitat.

System function

Application of management principles appropriate in one natural system may not work in another system that functions in a different way. For example, fire in tropical forest systems cause widespread devastation.

Land tenure

When applying a tool or approach, the resource manager must know the land tenure. Different value systems apply to different types of land tenure.

Water tenure

- As water is a private good in many countries, access to natural flows is linked to ownership of the land;
- Water as a public good. Some of the more progressive water legislation in the world has recognized water as a public good and stipulates that land managers can only register use of a certain amount of water.

Whatever water management approach is being advocated, it is crucial that it fits into the regulatory framework of the region or country. It is useless to try to apply a model taken from a scenario where water is seen as a private good to a country where water is regulated and managed as a public good.

Cultural beliefs and practices

Managers are considering any tools or natural resource management approaches. In all cases, the process has to take into account cultural beliefs and practices of local communities.

Bundling tools and markets

No single tool listed in this document will solve all natural resource management problems in a country or a region. It is, therefore, important for natural resource managers to integrate approaches, using multiple tools to enhance an ecosystem approach to natural resource management. No natural resource system can optimally serve human society function without regulation.

Table 14. Components of Iraq's well-being derived from the marshlands

Security
• A safer environment; • Greater resilience to the effects of disasters, such as drought, flood, pests and dust storms; • Secure rights and access to ecosystem services.
Basic material for good life
• Access to resources for a viable livelihood (including food and building materials) or the income to purchase them.
Health
• Sustenance and nutrition; • Avoidance of disease; • Cleaner and safer drinking water; • Cleaner air; • Energy for comfortable temperature control.
Good social relations
• Realization of aesthetic and recreational values; • Ability to express cultural and spiritual values; • Opportunity to observe and learn from nature; • Development of social capital; • Avoidance of tension and conflict over declining resource base.
Freedom and choice
• The ability to influence decisions regarding ecosystem services and well-being; • Opportunity to be able to achieve what an individual values doing and being.

Source: Millennium Ecosystem Assessment, 2004. Global Assessment Report. Linking Ecosystem Services and Human Well-being (chapter 3).

Impact of perverse incentives/subsidies

Catchment managers must remain aware of the possible impact of perverse incentives or subsidies that could still remain on statute books of rules and regulations.

Environmental flows

Natural resource managers should never forget the importance of environmental flows. Especially in the case of water, over-subscription of the resource leads to a collapse of the natural system. The same applies to grazing and other forms of consumptive use, such as harvest of roofing and craft materials from wetlands or medicinal plants and timber resources from woodlands.

An exercise, guiding users through catchment incentives, tools and objectives is presented in the annex (see exercise 8: Catchment incentives, tools and objectives).
In exercise 9: The Maward dam (see the annex), groups are taken through a hypothetical case study and exposed to two problems. Groups bring their own catchment information to discuss characteristics, issues and control measures in the framework of management objectives.

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Annex >>>

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Annex

Exercises

Exercise 1. Ecosystem services

Part A

Groups should organize themselves based on conceptual models. List ecosystem services for the three types of stakeholders shown in the table below. Services should be grouped following the Millennium Assessment categories. Rate each service as 1 (essential), 2 (beneficial), 3 (not critical). Groups should look for differences in priority among stakeholders, and consider ways that they would use to resolve those differences. The following table may be used to record their results.

Stake-holder group	Provis-ioning services	Rating	Regul-ating services	Rating	Cultural services	Rating	Suppo-rting services	Rating
Protected area managers								
Large-scale agriculture								
Down-stream urban community								

Part B

Referring to the table completed in the previous part of the exercise, each group should answer the following questions:

- What services are missing from this list?
- Which stakeholders should be added to incorporate missing ecosystem services?
- Decide which three stakeholders should be ranked as top priority and build a new table of ecosystem services.

Part C

In the last part, groups should answer the following questions:

- Which ecosystem services were expressed as priorities by stakeholders?
- How might management actions take these needs into account?
- What surprises did you encounter while exploring?
- Are there exemplary management practices that inspire new ideas for your home catchment?

Exercise 2. Catchment ecosystem state and indicators

Part A

Each group should identify a theme and develop a list of the most relevant issues to define the ecosystem state for a catchment that the group is familiar with. The following table may be used to record their results.

Theme	Issue	Ecosystem state examples
1		
2		

Part B

In the next part, each group should choose any of the ecosystem services listed in the table below; build a set of indicators for the workshop catchment that meet criteria for good indicators; and consider how it will assess these indicators, and what time scale will be appropriate for measurement and adaptive responses.

Ecosystem service	Indicator	Measure	Time frame
Drinking water			
Flood avoidance			
Adequate water for irrigation			
Avoidance of downstream nutrient impacts			
Avoidance of downstream sedimentation			
High aquatic biodiversity			

Part C

This part relates to adding drivers and pressures to the analysis. Each group should return to the one ecosystem service, for which it developed indicators and measures, and then identify key drivers and pressures that affect that service. The following questions are examples that each group should also discuss and document:

- How much influence can one exert on the drivers that the group identified for this catchment?
- How useful is this DPSIR analysis if one cannot change drivers (much)?
- How much can one change the state by focusing on pressures?
- What ways might catchment managers influence pressures?
- On a percentage basis, how much does each group feel they could improve the state by focusing on pressures?

Exercise 3. Ecosystem services in management

Part A

Each group should select a catchment and identify its 'home' catchment; alternatively each member of the group can identify a catchment of their own country that is different from the catchment selected for the group as a whole. The groups should then focus on present and desired states for their 'group' and 'home' catchments.

Step 1: What are societal priorities for ecosystem services?
Step 2: What ecosystem functions are needed to deliver those services?
Step 3: What ecosystem structure is needed to support those functions?
Step 4: Map the landscape to identify ecosystem structures.

After presenting their findings, each group should then address the following questions:

- What similarities were found between the 'group' and 'home' catchments?
- What difficulties did each group find translating the information from the 'group' and 'home' catchments?
- What can facilitators and other groups offer to overcome difficulties?

Part B

In this next part, each group is to focus on indicators and data development, by using ecosystem services identified as highly valued by stakeholders in their group catchment. Next, the group should choose a service and identify one or more indicators and an appropriate indicator range to sustain the selected service, and then answer the following questions:

- What is the appropriate temporal and spatial scale?
- What datasets are needed?
- Who has those datasets? How will that data be obtained?
- What analytical approach will be used to analyse the data?
- How will the analysis be communicated to other stakeholders (form and content)? Who are the other stakeholders? How will the information be conveyed (media, channels)?

Part C

Each group should focus on steps 1-5 from the seven-step process of setting management objectives (see chapter 4).

- First, using the conceptual model of the 'group' catchment, the group should add to its model the state and goals of ecosystem services and function;
- The group should then choose a component from its conceptual model and build an analysis and descriptions for steps 1-3;
- Last, the group is to identify the data needed to build landscape maps for step 4 of the seven-step process. The group should describe three management actions it would want to assess in step 5.

Exercise 4. Ecosystem issue and indicators

Each group should begin by identifying a key ecosystem issue, and then address the following questions that can be tabulated in the table below:

- Focus on an indicator that best represents that issue;
- Assess the current state and trend of the ecosystem indicator. What direction is the state likely to go in the future and why?
- Describe desired future state of the indicator. What timeframe is needed to reach the desired state?

	Response
General description of the identified ecosystem issue	
Environmental state variable (indicator) of focus	
Current state of the indicator	
Expected future state of the indicator	
Desired future state (target level and year)	
Key ecosystem services and human well-being aspects supported	

Exercise 5. Trade-offs in ecosystem management

Part A

Coastal and shallow seas play major roles in providing ecosystem services and are impacted by upstream management, whereas downstream waters are always impacted in some ways by upstream actions. Groups should divide into two sets, with one set listing ecosystem services empowered in downstream for both a) freshwater or b) marine systems, and the other set listing ecosystem services constrained in downstream for both a) freshwater or b) marine systems. When complete, the groups should compile and discuss with each other. Some of the questions to be discussed may include:
How much does that downstream influence affect upstream decisions?
Is that generic among freshwater systems?
Does it differ between freshwater and marine systems?

Part B

Each group is assigned two ecosystem services. Consider a holistic management context for your two services in your catchment. Tabulate goals, constraints and trade-offs.

Service	Conflicts	Constraints	Opportunities	Goal justification

Exercise 6. Catchment stakeholder analysis

In the first step, each group should choose two stakeholders for pollution control and summarize the understanding of its position with regard to management initiatives.

Current (C) and desired (D) position about intervention for each stakeholder class.

Stakeholder name and title	Block	Let	Help	Make	Diagnosis of stakeholder position	Recommended action to move person/group to desired position

Next, based on the stakeholders identified in the previous step in order to plan communication, groups are to conduct an analysis of each stakeholder as per the following table.

Stakeholder names and roles	Importance (low, medium, high)	Current level of support (low, medium, high)	What is needed from this stakeholder?	What is important to this stakeholder?	What is the strategy for enhancing support from this stakeholder?

Exercise 7. Monitoring and evaluation

Part A

In small groups, discuss and document the experiences of each group in monitoring and evaluation. Examples of leading questions:

- What would be the benefits of planning formative and summative evaluations in advance of implementing an EM plan?
- What would be disadvantages?
- How would you estimate costs of designing an evaluation strategy for your EM plan?

Part B

In small groups, discuss and document the experiences of each group in terms of constraints, users and evaluators:

Constraints: All organizations face constraints. Compile a list of areas of the EM process where catchment management could face constraints that limit effectiveness of monitoring and evaluation.
Identify users: List names of departments who are potential primary users of the results of monitoring and evaluation. Record the interest that primary users have in monitoring and evaluation, and what influence they will have in revising the IEA.

Identify evaluators: Decide on and justify evaluators you would use: external, internal or a combination.

Part C

In small groups, discuss and document the experiences of each group in piloting initiatives. Examples of leading questions:

- Were hypotheses clearly defined?
- Were key indicators developed, tracked and monitored?
- Was a review process incorporated?
- What were triggers for review?
- Were improvements made as a result of lessons learned?
- If these components were not part of the process, what barriers prevented thorough implementation?

Exercise 8. Catchment incentives, tools and objectives

Part A

Based on the catchment previously selected by the group, each group should build a list of incentives and tools that it feels would be appropriate to apply as part of its toolbox. Following are some useful questions to address:

- The group should describe the tools deemed appropriate and why?
- What organizational partners might provide support?
- Are initiatives already in place that can be leveraged or expanded through the toolbox?
- Who are the key stakeholders that ought to be involved in this process?

Part B

Thinking about its catchment, the group should consider the following:

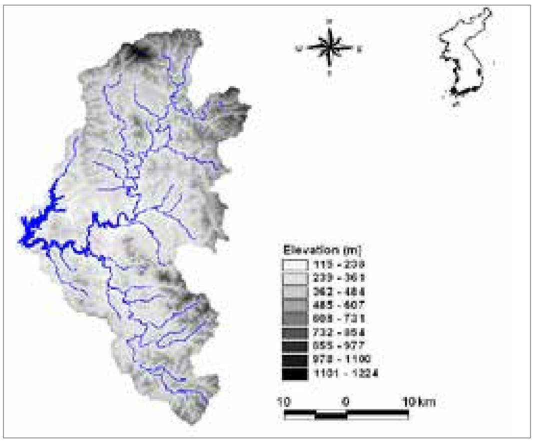
- Define what it sees as management objectives;
- List practices that might achieve those objectives;
- Identify the four highest priority practices;
- Choose tools supporting adoption of desired practices.

Exercise 9. The Maward dam

Background

The Maward dam (hypothetical case) is the largest multipurpose dam among 20 such dams constructed in the Atlantis region, and is located upstream of the Achlach River, which is the second largest river in the region. The Maward dam has a storage capacity of six hundred million cubic metres – 200 times that of the nearby Mazahr dam – and represents a major source of drinking water in the upper area of the Achlach river basin. The catchment area (see figure 20) measures 1,361 km2, while the length of the river is 98.1 km.

Figure 20. Catchment area



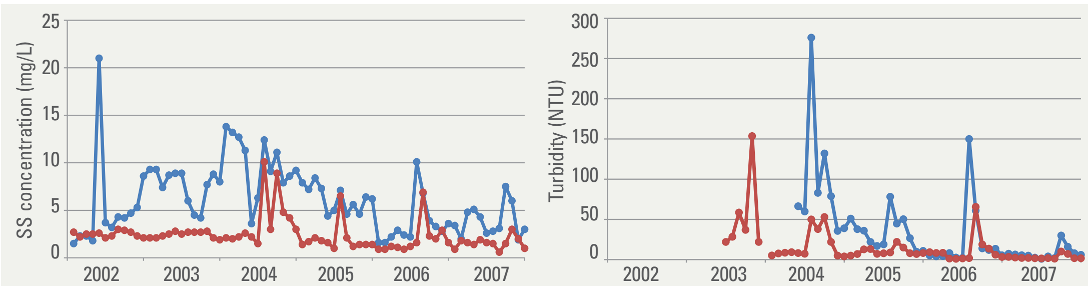
Beyond the central and local governments, stakeholders include farmers, fishing communities, urban communities and the Maward dam operator (X-water).

Problem #1

High levels of turbidity (see figure 21) can reach up to 1,221 NTU and was continuous for 340 days after two storms. High turbidity impacts the ecosystem including fish and benthic macro invertebrates. This problem is caused by:

- Heavy rainfall;
- Soil erosion from alpine field;
- Geological characteristics: soil layer consists of fine clay, which does not settle well.

Figure 21. Average SS (L) and turbidity (R) concentrations in two dams



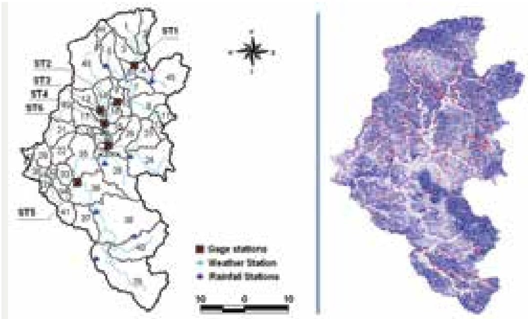
Problem #2

A diversion tunnel was constructed between the Mazahr and Maward dams to increase water storage by 30 million cubic metres, and fishermen have opposed this due to their fear that exotic fish found in Mazahr dam will enter the Maward dam and endanger native species.

Solution approach

The Maward Reservoir Commission was established, consisting of central and local governors, academic researchers, and X-water, with the aim of implementing a basin management plan (BMP). In addition, the Commission will undertake monitoring during rainy and dry seasons and foster research to find hot spots and evaluate the BMP effectiveness in reducing soil erosion. In addition, a facility to block fish migration has been proposed.

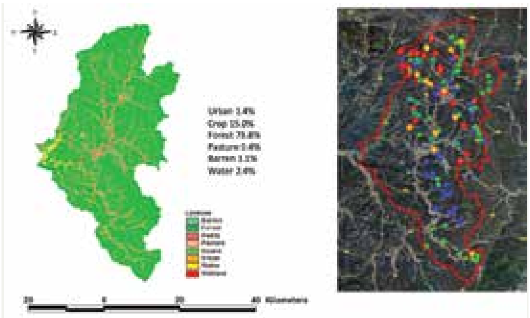
Figure 22. Monitoring stations (L) and hotspots (R)



Exercise steps

Each country team should bring a map of its chosen catchment (any level of detail including a sketch is acceptable), a textual description of the watershed (one paragraph is enough), a short (2-3 paragraph) discussion that addresses what are the management objectives (usually IWRM objectives) for the selected catchment.

Figure 23. Land use classification (L) and control measures (R)



Present the prepared material, including the catchment and its characteristics, the issues faced, the likely causes, and proposed or implemented control measures.

Some of the questions to be addressed by presenters and other participants include:

- Are there objectives that cannot be met at present?
- How would those objectives be framed if considering the ecosystem rather than focusing specifically on water?
- Are there any possible challenges or risks to the proposed adaptation measures?
- Are there any questions about how the adaptation measures might work?

ENVIRONMENT

Climate Change Adaptation and Ecosystem-Based Management
Using Integrated Water Resources Management Tools

AGRICULTURE

Climate Change Adaptation in Agriculture, Forestry and Fisheries
Using Integrated Water Resources Management Tools

HEALTH

Climate Change Adaptation in the Health Sector
Using Integrated Water Resources Management Tools

HUMAN SETTLEMENTS

Climate Change Adaptation in Human Settlements
Using Integrated Water Resources Management Tools

ECONOMIC DEVELOPMENT

Climate Change Adaptation in Economic Development
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