Part 2

Metrification of water uses

Chapter 5

Towards an Integrated Water Resource Management (IWRM)

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ABSTRACT: This chapter analyses the pros and cons of key tools and methods for achieving a more Integrated Water Resource Management (IWRM), with special reference to the application of the concepts of virtual water and water footprint. IWRM is widely recognized as a good idea but its practical guidance and implementation has hardly begun. IWRM requires consideration of the tangible (measurable or quantitative) and intangible values of water resources (difficult to quantify, such as cultural, spiritual values or intergenerational equity) and related socio-economic and environmental aspects both from the production and consumption perspective. The water footprint tool, coupled with other socio-economic and environmental data, can be a good tool providing a transparent and multidisciplinary framework for informing and optimizing water policy decisions and to facilitate the IWRM for the analyses of nations, regions, basins or products. It generally provides an easily communicable framework for sensibilisation and is usually a good tool to deal with the stakeholders. Nevertheless, it is necessary to keep in mind its limitations, such as data constraints or comparability limitations. By extension it seems that perhaps the most important issue to solve the global water problems is to achieve a more fair and equitable regulation of the food (virtual water) trade.

Keywords: integrated water resource management, water accounting, tangible and intangible values, water footprint, virtual water

1 INTEGRATED WATER RESOURCE MANAGEMENT

During the last two decades the concept of Integrated Water Resource Management (IWRM) has become very popular. The main reason for this has been the pervasive awareness that water resources need to be managed across subsectors at the basin level. Since the 1990s water management has expanded to cover efficient water use, equitable sharing of benefits and environmental sustainability aspects. IWRM is a process which promotes the coordinated development and management of water, land and related resources, in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems (GWP, 2000). IWRM involves collection and management of natural resources information, the understanding of the interactions that occur in the use of these resources, together with the implementation of policies, practices and administration structures, which enable the resources to be used. Water problems cannot be solved if they are considered from only one scientific or institutional perspective. It is necessary to focus them from a multidisciplinary perspective and it is not feasible that only one institution or governmental authority deals with all the uses of water. Participation and coordination among different institutions and stakeholders is necessary. The good governance of freshwater resources requires equilibrium between the utilitarian (measurable or quantitative) and the intangible values (difficult to quantify, such as cultural, spiritual values or intergenerational equity). It was at the UNESCO Working Group meeting on the Ethics of Fresh Water Uses in the year 2000 when the need of this equilibrium was stated (Llamas & Delli Priscoli, 2000).

2 WATER ACCOUNTING AND ASSESSMENT: CHALLENGES AND OPPORTUNITIES

In most parts of the world, the development of consistent and systematic water accounting systems both from the production and consumption perspective are in their infancy, but rapidly developing. There is a need to quantify and account for water flows within the economy (including for environmental needs) and related impacts in the appropriate time and spatial scales, to enable transparent information systems which could be used to develop robust allocation and management systems that underpin a green economy.

The better informed the decision-makers are, the more likely they are to make the right decisions. For water managers this means being able to provide reliable information about where and when water is available, of what quality, where and how it is used, what happens to wastewater, how much water leaves the country in exports of goods that use water in their production (virtual water) and how much enters the country in imports, impacts on the social, economic and environmental sectors, and the intangible values.

From the production perspective, water balances (i.e. inventories or registers) represent the fundamental approach to accounting for the flow of water into and out of a system.

Consumption-focused instruments present difficulties in linking consumption back to impacts in specific river basins at specific times. The impacts of consumers on water resources are generally indirect and linked to long supply chains, not only related to human activities in the same watershed but also via inter-basin exchanges and international trade. In addition these supply chains and interdependencies are not restricted to single sectors (e.g. agriculture, industry or urban water supply) but evolve into interdependencies between sectors.

This will be a challenge for water managers in most countries, which lack the necessary measurements and do not systematically collect the necessary data. When the information is available, it will be possible to calculate the country's water balance and the water footprints (volume of water used) of various users. Using this information, water managers can advise decision-makers in other sectors of the feasibility of their plans and the implications for water.

To provide a robust basis for analysis and decision-making, such assessments must meet certain criteria.

3 THE VIRTUAL WATER AND WATER FOOTPRINT CONCEPTS

The virtual water concept was coined in the 1990s by Professor Tony Allan (Allan, 2011). The virtual water of a product or service is the volume of freshwater used to produce the product or service. The water footprint (WF) is an indicator that looks at both direct and indirect water use of a consumer or producer (Hoekstra, 2003). A water footprint can be calculated for a process, a product, a consumer, group of consumers (e.g. municipality, province, state or nation) or a producer (e.g. a public organization, private enterprise). All components of the water footprint are specified both geographically and temporally (Hoekstra *et al.*, 2011). The blue water footprint refers to consumption of blue water resources (surface and ground water) along the supply chain of a product. The green water footprint refers to consumption of green water resources (rainwater stored in the soil). The grey water footprint refers to pollution and is defined as the volume of freshwater that is required to assimilate the load of pollutants based on existing ambient water quality standards. This is still an interesting, complex, and controversial concept. Since this book is intended mainly for the water policy makers and not for the academic community, the grey water concept is not usually included.

There is a growing need to integrate nature conservation, social equity and economic growth into the process of decision making. For the time being and almost in the entire world, water footprint analysis has focused on hydrological aspects. A significant innovation of this work is to consider the economic, social, ecological and intangible aspects. The water footprint combined with other socio-economic and environmental methods, as suggested in this book, seems to be a useful tool that provides a transparent and multidisciplinary framework for informing and optimizing water policy decisions and the needs of economic sectors and healthy ecosystems. This is being developed in a progressive way. For instance, already in 2008 in the Guadiana Basin analysis, the economic values related to water uses were already included (see Chapter 9). This was probably the first time that this approach was used in the world. In the study of the Guadalquivir basin (see Chapter 8), also probably for the first time, the uses of green and blue water by the natural ecosystems were included.

Traditionally, countries formulate national water plans by evaluating how to satisfy water users. Although countries consider both options to reduce water demand and to increase supply, they generally do not include the global dimension of water management. Many countries import agricultural or industrial goods without determining whether imported products cause water depletion or pollution in producing countries. Governments could engage with consumers and businesses to work towards sustainable consumer products. National water footprint accounting could be one of the components in national water statistics, supporting the formulation of national water plans and river basin plans.

In this context, Spain has been the first country in the world to adopt the water footprint evaluation in governmental policy making. In September 2008 the Spanish Water Directorate General approved a regulation that includes the analysis of the water footprint of the different socio-economic sectors as a technical criterion for the development of the River Basin Management Plans, that all EU Member States will have to accomplish every six years as part of the requirements of the Water Framework Directive (Official State Gazette, 2008).

3.1 Strengths of the water footprint

- **When coupled with other tools, the water footprint is a comprehensive and transparent tool** providing the *big picture* for strategic planning purposes.
- **Easily understood by non-technical audiences**. The water footprint can be an effective public awareness-building tool. It has also been a useful tool to deal with the different stakeholders, mainly the farmers' associations or lobbies.
- **The influence of technology in the yield of crops**. The type of agricultural technology available has a significant role in the determination of the virtual water of crops (m^3/t of product) [t = tonne = 10^3 kg]. It may be more significant than the conventional calculations of the water use per crop (m^3/ha), and this technology usually improves with time (see Garrido *et al*., 2010 and Chapter 6).
- Water footprint and virtual water trade assessments are a relevant input into various governmental policy areas, such as national, state, river basin or local water policy; environment; agriculture; industry/economic policy; energy; trade; foreign policy and development cooperation.
- Hitherto, decision-makers have focused on water issues related to production within the related territories, without considering the **virtual water flows** linked to trade in agricultural and industrial products. Water challenges and opportunities are often tied to the structure of the global economy. By looking only at water use within their territories, decision-makers have a blind spot to the issue of sustainability of consumption.
- **Improving water efficiency**. The water footprint provides new dimensions of water use efficiency: user, basin, and trade. At the user level, technology, education and pricing play a key role. There are opportunities to significantly improve agricultural, domestic and industrial sector water use efficiencies. Overall, food supply chains should be made more water efficient. At the basin level, water allocation efficiency is required to ensure water use is sustainable, equitable, and that appropriate *value* is derived from the resource. All sector requirements must be considered holistically, including environmental water requirements. At national, regional, and global scales, virtual water trade can be used as a tool to improve overall water use efficiency by considering the comparative advantages of certain water uses in particular regions. A good example is seen in the analysis of the Guadalquivir basin (see Chapter 8).
- In industrialized and emergent economies the water footprint, associated with other instruments, has become a good tool to inform water rights re-allocations in order to move from the motto of *more crops and jobs per drop* to a motto of *more cash and care of nature per drop*. In other words, to achieve a win-win type solution (see Guadalquivir analysis, Chapter 8).

3.2 Weaknesses of the water footprint

The water footprint tool presents the following difficulties:

- **Terminology confusion**: Different water footprint studies use different terminology to refer to the same concepts. The recent analyses of the WF done by the Spanish Government for some Spanish basins are an example of this. Therefore, it seems important to use the same terms in such studies. This is why in this book a glossary has been included.

- **Problems with data availability**: The available data do not always fit to the requirements of the water footprint studies. A clear example is the territorial scope of the data. Some data are available at provincial, regional or national level but do not agree with the watershed boundaries (e.g. trade data). Adjustments and simplifications are necessary, which introduce uncertainties and errors.
- **Inadequate data**: A lack of sufficient data about climate, soils and growing periods of crops is in many cases the greatest factor limiting the ability to provide meaningful information on the water consumption of crops or other products. This is most often due to inadequate databases, or lack of access to existing data, and this causes a cascade of errors in the final estimation of the consumptive water uses per crop and surface.
- **The concept of grey water**. This concept used as an assessment of pollution can be misleading (e.g. sometimes wrongly understood as an approach to dilute pollutants). This relatively new concept, created in 2006, is currently being developed and refined. For the moment, natural improvement is not taken into account, which may be important for some pollutants.
- **The water footprint, when not connected to the socio-economic and environmental values related to the different uses, provides partial information and may be misleading**. The emphasis is placed on the concept of water self-sufficiency. This causes a *hydrocentric* unrealistic approach.
- **Dry matter**. When estimating the water footprint of a product (m^3/t), based on available crop yields, we are considering fresh weights. However, from an ecological viewpoint, primary production is measured as dry matter yield. In this line, results would change when taking the dry matter into account; the fresh weight is mostly water in vegetables but cereals have a much higher dry matter.
- The usefulness of the water footprint in water planning; **the water footprint linked to other data**. The water footprint *per se* generates little direct practical conclusions for planning purposes, except the knowledge of the environmental impact in time and space of water use by the inhabitants of a region. However, from the planning point of view, it can be very useful if water footprint data are linked with other data consistent in space and time, including:

  a Socio-economic indices (e.g. gross value added, profit, employment) in each economic sector. Socio-economic data can be used along with the water footprint (€/ha; €/m^3; employment/m^3), providing information on the apparent productivity and efficiency of water use, so that the effects of the water use in human activities are assessed.
  b Hydrological and environmental indices. The water footprint can be compared to the potential resource available and environmental water requirements in terms of both green and blue water.
  c A balance between utilitarian (quantifiable or measureable) and intangible values (cultural, emotional or religious aspects, which are harder to quantify) is also necessary.

In sum, the water footprint linked to other data (hydrological, socio-economic, environmental, intangibles) could contribute to awareness-raising and transparency development, which could contribute to the proper use of water resources and support the water planning process, particularly in water resource allocation, which is related to socio-economic development, reducing consumption and transfers of resources, environmental improvement and the achievement of social objectives, and in summary, to a suitable and efficient use of scarce resources. This fits perfectly with the main objectives of the European Water Framework Directive.

4 CONCLUSIONS

i Integrated Water Resources Management (IWRM) requires consideration of the tangible (measurable) and intangible values of water resources and related socio-economic and environmental aspects both from the production and consumption perspective.

ii The water footprint tool, coupled with other socio-economic and environmental data, is a good tool providing a transparent and multidisciplinary framework for informing and optimizing water policy decisions and to facilitate the IWRM for the analyses of nations, regions, basins or products.

iii Nevertheless, it is necessary to keep in mind the limitations of the tool (e.g. cascade of errors in large territories, data constraints).

iv The water footprint is usually a good tool to deal with the stakeholders, mainly with the farmers' associations or lobbies. This is relevant because the farmers are usually the main human water users.

v The analysis of Spain, the most arid country in the EU, seems to show that, due to the recent advances in science and technology, and mainly to globalization, many of the current Spanish water conflicts can be solved in the short or middle term. A crucial issue for that will be achieving a water pact between the main political parties so that water issues are not used as a political means to win votes for the next election.

vi By extension it seems that perhaps the most important issue to solve the global water problems is to achieve a more fair and equitable regulation of the food (virtual water) trade.

vii This better regulation would allow the reallocation of water rights or uses in the arid and semiarid regions and the use of the scarce water resources for the more profitable uses.

REFERENCES

Allan, T. (2011). *Virtual Water: tackling the threat to our Planet's most precious resource*. I.B. Tauris Publishers. 384 p.

Garrido, A.; Llamas, M.R.; Varela-Ortega, C.; Novo, P.; Rodríguez-Casado, R. & Aldaya, M.M. (2010). *Water Footprint and Virtual Water Trade in Spain. Policy Implications*. Series: Natural Resource Management and Policy, Vol. 35. Botín Foundation and Springer, New York, USA. 153 p.

GWP (Global Water Partnership) (2000). *Integrated Water Resources Management*. Technical Advisory Committee (TAC) Background Paper No. 4. Global Water Partnership, Stockholm, Sweden.

Hoekstra, A.Y. (ed.) (2003). *Virtual water trade*. Proceedings of the International Experts. Meeting on Virtual Water Trade, 12–13 December 2002. Value of Water Research. Report Series No 12, UNESCO-IHE, Delft, the Netherlands. Available from: www.waterfootprint.org/Reports/Report12.pdf [Accessed May 12th 2012].

Hoekstra, A.Y.; Chapagain, A.K.; Aldaya, M.M. & Mekonnen, M.M. (2011). *The Water Footprint Assessment Manual: Setting the Global Standard*. Earthscan, London, UK.

Llamas, M.R. & Delli Priscoli, J. (2000). *Report of the UNESCO Group on the Ethics of Freshwater Uses*. Papeles del Proyecto Aguas Subterráneas [Groundwater Project Papers], Botín Foundation, Santander, Spain. A Series, 5: 58–99.

Official State Gazette (2008). Approval of the Water Planning Instruction. Ministry of the Environment and Rural and Marine Affairs. Official State Gazette, 229, 22nd September 2008. Available from: http://www.boe.es/boe/dias/2008/09/22/pdfs/A38472-38582.pdf [Accessed May 15th 2012].