United Nations
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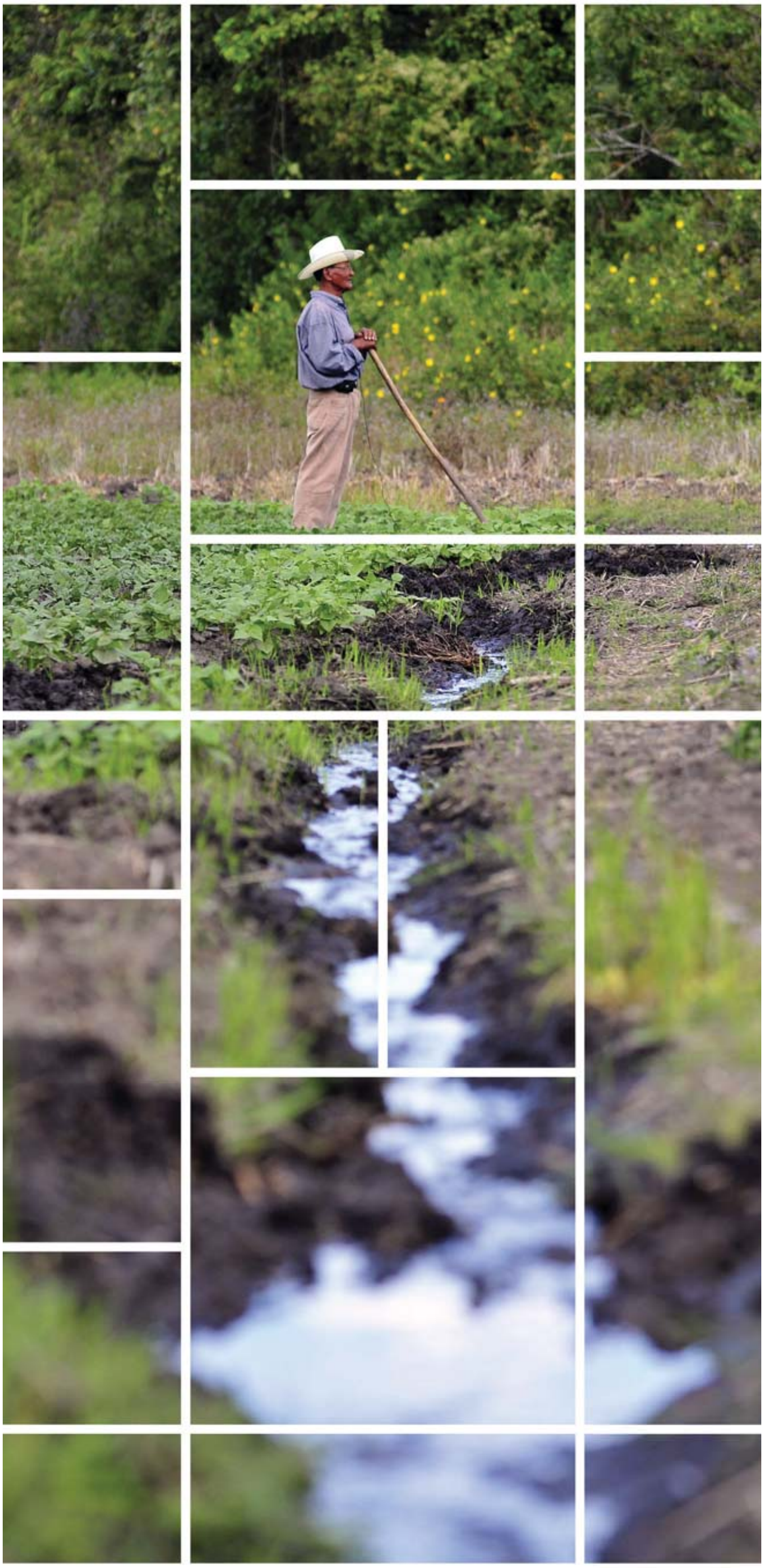
World Water
Assessment Programme

Capacity Development



TRAINING WORKSHOP

on Water and Sustainable Development

World
Water
Assessment
Programme

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Cover photo: Smallholder farmer in Nicaragua using rainwater harvesting to boost food production during dry season/Photo: Neil Palmer (CIAT)

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Chapter 3
Managing water nexus conflicts

Woman in Gilgil (Kenya) demonstrates how to irrigate her garden and make it more productive by using a drip watering kit
Photo: Kate Holt/AusAID

Carlo Giupponi, Venice Centre for Climate Studies,
Department of Economics – Ca' Foscari University of Venice

This chapter examines the main issues related to the competition for water resources and provides some possible solutions for problem solving. Issues are examined at the global scale with examples and more detailed considerations for the African continent. The potential of the "Water, Energy and Food Nexus" (WEF Nexus) is examined as a possible paradigm for inspiring policy-makers in the search for integrated approaches contributing to the sustainability of social and ecological systems. Water allocation can be approached with different strategies. Optimal solutions often are found in the combination of multiple approaches, based on economic theories, but internalising environmental and social objectives. Policy-makers can find the adoption of decision support systems beneficial, provided that a series of conditions discussed in the chapter are respected.

Learning outcomes

At the end of the learning programme you should be able to understand:

- Identify and evaluate the main factors of water conflicts; Learn how to use and calculate different indicators.
- Understand the potential of the Water, Energy and Food Nexus as a new paradigm for the development of case specific solutions (e.g. policies, measures, etc.);
- Learn about possible strategies to improve water allocation and water-use efficiency; and
- Learn how preferable solutions can be identified for local issues.

Key concepts

These concepts will help you better understand the content of this chapter:

- The importance of approaching water management with in-depth knowledge of the social, economic and environmental systems;
- The strict relationships and feedbacks between human behaviour and the functioning of ecosystems and in turn the services they offer for free to humans; and
- The opportunity to develop new avenues for solving water conflicts at the local scale, without repeating the errors already experienced elsewhere.

Guide questions

You should be able to answer the following questions after having read this chapter and its suggested readings:

- What is the balance between availability and demand of water?
- What are the main actors of existing conflicts?
- Are there experiences already in place elsewhere from which to learn?
- How can we exploit the integration between water, energy and agriculture to increase efficiency of our system and control negative side effects?

Suggested Readings

Bakker, K. 2012. Water security: Research challenges and opportunities. Science, 337(6097): 914–915. Doi: 10.1126/science.1226337

Giupponi, C. and Sgobbi, A. 2013. Decision support systems for water resources management in developing countries: Learning from experiences in Africa. Water, 5(2):798–818. Doi: 10.3390/w5020798

Monforti-Ferrario, F. (ed.). 2011. Renewable energies in Africa: Current knowledge. JRC Scientific and Technical Reports. Luxembourg, Publications Office of the European Union. https://ec.europa.eu/jrc/sites/default/files/reqno_jrc67752_final%2520report%2520.pdf

Olsson, G. 2013. Water, energy and food interactions - challenges and opportunities. Frontiers of Environmental Science & Engineering, 7(5):787–793. Doi: 10.1007/s11783-013-0526-z

Vörösmarty, C. J., Douglas, E. M., Green, P. A. and Revenga, C. 2005. Geospatial indicators of emerging water stress: An application to Africa. Ambio, 34(3): 230–236. http://www.jstor.org/stable/4315590

3.1 Introduction

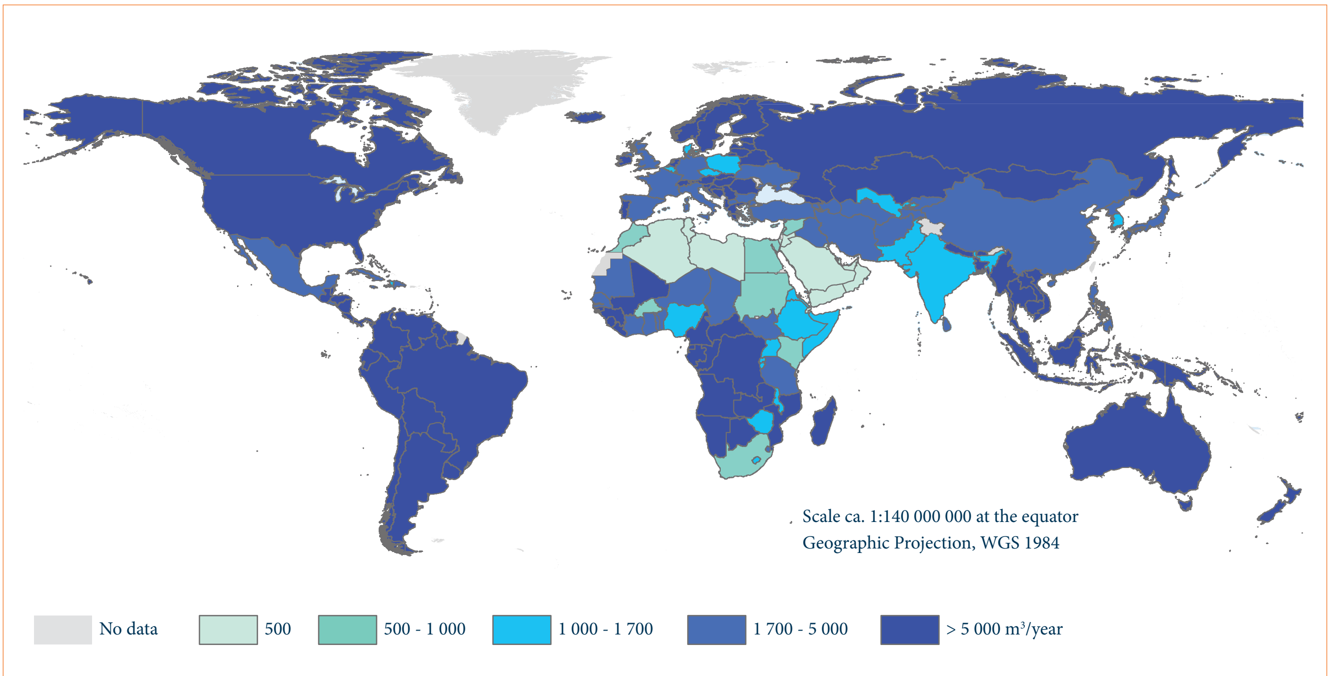
Water covers about three-quarters of Earth's surface and is a necessary element for life, but globally, approximately 97% of water is salt water and only 3% is freshwater, of which two thirds is frozen in glaciers and polar ice caps. The remaining third is unfrozen freshwater found mainly as groundwater and only less than 1% is surface freshwater. This means that all human activities utilising freshwater from rivers and lakes should compete for the 0.013% of water available in the Planet, for all the possible services those ecosystems may provide us, such as provisioning irrigation, domestic water, power, and transport, as well as recreation, scenic values, maintenance of fisheries and biodiversity, and ecosystem function (Aylward et al. 2005).

According to Oki and Kanae (2006), globally, the available renewable freshwater supply exceeds the current human demand. Does this mean that we should not be concerned about the availability of water resources? The answer is no, due to the high variability and the uneven distribution of water resources in time and space (Postel et al. 1996; Wada et al. 2011), determining substantial unbalances between the supply and the demand of water with excesses and scarcities in different places and, within the same area, in different times. Figure 3.1 depicts the most recent information regarding the global per capita availability of renewable freshwater (averages per country), as a first proxy of supply and demand relationships concerning human demands.

In addition, water resources are exposed to the effects of extremely complex combinations of anthropogenic and natural drivers, of which it is worth to mention at least three: demography, economic development and climate change.

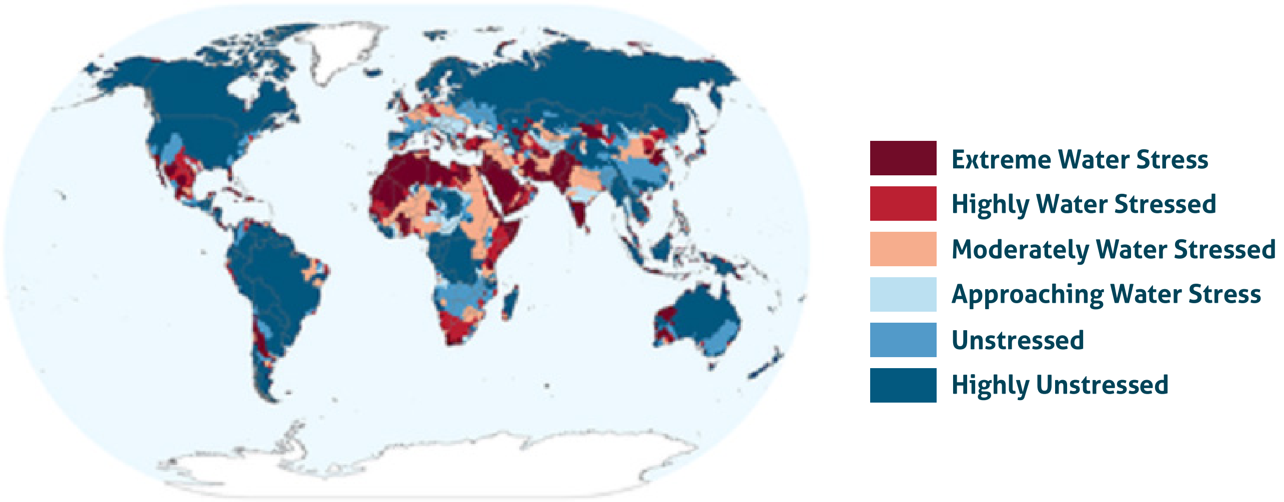
The Intergovernmental Panel on Climate Change (IPCC) suggests with high likelihood that observed and projected increases in temperature and change in precipitation patterns will result in an overall decrease in precipitation in the tropics and increase in the mid-latitudes (IPCC, 2014). As a consequence, drylands will get drier, while temperate zones will become wetter with a net negative impact on water availability and the health of freshwater ecosystems (Bates et al., 2008; Field et al., 2012; IPCC, 2014; Kundzewicz et al., 2007; Stocker et al., 2013). In addition to climate change, current population growth, economic development and related land use changes have direct impacts on the increasing demand for freshwater resources (Gain et al., 2012; Sophocleous, 2004). In the case of Africa, even with a relatively poor availability of data,

Figure 3.1 Availability of renewable freshwater per inhabitant



Source: FAO (2015, http://www.fao.org/nr/water/aquastat/maps/TRWR.Cap_eng.pdf)

Figure 3.2 Projected levels of water stress[10] in the 2080s under SRES A1B emissions scenario simulated with the HadCM3 model, due to population, climate change and carbon dioxide effects of plants



SRES – Special Report on Emissions Scenarios
A1B – Balance across all sources
HadCM3 – Hadley Centre Coupled Model version 3

Source: Wiltshire et al. (2013. Fig. 5, p. 1990). Crown copyright © 2013 Published by Elsevier Ltd. All rights reserved.

scholars tend to agree that the magnitude of effects of non-climatic drivers, such as demographic, economic development, and urbanization, will exceed by far the effects of the climate on the availability of resources, water in particular, in the next few decades (IPCC, 2014).

Human demands driven by economic development and demographic growth induce over-withdrawal of surface water and groundwater and lead to the depletion of water resources and environmental damage in some regions. According to the *United Nations World Water Development Report*, 20% of the world's aquifers are considered to be over-exploited (WWAP, 2014). In addition to growing demand and uneven distribution of supply, unsustainable water management practices, pollution and biotic stressors have mounted pressures on water systems across the planet (WWAP, 2009; WWAP, 2012). Providing safe drinking water to the world's growing population has thus become one of the greatest challenges of the twenty-first century (Oelkers et al., 2011). As a consequence of humans interventions in the biogeochemical cycle of water, human decision-making has become a major factor in the shaping the contemporary hydrologic cycle (Pahl-Wostl et al., 2013), to the extent that humanity is driving global environmental change and has pushed us from Holocene into a new geological era, the Anthropocene (Vörösmarty et al., 2013a). Unfortunately, human actions are implemented with poor water governance (Vörösmarty et al., 2013b) and without adequate knowledge of the consequences on global socio-ecosystems (Vörösmarty et al., 2013a).

[10] Water stress occurs when the demand for water exceeds the available amount during a certain period or when poor quality restricts its use. Water stress causes deterioration of fresh water resources in terms of quantity (aquifer over-exploitation, dry rivers, etc.) and quality (eutrophication, organic matter pollution, saline intrusion, etc.). See: http://epaedia.eea.europa.eu/alphabetical.php?letter=W&gid=108#viewterm

3.2 Competing users and figures of water use

Understanding the dynamics of competing demands for water and the emergence of conflicts between users is at the basis of any management attempt. The main concepts upon which those efforts are based on are, first of all, supply and demand, as well as the needs of communities, economic performance s well-being. In addition, ecosystems need to be taken in consideration not only as service providers but mostly for their role in the overall balance of water cycle. Other fundamental concepts are the notions of water scarcity and competition. In general, whenever a resource is scarce, competition emerges. From a social viewpoint, ensuring the satisfaction of needs also means solving scarcity problems, which is one of the ways to solve security issues. According to Falkenmark et al. (1989), water scarcity occurs when the per capita availability of renewable freshwater resources falls below 1,000 m^3 per year.

Water is often considered as the lifeblood of social and natural systems, which should be managed jointly by adopting the notion of 'socio-ecosystems' as the unit of analysis. The dynamics of the systems and the interaction among the main drivers (e.g. exogenous and endogenous economic forces, climate change, etc.) may determine stable behaviour or evolution, which may lead to improved or worsening performances. When the main drivers are unbalanced, the systems go under stress, causing limitations in the ecosystem services provided, and in turn stressing social systems. Vörösmarty et al. (2005) defined 'water stress' as a condition when the ratio of estimated annual freshwater demand to availability exceeds 0.4% and calculated that 64% of Africans rely on water resources that are limited and highly variable.

Another important concept which contributes to understanding water cycle and water uses is the categorisation of water footprint. The total water FOOTPRINT of an individual or community breaks down into three components: the blue, green and grey water footprint. The blue water footprint is the volume of freshwater that is evaporated from the global blue water resources (surface and ground water) to produce

Box 3.1 – Virtual water

Virtual water (with various combinations of blue, green and grey waters), as defined by Allan (1998), is the volume of water used to make a product in the various steps of the production chain. In regions affected by water scarcity the resource must be imported, although it is much more efficient to import final products (i.e. agricultural commodities), instead of using water to produce them. Therefore, it would be preferable for societies to trade food commodities rather than transfer water. This kind of trade is associated with the virtual transport of water used for production (Hoekstra and Chapagain 2008). Although the use of this indicator is widely disputed, because it neglects fundamental strategic and national security issues, it is evident that global food security strongly depends on virtual water trading.

In a globalized world, political boundaries and the geographical location of resources is becoming less important than in the past. Not only the trade of water hidden in agricultural products has gained the attention of scholars and media, but the "appropriation" of resources across the globe has also emerged under the label of land grabbing, i.e. large scale acquisition of farmland, in developing countries by international investors (privates of sovereign funds). Scarcity of water, food and biofuels can either drive the international trade of commodities or stimulate the direct acquisition of resources, i.e. land grabbing, which is currently amounts to millions of hectares.[11] Without entering into the debate about large-scale land deals (see Cotula et al. (2009) for more details), it is important to note that in some instances, land grabbing should instead be called water grabbing, since it is water the resource that lacks and drives the acquisitions, more than land.

Source: Author.

[11] Please see The Land Matrix Global Observatory, http://landmatrix.org/en/

the goods and services consumed by the individual or community. The green water footprint is the volume of water evaporated from the global green water resources (rainwater stored in the soil). The grey water footprint is the volume of polluted water, which can be quantified as the volume of water that is required to dilute pollutants to such an extent that the quality of the ambient water remains above agreed water quality standards (Hoekstra, 2011).

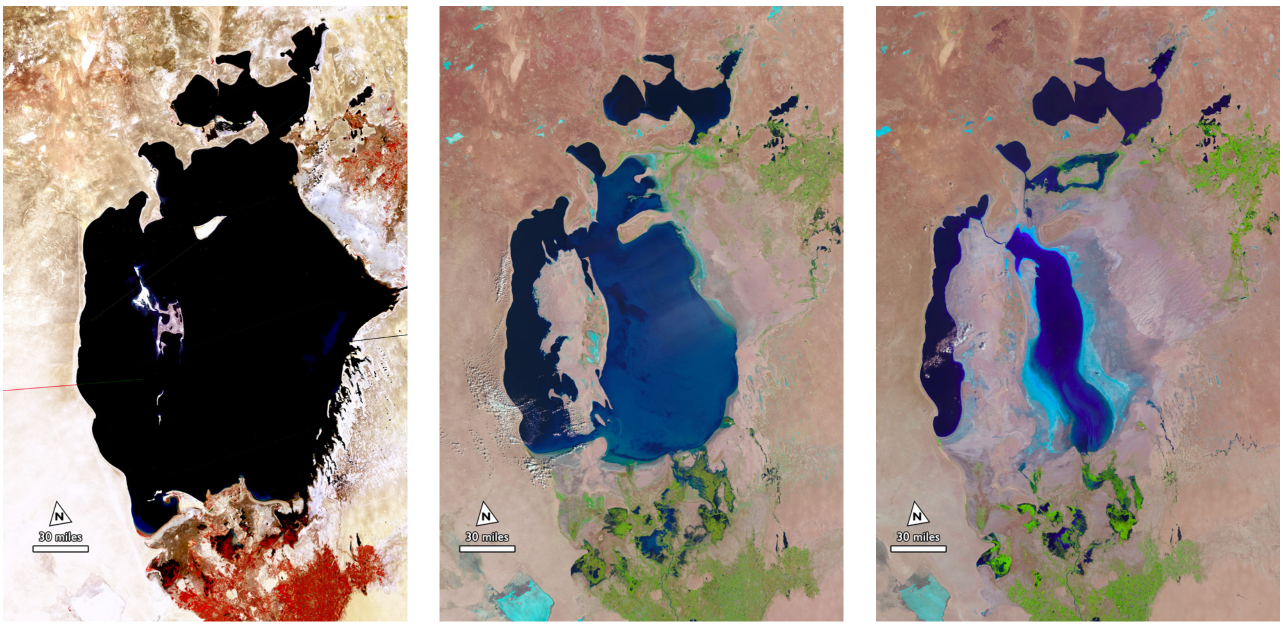
Competing demands for limited resources can limit development opportunities, in particular in areas where there is limited availability of technology, inadequate governance and management systems. This situation not only reduces the efficient exploitation of water resources, but also increases social inequalities and the probability of conflicts between water 'uses' and water 'users'.(WWAP, 2014).

The sharing of water resources belonging to transboundary river basins or aquifers is an emblematic example of potential conflict, which is sometimes generated through the water management context and could spread to become political or even military. Currently, over 260 river basins are shared by two or more countries. In the case of the Nile Basin, there are up to 10 Nile riparian countries, while the Danube River Basin extends to around 19 countries. The African continent holds one of the most important water resources being shared across countries, which gives rise to social and political conflicts. For example, the disputes between Egypt and Ethiopia, and between Ethiopia and Kenya, deriving from the plans for dam development in upstream areas.

If not political, some conflicts arise from cases of mismanagement of shared water resources, such as the case of the Aral Sea which is shared between Kazakhstan and Uzbekistan. Having lost more than half of its surface (two-thirds of its volume) in the last 40 years, salinized soils have now replaced thousands of square kilometres of water(see Figure 3.3).

The case of the Aral Sea illustrates how over-exploitation of transboundary resources can lead not only to conflicts but also to natural disasters and, consequently, to economic losses. It should therefore be recognized that any strategy for the sustainable management of water resources must be based on sound scientific and technical knowledge of the water cycle (e.g. rates of renovation, seasonality, involved ecosystems, etc.) as well as the related notion of water budgets (demand and supply) within the system.

Figure 3.3 Evolution of the Aral Sea (1977-2010)



Aral Sea 1977 | Aral Sea 1998 | Aral Sea 2010

Source: USGS EROS Data Center.

The adoption of an analysis-based approach that takes into consideration systems dynamics allows the understanding of the causes, effects and feedback mechanisms. This understanding should be at the basis of any policy and management decision (i.e. the capability of foreseeing the most likely effects of our decisions under the effects of multiple drivers and stressors which are out of our direct control). The analytical approach is of particular importance for the study of ecosystems and their interactions with water resources, in order to identify and sustainably benefit the services they provide. In particular, concerning water, among the important services that ecosystems can provide and thus substitute otherwise costly human interventions are: regulation (of climate, flows, etc.), protection against extreme conditions (i.e. floods) and provision of water of good quality and pollution control.

The role played by ecosystems in the provision and maintenance of freshwater resources is often neglected, leading to waste not only of water, but also of financial resources. The provision of ecosystem services, including cleaning and restoring primary ecosystems, which are provided for free by Nature but are necessary to our societies, need to be taking into consideration in decision making. In view of current and projected trends, sustainable decision-making can only be supported by adequate capability for identifying and valuing ecosystems services. If no innovative solutions are implemented, substantial increase in demand and decreasing supply as a consequence of climate change will exacerbate the current stress borne by ecosystems.

3.3 Water, energy and food nexus as a new paradigm to analyse and manage conflicting uses and users

Recognition of recent developments has prompted reflection on current water paradigms. Until recently, the paradigm for water resource management was based on traditional command and control approach, which assumes the existence of predictable outcomes and reversible trajectories of change within natural systems (Milly et al., 2008). In this traditional approach the goal of water management is to maximize resource exploitation by reducing natural variability and the approach is characterized by centralized, sectorial institutions, limited stakeholder involvement and expert-led problem solving focused on technical engineering solutions (Schoeman et al., 2014). However, a peculiar characteristic of the Anthropocene is the increased complexity of the Earth system interactions affecting both social and ecological sub-systems, which makes the traditional fragmented approach unsuitable for decision-makers, asking to be replaced by more holistic approaches. Mounting evidence of the failure of conventional approaches to achieve equitable and sustainable water management has prompted to discourse around three emerging approaches (Pahl-Wostl et al., 2011): Integrated Water Resources Management (IWRM) (GWP, 2012), Adaptive Water Management (AWM) (Pahl-Wostl, 2007; Pahl-Wostl et al., 2007; Holling, 1978; Engle et al., 2011) and Water-Energy-Food (WEF) Nexus (Bazilian et al., 2011; Hoff, 2011).

Water, energy and food security are closely linked and highly important for societies and economies – (Hussey and Pittock, 2012; Beck and Villarroel Walker, 2013; Olsson, 2013). Whereas IWRM tries to engage all sectors from a water management perspective, the WEF nexus approach addresses water, energy and food security as equally important (Bach et al., 2012). Furthermore, IWRM integrates management and governance across sectors and scales, with a new focus on security concerns (Bakker, 2012; Cook and Bakker, 2012) and on the opportunity to create sustainable business solutions for green growth, though public-private partnership (Bizikova et al., 2013; Benson et al., 2014). Hoff (2011) stated that given the interconnectedness across sectors (water, energy and food), space and time, a reduction of negative economic, social and environmental externalities can increase overall resource-use efficiency and sustainability. Indeed, to achieve sustainability, key dimensions of IWRM (e.g. multi-stakeholder involvement, assessment and management at river-basin scale, demand management) and AWM (e.g. adaptable and flexible decision-making, and consideration of uncertainty) need to be aggregated with the WEF nexus principles: involvement of stakeholder, policy integration through coordination and harmonization, governance and multi-stakeholder resource planning, promotion of innovation, influencing policies on trade, investment in uncertain environment and climate conditions (Scott et al., 2011; Bizikova et al., 2013).

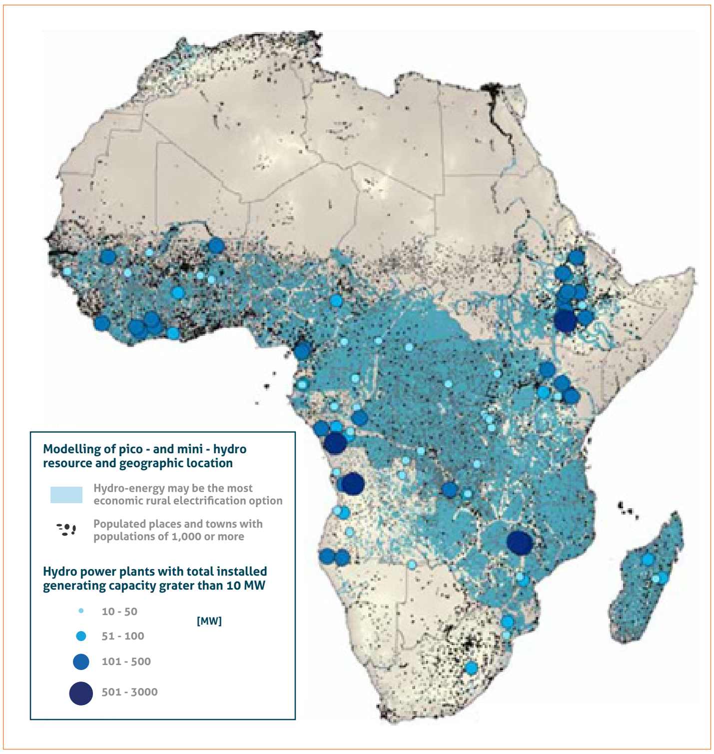
An example of the nexus between water and food production is evident in the role played by irrigation to boost productivity and overcome environmental constrains. Adequate consideration of the different typologies of water (blue, green and grey) allows the analysis of the synergies between the two.

The search for efficiency through the water and food nexus means finding the optimal combination among the main factors ruling the systems of crop and livestock production. One of the important concepts in this regard is the combined effects of a long cascade of efficiencies that characterize the overall efficiency of water use in the agricultural systems. For example, according to Hsiao et al. (2007), the efficiency of an irrigation system can be calculated by multiplying a series of coefficients: conveyance, farm, application, crop consumption, plant transpiration, assimilation, biomass conversion and harvested yield. It is evident that even one of the coefficient with a very low value will affect the whole chain. In extreme cases where there even seven coefficients at 100% and one at 0%, the overall efficiency will be 0%. Consequently, it is more effective to undertake small improvements throughout the system, rather than concentrating on substantially improving one or two steps. In Africa, as in many other cases, there is a high potential which is not yet exploited. IFPRI recently estimated that given that the agricultural production of the continent (Sub-Saharan region in particular) is still in its vast majority rainfed (>90%), irrigation in Africa has the potential to boost agricultural productivities by 50% or more (You et al., 2010).

Water and energy are evidently interdependent: water can be used to produce energy, and energy is needed for every step of the water infrastructural chain (extraction, distribution and treatment) (WWAP, 2014). According to IEA (2013), electricity accounts for between five to 30% of the total operating cost of water and wastewater utilities. On the other hand, water is required to produce and deliver any form of energy, and approximately 15%of the global water uses are dedicated to energy production. A study on renewable energies in Africa (Monforti-Ferrario, 2011), while evidencing the gaps in available information, estimated that Africans have up to 35 times less energy, and up to 100 times less electricity, compared to persons in the European Union. Moreover, the number of people without access to electricity in Africa is increasing because demographic growth is faster than the development of energy infrastructures.

The first example of the water and energy nexus that usually come to our mind is hydropower. Dams and reservoir have experienced waves of positive and negative feedbacks over time, because of the disputes concerning balancing their economic performance and the impacts on social and environmental systems. Currently, we can see two distinct directions of development, with huge projects on the one side and micro hydroelectric plants on the other. In Africa, the foremost case is illustrated by the construction of the Grand Ethiopian Renaissance Dam (GERD)[12] in Ethiopia, just upstream from the Sudanese border. GERD will become the highest (145 m) and largest dam of Africa, with a reservoir of 74 billion m^3 of water and an expected production of up to six gW of energy. The other direction of hydropower development tends towards small decentralised plants which could also serve remote rural communities who are far from the main infrastructures. The Joint Research Centre (JRC) of the European Commission explored the economic performances of the mini-hydro solution as compared to other renewables (Monforti-Ferrario, 2011) and demonstrated that huge areas have very good potential for mini-hydroelectricity sources in Africa (see Figure 3.4).

Figure 3.4 Regions in Africa where mini-hydro could be the most economical rural electrification option



Source: Monforti-Ferrario (2011, Fig. 5.2, p. 43).

[12] For further reading, see: http://www.salini-impregilo.com/it/lavori/in-corso/dighe-impianti-idroelettrici/grand-ethiopian-renaissance-dam-project.html and http://www.water-technology.net/projects/grand-ethiopian-renaissance-dam-africa/

Desalination is characteristic of the opposite sign of the water and energy nexus: energy is needed for water provision. Even though desalination systems powered by solar energy are available, most of the existing plants still use fossil fuels, with consumptions that may range from around five to up to more than 50 kWh per cubic metre of desalinised water.

Concerning the nexus between energy and food production, the two sectors clearly compete for water and other resources. At the same time, they can also substitute each other in the case of energy crop and biofuels, with obvious side effects on water, since for example bioenergy could be substantially more water intensive than energy generated from fossil fuels. In turn, fields allocated to bioenergy compete with food production, for both land and water, once again with substantial differences in terms of conflicts and depending on which water is used: green or blue. Further, the development of energy crops is considered one of the driving forces of the instability of the agricultural commodities market and rise of food prices. Moreover, the food supply chain consumes about 30% of globally energy consumption (FAO, 2013). In terms of water footprint, it takes about the same amount of water to produce one litre of liquid biofuel (2,500 litres) as it takes to produce food for one person for one day (UNESCO, n.d.).

3.4 Policies and measures to solve conflicts and provide rational allocation of water

Competition for water resources creates conflicts involving not only different sectors and economic factors, but also the environment. As stated previously, although water management should be approached with sound scientific knowledge of the biogeochemical cycle of water in all its relationships with human and natural elements of the socio-ecosystem, the instruments that humans have to manage and solve water problems nevertheless fall within the economic sphere.

The economic policy instruments (EPI) for water management have been recently studied by an EU funded project, called EPI-WATER.[13] The project examined several policy instruments, three of which are of particular interest (water pricing, water trading and payments for ecosystem services)[14] because they exemplify possible solutions that policy-makers can consider when addressing problems generated by conflicting water demands, such as water allocation.

Water pricing is one of the preferable mechanisms which facilitate matching water supply and demand, thus the move towards efficient allocation of resources. In this light, a given water volume can assume different prices depending on its role in and contribution to the common interest. For example, increasing prices can emerge from the market or be imposed by the government as a function of the availability of a given source, such as the case of the exploitation of an aquifer at risk of depletion. Incentive water pricing is the strategy to make individuals pay for water resources use and, in addition to economic criteria, such as cost recovery of the service, investments, etc., it typically includes environmental (i.e. the cost of externalities such as pollution) and social considerations (i.e. use for basic needs vs. other uses). Price incentives are expected to pursue multiple policy goals, such as increasing water use and allocation efficiencies, guaranteeing financial viability and social equity.

A prerequisite for efficient pricing mechanisms is the in-depth knowledge of the environment and water demand curves by different users (i.e. environmental flows in rivers). There are various mechanisms possible, such as water supply and sanitation multi-part tariffs, where the price is determined with a combination of a volumetric part (possibly further broken down with progressive rates) as an incentive for water saving, and a fixed tariff-part to contribute to cost recovery. However, similar pricing systems are usually difficult to apply to the agricultural sector, where water is often provided for free or at a low flat-rate price, as a form of subsidy in support of an economic activity of strategic relevance.

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[13] The EPI-WATER Project sets to assess the effectiveness and the efficiency of economic policy instruments in achieving water policy goals, and to identify the preconditions under which they complement or perform better than alternative (e.g. regulatory or voluntary) policy instruments. See http://www.feem-project.net/epiwater/

[14] For further reading, see http://www.unesco.org/new/en/natural-sciences/environment/water/wwap/wwdr/wwdr4-2012/ and http://unesdoc.unesco.org/images/0022/002257/225741E.pdf

The second policy instrument that can be considered is water trading, which refers to the exchange of water rights within an institutionalized market. Trading can increase economic efficiency of allocation and can be considered as one of the measures to be activated within the package of policies for water management. In this situation, the size of the market is clearly constrained by the existing infrastructures allowing for the transfer of water volumes from one user (seller) to another (buyer). Within an efficient market, demand and supply mechanisms should provide the most economically efficient allocation of water.

The third instrument, which supports efficient water allocation with an emphasis on the environmental issues, is the payments for ecosystem services (PES) scheme. In this case, the focus is on the valuation of the benefits derived from the ecosystem services (ES) offered by nature to society, which typically have no market, but a great importance for human well-being (MEA, 2005). In other words, whenever human behaviour interacts with ES, there is a theoretical opportunity to create a market for the services, with beneficiaries paying the service providers to adopt the optimal management of water resources with mutual benefit. Typical cases are those where people living downstream pay for the management of water and land upstream in order to, for example, limit water pollution and save money required for building treatment plants. Beneficiaries can be identified in the whole society, and consequently the government would be able to consider adopting, for example, a system of incentives or voluntary measures supported by public funds and targeted to service providers, to ensure the improvement of the whole socio-ecosystem.

The above-mentioned water policy measures cannot be implemented if the institutional setup is weak or inadequate. As pointed out by the EPI-WATER Water Synthesis report, Management of natural resources involve legal, environmental, technological, financial and political considerations associated often with sizeable transaction costs (EPI-WATER, 2013, p. 9). Improvements in water management policies and measures should therefore go hand-in-hand with the consolidation or improvement of institutions.

The water sector and related policies are just one of the elements of a broader strategy for sustainable development which require multi-sector policy integration with the overall aim of securing well-being standards to both society and ecosystems. With regard to the human dimension, this means, for example, the integration of water policies with those of energy and agriculture, to guarantee collective water security under evolving boundary conditions, e.g. changing climate, and demographic and economic development.

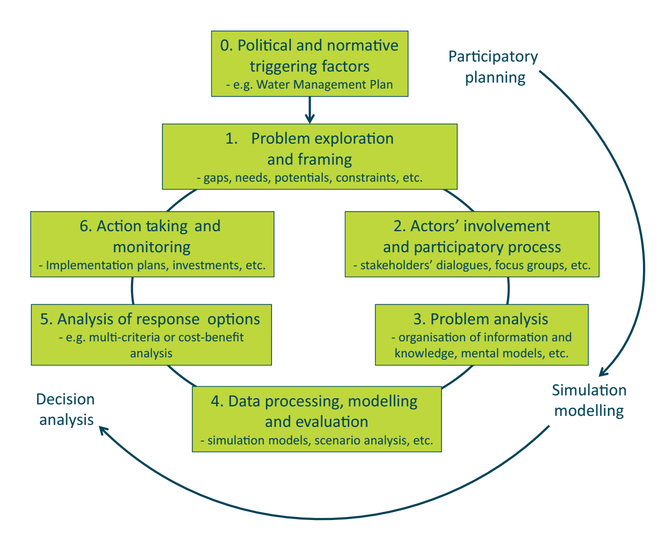
In general, the identification of "best" solutions (e.g. policies, measures, mechanisms, technologies, etc.) implies the choice between a set of plausible options typically characterized by trade-offs between various dimensions: environment, society and economy. In the next section, these choices are explored and discussed how they can be implemented, as well as to identify the "preferable" solutions, i.e. those that emerge from the participatory involvement of all the main actors and stakeholders, comprising environmental, economic and social representatives.

3.5 Identifying preferable solutions

As discussed in previous sections, the current situation requires integrated approaches where the knowledge of diverse disciplines converges in a unified methodological and operational framework. The research community is asked to develop and transfer approaches to support the implementation of transparent planning/management processes to meet policy- and decision-makers' requirements, and achieve more robust and informed decisions (Geertman and Stillwell, 2009).

Significant contributions can come from the innovative methods for structured integration of methodological and operational approaches pertaining to three different disciplines: simulation modelling (SM), participatory planning (PP) and decision analysis (DA). Decision and information support tools (DISTs) offer promising opportunities for the integration of different disciplines and methodologies in support of decision-making processes and, in particular, by providing the methodological and operational framework to integrate SM, PP and DA. DISTs, as a broad category of computerized instruments, can facilitate the transfer of skills and methods for structuring and exploring problems and the generation of information to analyze and support decision-making (McIntosh et al., 2009).

Figure 3.5 A generic decision-/policy-making process, including main steps and areas of influence of participatory planning, simulation modelling and decision analysis



Source: Giupponi and Sgobbi (2013, Fig. 1, p. 801).

Numerous solutions can be proposed for the integration of the required disciplinary components in one or more DISTs, considering all the phases of the policy- or decision-making processes. Figure 3.5 presents the methodological framework proposed by Giupponi and Sgobbi (2013) in a recent paper which analysed decision-making for water management in Africa, with a focus on decision support system (DSS) tools.

Literature review and experts' survey not only evidenced the need to exploit the potential of DSS tool, but also identified the following prerequisites for effective implementation: (i) a comprehensive methodologically sound, participative and coherent legislative and planning frameworks and decision process; (ii) combined with training and capacity building; (iii) adequate networking and cooperation with pre-existing experiences; (iv) harmonised with transnational data infrastructures; and (v) readiness to adopt enhanced protocols for DSS development (Giupponi et al., 2011; Giupponi, 2013; Giupponi and Sgobbi, 2013). The tool should provide decision-makers with solid valuation methods, in particular, which can be fully monetary (cost-benefit analysis, or CBA), or partially based on monetisation (cost-effectiveness analysis, or CEA) or not necessarily based on money as a valuation unit (multi-criteria analysis, or MCA).

GENDER and the WATER, FOOD and ENERGY NEXUS

"The same people who lack access to improved water and sanitation are also likely to lack access to electricity and rely on solid fuel for cooking" (WWAP, 2014, p. 13). The health consequences are devastating: indoor air pollution is linked to respiratory diseases, and the lack of safe drinking water and sanitation can result in chronic diarrhea. Women and children represent a disproportionately high fraction of the unserved (WWAP, 2014).

Bioenergy investment and the consequent rapid change in land-use can have negative consequences for traditional land tenure arrangements. This is particularly the case for marginal land, which provides important ecosystem services such as pasture land or fuel wood for local traditional communities (Cotula et al., 2008). Women, in particular, are the most affected by the loss of marginal lands because in rural areas these environments are the main providers of fuel-wood, water, and vegetables, traditionally carried, managed and transformed by women and girls. Women could be therefore forced to walk longer distances to provide their households with the same amount of energy, food and water.

Contributed by Francesca Greco and Roselie Schonewille (WWAP).

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3.6 Conclusions and main messages

Water is a fundamental enabler of economic development, social welfare and healthy ecosystems, but when the resource is scarce it could also become one of the critical constraints (WWAP, 2015).

Projections of the trends of the most important – economic, environmental and social – variables show the unsustainability of business-as-usual (BAU) approaches, thus pushing the adoption of new paradigms in economic development and natural resources management. Holistic approaches are needed for development plans, and the WEF Nexus can represent a pragmatic compromise between ambitions and feasibility. Likewise, approaches such as on ecosystem-based management ('ecosystem-based adaptation', when climate change is the main issue considered) can represent the inspirational key to ensuring long-term sustainability (WWAP, 2014).

According to the World Water Council (WWC, n.d.), in order to contribute to solve current and future water crises, the following approaches should be jointly considered:

- guarantee the right to water;
- decentralise the responsibility for water;
- develop know-how at the local level;
- increase and improve financing;
- evaluate and monitor water resources.

Socio-ecosystems are inherently complex and thus solutions are neither simple nor evident. In a context of competing actors (not only humans), only a robust, ethically sound and scientifically-based system of values can support choices and decisions about water allocation and DSS tools can contribute significantly. In general, economic arguments and assessment methods can make the valorisation of water resources and related ecosystems relevant to decision-makers and planners. Economic valuation can demonstrate the cases in which benefits exceed costs of water-related investments and point out trade-offs, for example in cases of ecosystem conservation (WWAP, 2014). Nevertheless, it is evident that the system of values to be adopted for sustainable decisions about water management should not be limited to consider only economic criteria. In order to have them implemented with coherent water policies, they require an enabling environment based upon a hierarchy of actions, including the development of coherent (Water, Energy and Food) policies, and legal and institutional frameworks, implementing monitoring both for data collection and for the assessment of decision outcomes, raising awareness, supporting innovation, with adequate financial resources, and facilitating the role of the market (WWAP, 2014).

Solutions are not easy and not universally valid, but they can be found in each local context through the integration of the three dimensions of the WEF Nexus. For example, in the use of renewable energies for electricity production (IRENA, 2015) which limit the competition for water with the other sectors (wind, geothermal, solar). Hydroelectric energy is indeed an option that is still substantially underdeveloped in various parts of the world, and in particular in Africa, but traditional dams designed for power generation should be abandoned in favour of multi-use reservoirs and integrated plans for the (re)use of water released from hydro-power plants. A characteristic example is the case of agricultural development paradigm. According to FAO, it should be inspired by Climate Smart Agriculture wherein ' the multiple challenges faced by agriculture and food systems are addressed simultaneously and holistically, which helps avoid counterproductive policies, legislation or financing' (FAO, 2013, p. xi). Other examples of integrated solutions could be found in the promotion of wastewater for multiple uses, from the treatment of urban wastewater, through its use in agriculture and in desalination.

According to the African Progress Panel (APP), 'nowhere are the threads connecting energy, climate and development more evident than in Africa. No region has made a smaller contribution to climate change. Yet Africa will pay the highest price for failure to avert a global climate catastrophe' (APP, 2015, p. 14). Perverse cycles of high prices for energy, limits in available infrastructure and unstable services characterize the current situation, but they can also represent one of the driving forces for innovative solutions for climate-resilient, low-carbon development and more resilient societies. 'It would take the average Tanzanian around eight years to consume as much electricity as an American uses in one month" and estimates at current trends say that it would take up to 2080 to achieve universal access to electricity to all, while it would take possibly another century to for clean cooking facilities (APP, 2015, p. 16). According to the International Energy Agency, in Sub-Saharan Africa, 950 million people may gain access to electricity in 2040, but 530 million people may still remain without it (IEA, 2014).

Therefore, Africa should become the continent in which new avenues for green growth can be explored and successfully implemented as a necessary solution for current challenges and crises.[15] It is in line with this orientation that the African Centre for Economic Transformation has released its 2014 report, entitled Growth with DEPTH, where DEPTH identifies a new paradigm for African countries: "Diversify their production, make their Exports competitive, increase the Productivity of farms, firms, and government offices, and upgrade the Technology they use throughout the economy—all to improve Human well-being"(ACET, 2014, p. iv).

With a specific focus on the support of decision- and policy-making, Giupponi and Sgobbi (2013) provided the following suggestions to be considered in future efforts:

1. Let everybody benefit from the big and most favoured ones: a jointly funded activity with a transnational approach to establish a permanent forum for exchanging experiences in DSS development and implementation in Africa, with the main references to be found, first of all, in the Nile and Volta River basins;
2. Knowing who is around and exploiting others' experiences: development of a knowledge base about recent and ongoing efforts in the field of DSS tools, to avoid duplication of efforts and facilitate exchanges and synergies;
3. Training and motivating the main actors of IWRM in Africa: north-south and south-south training and capacity building activities aimed at facilitating the transfer of skills and experiences amongst the main transnational river basins; and
4. Towards a continental data infrastructure for IWRM: establish an expert group with the support and participation of the most important international institutions (FAO, the World Bank, CGIAR, the EU Commission, etc.) for the development of a joint strategy on data: standards, repositories, maintenance, etc. This should be squarely set within national statistical frameworks, so as to ensure reliability, consistency and sustainability.

15 See http://www.afdb.org/en/news-and-events/multimedia/video/green-growth-the-future-for-africa-video-report-am-2014-845/

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