TEC BACKGROUND PAPERS NO. 20

Water Security: Putting the Concept into Practice

By Eelco van Beek and Wouter Lincklaen Arriens

Global Water Partnership
Technical Committee (TEC)

Global Water Partnership, (GWP), established in 1996, is an international network open to all organisations involved in water resources management: developed and developing country government institutions, agencies of the United Nations, bi- and multilateral development banks, professional associations, research institutions, non-governmental organisations, and the private sector. GWP was created to foster Integrated Water Resources Management (IWRM), which aims to ensure the co-ordinated development and management of water, land, and related resources by maximising economic and social welfare without compromising the sustainability of vital environmental systems.

GWP promotes IWRM by creating fora at global, regional, and national levels, designed to support stakeholders in the practical implementation of IWRM. The Partnership's governance includes the Technical Committee (TEC), a group of internationally recognised professionals and scientists skilled in the different aspects of water management. This committee, whose members come from different regions of the world, provides technical support and advice to the other governance arms and to the Partnership as a whole. The Technical Committee has been charged with developing an analytical framework of the water sector and proposing actions that will promote sustainable water resources management. The Technical Committee maintains an open channel with the GWP Regional Water Partnerships (RWPs) around the world to facilitate application of IWRM regionally and nationally.

Worldwide adoption and application of IWRM requires changing the way business is conducted by the international water resources community, particularly the way investments are made. To effect changes of this nature and scope, new ways to address the global, regional, and conceptual aspects and agendas of implementing actions are required.

This series, published by the GWP Global Secretariat in Stockholm, has been created to disseminate the papers written and commissioned by the Technical Committee to address the conceptual agenda. See the inside back cover for a list of publications in this series.

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Water Security:
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FOREWORD

The concept of water security has wide intuitive appeal as it expresses the main goal of water management, which is to improve the quality of life for everyone. It is a concept that provides politicians, business leaders, water professionals, and many different disciplines and interest groups with a common language. Water security is a starting point for negotiating the complexities of allocating limited water resources among many competing and often conflicting demands.

A water secure world is one where every person has enough safe, affordable, clean water to lead a healthy and productive life and where communities are protected from floods, droughts, and water-borne diseases. Water security promotes environmental protection and social justice by addressing the conflicts and disputes that arise over shared water resources. This is the Global Water Partnership's vision and, over the past 20 years, researchers and practitioners have sought to understand the economic, social, and environmental implications of increasing water security and what this means in practice.

There is now growing international consensus for increasing water security in a sustainable manner and for building more resilient and robust water systems and so the concept of water security is rapidly evolving from a vision to a development imperative. However, as yet there is no consensus on how to frame, approach, and operationalise what is a real and complex problem.

This landmark paper addresses these real issues. It brings together a wealth of information on what water security means and how to put this concept into practice. It discusses the many different ways in which it is currently being framed and operationalised through developmental and risk-based approaches. It describes the journey over the past two decades in which the process of integrating water resources management has developed and is reaching adulthood. People are beginning to see water management as a cross-sectoral issue which includes water for people, food, ecosystems, and industry, and they are looking ahead towards sustainable resource use and 'the future we want'.

But we cannot manage what we cannot measure and so measurement will be fundamental to increasing water security. This means identifying its various dimensions, setting targets, and seeking actions to achieve them. Thus, the final part of this paper deals with quantifying water security to enable practitioners to focus on current problems and set targets for improvement, assess the effect of planned measures, compare progress against benchmarks and experiences elsewhere, and learn lessons from good practice.

My thanks to the authors of this paper, Eelco van Beek and Wouter Lincklaen Arriens, who are members of the GWP Technical Committee for their comprehensive analysis of water security and its challenges and for setting down a clear pathway towards a more water secure world. I also extend thanks to the members of the GWP Technical Committee for their invaluable comments and suggestions during the preparation of this paper. I also wish to express appreciation for the editing support provided by Melvyn Kay.

Dr Mohamed AIT KADI
Chair, GWP Technical Committee

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EXECUTIVE SUMMARY

Increasing water security lies at the heart of GWP's vision and has attracted widespread attention in recent years. The term water security is intuitively attractive to express the main goal of water management: to improve the quality of life for people around the world. But how can this be put in practice?

Water security has multiple components, including supplies of sufficient good quality water to users and the environment; mitigating risks of flooding, drought, and pollution; and avoiding conflicts over shared waters. As such, water security has economic, social, and environmental dimensions, which reflect the pillars of integrated water resources management (IWRM). The authors argue that water security and IWRM are symbiotic and that adaptive management as embodied in IWRM processes helps to bring about water security – at national level, in river basins and cities, and at local level (e.g. in projects).

Water security can never be fully achieved, because ever-changing physical and economic conditions will require the continuous adaptation of water systems and behaviours in order to meet the growing demands and changing climatological conditions. Furthermore, there are no 'one-size-fits-all' solutions to increasing water security, and that appropriate measures will depend on local conditions and available coping capacity.

There are two approaches to increasing water security. The developmental approach seeks to increase water security over time. It identifies outcomes that are achieved over time through a combination of policies and projects. The risk-based approach seeks to increase water security by managing risks and reducing vulnerabilities resulting from climate variability and water-related disasters. Planners and practitioners should take care to avoid increasing water security in one location at the expense of other locations. A balance has to be achieved between upstream and downstream uses within a basin, and also between basin water use and 'virtual' water imported from regions that are already water insecure. Water footprint analysis helps to identify when this is the case. Another issue is how to prepare for increasingly uncertain futures with respect to socio-economic developments and climate change. Charting adaptation pathways will help to select appropriate strategies and projects.

Quantifying water security is important and will need much more attention in the years ahead. This paper explores some examples of how this can be done. A first step is to determine the relevant dimensions of water security. Examples include household water security, economic water security, and environmental water security. The dimensions selected will depend on the situation, and the specific objectives of stakeholders and decision-makers.

A second step is to select indicators that reflect the main characteristics of the key dimensions. For example, indicators and sub-indicators in agriculture, industry, and energy could measure economic water security. A third step involves measuring indicators, and scoring and combining indices for each of the dimensions of water security. Combining indices for all dimensions can provide an overall water security index. An important distinction is whether the assessment of water security will be for comparison and benchmarking (e.g. to compare water security among countries, cities, and river basins), or for decision-making (e.g. to determine a preferred investment strategy to increase water security in a specific case).

Understanding the concept of water security and its applications, including how to quantify water security, is still developing. The authors encourage planners and practitioners to start quantifying water security and to share the lessons they learn in the global community of practice facilitated by GWP. They also advocate simplicity. Clear concise presentations of quantified results are most likely to encourage decision-makers and stakeholders to take collaborative action.

WATER SECURITY: WHAT IT IS AND WHAT IT TAKES

Water security is high on the agenda of political and business leaders, and the academic community. As concerns about water resources grow, policy-makers, institutions, funders, and individuals are now using the term 'water security' to express their views. There is growing international consensus for increasing water security in a sustainable manner, and for building more resilient and robust water systems. However, as yet there is no consensus on framing and approaching what is a real and complex problem. Nevertheless, water security as a concept provides different disciplines and interest groups with a common language and starting point.

So what is water security? What does it mean in practice? If we are to improve water security can we quantify it and measure it? What can we measure that reflects the dimensions of water security we value? What is it feasible to actually measure? These are key questions to which policy-makers, who are responsible for making well-informed decisions and investment in national and regional development, seek answers.

Operationalising the concept of water security means identifying its various dimensions, setting targets, and seeking action to achieve these targets. This will be a complex process and will take time. Gradual steps will improve our understanding but the heart of increasing water security lies in:

- ensuring the availability of adequate and reliable water resources of acceptable quality to provide water services for all social and economic activity in a manner that is environmentally sustainable;
- mitigating water-related risks such as floods, droughts, and pollution; and
- addressing the conflicts that may arise from disputes over shared waters, especially in situations of growing stress, and turning them into win-win solutions.

This paper brings together current thinking about water security and suggests ways of putting the concept into practice. It draws on the scientific literature and on the experiences of partners in the GWP knowledge chain in applying the concept in practice. The paper has three parts. The first part explains the concept of water security and describes the different frames in which the concept is used. A distinction is made between the developmental approach and the risk-based approach to water security. The second part describes the relationship between the concept of water security and IWRM and argues that they are symbiotic and that water security should be seen as the goal of IWRM. The third part proposes frameworks to quantify water security, giving examples and recommending how to apply them at the national, river basin or city, and project scale. There is no 'one-size-fits-all' solution. Solutions to increase water security will need to be adapted to the local conditions in each country, river basin, city, project, and other area of management.

Box 1. GWP's vision of a water secure world

A water secure world is vital for a better future: a future in which there is enough water to support social development, sustainable and inclusive growth, and ecosystems. In a water secure world, we will respect the intrinsic value of water and recognise its vital role in supporting human lives and livelihoods.

A water secure world harnesses the productive power of water and minimises its destructive force. It is a world where every person has enough safe, affordable, clean water to lead a healthy and productive life. It is a world where communities are protected from floods, droughts, landslides, erosion, and water-borne diseases. Water security promotes environmental protection as well as social justice, and addresses the impacts of poor water management. All of these will become even greater challenges as climate variability increases.

A water secure world reduces poverty and improves living standards. The human right of access to clean water and sanitation are now enshrined in international law. Putting this into practice will improve the quality of life for the most vulnerable, especially women and children, who benefit most from good water governance.

We believe that an integrated approach to managing and equitably sharing the world's limited water resources among the many different and competing uses is the best way to achieve a water secure world.

Source: GWP (2014) GWP Strategy Towards 2020 - A Water Secure World

Water security as an emerging paradigm

Water security is rapidly evolving from a vision into a development imperative. In 2009, the World Economic Forum (WEF) prioritised water security as a global risk, stating that 'water security is the gossamer that links together the web of food, energy, climate, economic growth, and human security challenges that the world economy faces over the next decades' (WEF, 2009). The international water community began using the term 'water security' much earlier. At the 2nd World Water Forum in 2000, the

World Water Council (WWC) introduced its vision for 'A Water Secure World – Vision for Water, Life, and the Environment,' (WWC, 2000) and the GWP published 'Towards Water Security: A Framework for Action' (GWP, 2000).

'Water security' has triggered academic researchers and practitioners to review the concept in scientific articles, edited books, and publications, using different framings and scales (Cook & Bakker, 2012; Lankford et al., 2013). So how is water security being framed and defined, and at what scales can it be applied?

Box 2. Water security as defined by GWP in 2000

Water security, at any level from the household to the global, means that every person has access to enough safe water at affordable cost to lead a clean, healthy, and productive life, while ensuring that the natural environment is protected and enhanced.

Framing the dimensions of water security

Water security is not only about having enough water. It involves all issues related to water. In simple terms, water security addresses the 'too little', 'too much', and 'too dirty' issues of water management. These are the problems that many people face, and which good water management should solve or at least alleviate. But, water security is much more than this. It is about mitigating water-related risks, such as floods and droughts, addressing conflicts that arise from disputes over shared water resources, and resolving tensions among the various stakeholders who compete for a limited resource. Water is recognised as a central plank of the green economy. It is critical to sustainably managing natural resources and it is embedded in all aspects of development – poverty reduction, food security, and health – and in sustaining economic growth in agriculture, industry, and energy generation.

Water security has three key dimensions – social equity, environmental sustainability, and economic efficiency – also known as people, planet, and profit (the three Ps).

Economic dimension

- increasing water productivity and conservation in all water-using sectors
- sharing economic, social, and environmental benefits in managing transboundary rivers, lakes, and aquifers.

Social dimension

- ensuring equitable access to water services and resources for all through robust policies and legal frameworks at all levels
- building resilience in communities in the face of extreme water events through both hard and soft measures.

Environmental dimension

- managing water sustainably as part of a green economy
- restoring ecosystem services in river basins to improve river health.

There are two approaches to addressing water security. One is a developmental approach that seeks to improve water security over time. This approach typically seeks outcomes, in the form of goals and targets, through a combination of policies, reforms, and investment projects. The second is a risk-based approach, which seeks to manage risks and reduce vulnerability to shocks resulting from climate variability and water-related disasters. In this paper, we argue that these two approaches are complementary, and need to be pursued simultaneously and in a balanced manner.

Developmental approach

The developmental approach can frame water security in many ways. This ranges from a narrow disciplinary or 'special interest' focus to one that is broad, integrated, and comprehensive. A narrow disciplinary approach is valid, and even preferable in some situations, as it focuses attention on the core, critical water security issues for a country or location (Table 1). As water scarcity and variability increase, water security may also be framed to particular interest groups such as an industry, city, province, or island. On a much larger scale, the USA investigated the impacts of various river basins across the world in the frame of US national, political, and economic interests (ICA, 2012).

An example from Java takes a developmental approach but with a 'special interest' focus. In this case water security draws upon key dimensions from national water legislation (Ministry of Public Works, 2012). It focuses on specific issues of erosion and sedimentation, which are major water security issues on the island (Box 3).

Box 3. Java Water Resources Strategic Study (JWRSS)

Water security as defined in Indonesia's Water Resources Law:
- conservation of water resources
- utilisation of water resources
- control of damage from water

Indicators:
- water utilisation (sufficient, stressed, shortage)
- flood management (no of people, share of people affected, hindrance for traffic)
- erosion and sedimentation (low, medium, high impacts)
- water quality (quality of river water compared to standard)

Table 1. Narrow disciplinary framing of water security - selected examples

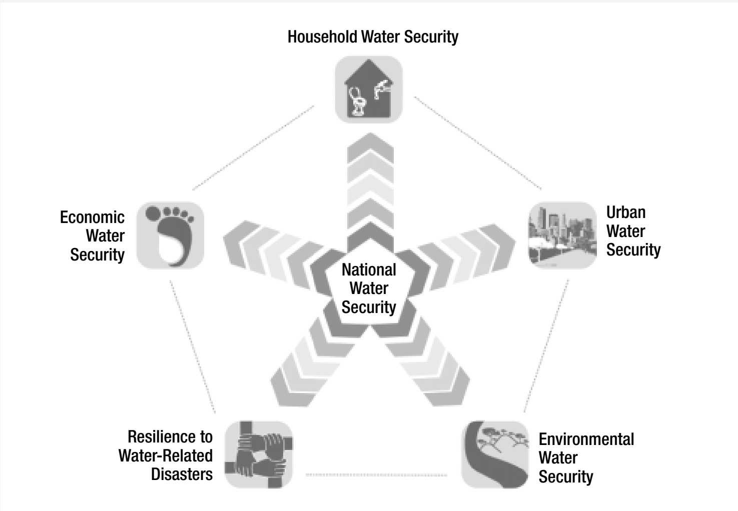
Discipline	Water security focus or definition
Agriculture	Input to agricultural production and food security
Engineering	Protection against water-related hazards (floods, droughts, contamination, and terrorism) Supply security (percentage of demand satisfied)
Environmental science	Access to water functions and services for humans and the environment Water availability in terms of quality and quantity Minimising impacts of hydrological variability
Fisheries, geology/ geosciences, hydrology	Hydrologic (groundwater) variability Security of the entire hydrological cycle
Public health	Supply security and access to safe water Prevention and assessment of contamination of water in distribution systems
Anthropology, economics, geography, history, law, management, political science	Drinking water infrastructure security Input to food production and human health/wellbeing Armed/violent conflict (motivator for occupation or barrier to cooperation and/or peace) Minimising (household) vulnerability to hydrological variability
Policy	Interdisciplinary linkages (food, climate, energy, economy, and human security) Sustainable development Protection against water-related hazards Protection of water systems and against floods and droughts; sustainable development of water resources to ensure access to water functions and services
Water resources	Water scarcity Supply security (demand management) "Green" (versus "blue") water security

Source: Cook and Bakker (2012)

However, a broad, intersectoral, and collaborative multi-stakeholder framework approach is essential in order to take account of all the important dimensions of water security. This is particularly so where water is seen as a critical resource for sustainability in countries, river basins, cities, and other entities, such as islands, in the context of interdependent regional and global trade and development. The following are two recent examples of this broad approach to assessing water security.

The Asian Development Bank (ADB) and the Asia-Pacific Water Forum, in collaboration with ten knowledge partner institutions, developed a comprehensive framework for national water security (AWDO, 2013). It is an outcome-based approach and crafts a comprehensive vision of water security recognising the need for security in households, economies, cities, the environment, and resilient communities. The framework transforms the vision of water security into a quantitative assessment in five key dimensions (Box 4).

Box 4. Asian Water Development Outlook (AWDO) approach to framing water security



Societies enjoy water security when they successfully manage their water resources and water services to:

- satisfy household water and sanitation needs in all communities
- support productive agriculture and industry
- develop vibrant, liveable cities and towns
- restore healthy rivers and ecosystems
- build resilient communities that can adapt to change.

Source: AWDO (2013)

The key dimensions of water security are related, interdependent, and should not be treated in isolation. Measuring water security by aggregating indicators in these key dimensions recognises their interdependencies. Increasing water security in one dimension may simultaneously increase or decrease security in another dimension and affect overall national water security. This integrated approach reflects efforts to 'break traditional sector silos and find ways and means to manage the linkages, synergies, and trade-offs among the dimensions'.

The AWDO assessment focused on countries, and targeted government leaders and ministers of finance and planning. It relied on publicly available data and initially assessed Asia-Pacific countries. The assessment then expanded to include countries in four other regions. The approach was also piloted at river-basin level in three countries.

The Overseas Development Institute (ODI), UK, identified five key themes for an inclusive water security framework (Mason & Calow, 2012):

- availability and access: water security goes beyond immediate physical availability
- risk and variability: water security needs to address risks such as floods and droughts
- equity and livelihoods: water security needs a human focus
- ecosystems and biodiversity: water security must meet environmental needs
- institutions and actors: water security should address management, competition, and conflict.

Both AWDO and ODI have similar approaches and identify a limited number of key dimensions of water security. AWDO assessments focus on outcomes and treat water governance independently as a crosscutting issue and an enabling factor. ODI includes governance within in its five key themes. Some argue that institutions and actors are a condition for increasing water security and not a key dimension (goal) per se.

Risk-based approach

The risk-based approach to water security looks at how societies cope with variability. Rainfall, in particular, can be unpredictable and highly variable. There will always be dry and wet years and within those years there will be wet and dry periods. Many societies cope with variability by growing rainfed crops in wet periods, by investing in irrigation, and by building reservoirs with over-year storage to secure drinking water supplies for cities. Whatever steps are taken it is not possible to eliminate all water-related risks. This may be technically possible but may be too expensive. The question is – how much risk is socially acceptable? The answer depends on the socio-economic impacts of system failure. In agriculture a 20% risk (1 in 5 years) is often considered acceptable. Designs for urban drinking water supply systems consider a much lower level of risk (e.g. 1 day in 5 years) acceptable.

A risk-based approach to water security generally consists of three steps: (i) knowing the risks, (ii) setting targets, and (iii) managing the risks. Various frameworks apply this approach (Rees, 2002; Renn and Graham, 2006; OECD, 2013). The main challenge is to define, in step (ii), the risks that are acceptable, tolerable, or intolerable. Figure 1 illustrates the relationship between risks, probability, and impact.

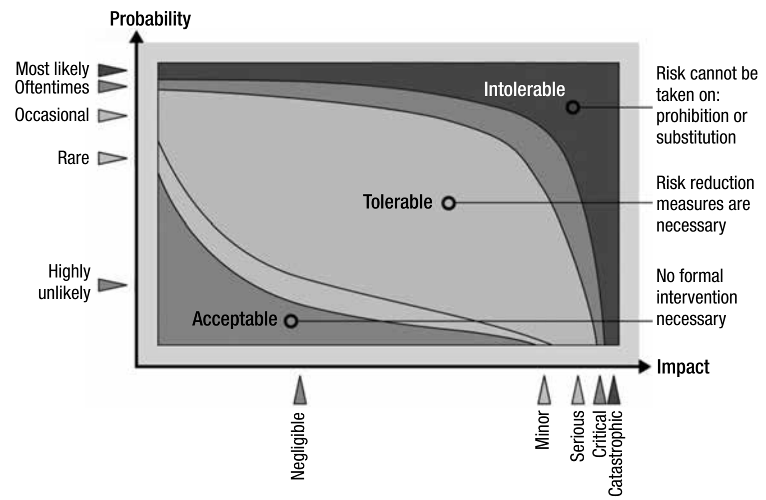


Figure 1. Acceptable, tolerable and intolerable risks. Source: Klinke and Renn (2012)

While the 'present' risks of climate variability are reasonably well known from statistical analysis of historical records, 'future' risks are unknown. This uncertainty applies not only to climate change and socio-economic development, but also to society's perspectives on what is acceptable and tolerable. Perspectives may change, depending on socio-economic conditions.

Two challenges deserve special attention in the risk-based approach.

First, some low-income countries are highly vulnerable to water-related disasters and poorly endowed with water resources. In such countries, advances in economic growth can be repeatedly reversed in a vicious cycle of droughts and floods. To prevent these reversals, countries need to reduce risks and achieve a minimum (threshold) level of water security. This may mean combining investments in infrastructure with improvements in governance to put their economies onto more sustainable growth pathways.

Second is the challenge to harmonise public and private sector perspectives on risk. Businesses increasingly recognise the need for partnerships in cities and river basins in order to manage their short, medium, and long-term risks in an integrated manner. In 2013, 70% of companies engaged in the United Nations CEO Water Mandate initiative reported exposure to water-related risks that could substantially affect their business (Orr, 2013). More often than not, however, governments, businesses, and civil society still speak different languages when addressing water security, IWRM, and risk management. This lack of effective communication can hinder collaboration and developing solutions.

Defining water security at scale

While there is growing agreement that water security is a development imperative – not just for water management, but for sustainable development – there is no universal agreement yet on how water security is defined. Is there a minimum level of water security that would allow households, cities, river basins, and countries to develop without the risk of having their economies wiped out by the next flood or drought? If so, how do we define and measure it? Or should we adopt a more development-oriented approach to achieve full water security in stages? And how do we address water security at different scales?

Grey and Sadoff (2007) offer the most widely accepted definition of water security (Box 5). This definition firmly embeds sustainable development–development that seeks to ensure a triple bottom line of social, environmental, and economic outcomes. Moreover it can be interpreted at different scales and it acknowledges that risks to people, environments, and economies will always persist, whatever is done to improve water security.

Box 5. Defining water security

The availability of an acceptable quantity and quality of water for health, livelihoods, ecosystems, and production, coupled with an acceptable level of water-related risks to people, environments, and economies.

Source: Grey and Sadoff (2007)

UN-Water's 'working' definition of water security (Box 6) illustrates the difficulty in reaching a unanimously accepted definition. UN-Water uses this definition to provide a common framework for collaboration across the UN system. The scientific literature includes many more definitions of water security (Cook & Bakker, 2012). Most have similar elements to those offered by Grey and Sadoff, and UN-Water. Definitions also vary geographically, reflecting the specific conditions that apply in a region or country. In arid areas, such as Australia and North China, definitions focus on water availability. In the Middle East and North Africa (MENA) region the focus is on sharing a scarce resource amid increasing demand in an unstable geopolitical situation. Different definitions for different conditions can encourage recognition and acceptance of the concept of water security among stakeholders and decision-makers.

Box 6. UN-Water Analytical Brief on Water Security and the Global Agenda

Water security is the capacity of a population to safeguard sustainable access to adequate quantities of acceptable quality water for sustaining livelihoods, human wellbeing, and socio-economic development, for ensuring protection against water-borne pollution and water-related disasters, and for preserving ecosystems in a climate of peace and political stability.

Source: UN-Water (2013)

Some definitions of water security take account of governance issues. However, governance can best be seen as a means to an end and not as an end in itself. Water security is defined as a goal, and so it can be argued that conditions and processes should not be included in outcome statements.

Water security relies on effectively integrating water resources management at various scales, in particular at national, river basin, and local scales and includes the essential elements of economic efficiency, social equity, and environmental sustainability.

People assign meaning to the concept of water security depending on the scale at which it is applied. Most reports to date address water security at a national scale. This, together with food and energy security, underlines the critical importance of water security to countries' sustainable development.

Most commonly, water security is addressed at country, river basin, city, and community scales. In some cases, water security may be considered for a specific region or unit, such as a large metropolitan area, a delta, or an island. Although the broad definition of water security is applicable at all scales, it is logical, at each scale, to focus on specific issues. Considering water security at the national level facilitates strong links with national goals on food security and energy security. For countries that share water resources, considering water security at the national level also helps to clarify transboundary issues. Applying the concept at community level puts more emphasis on individual water users and their social and environmental context.

Water and other securities

Applying the concept of water security at different scales raises the question – who benefits from water security? This is critical from the viewpoint of social equity, and equitable benefits from shared water resources. At a national scale this can apply to upstream or downstream countries that share the same water resource. Where inter-basin water transfers are being considered it will be important to look at the impacts this has on alternative potential uses in the donating basin.

Globally, food production accounts for over 70% of all water withdrawals and as much as 90% in arid countries. Thus, there is a strong link between water security and food security. Countries need to strike a balance between the amount of food they produce locally, using available water resources, and the amount of food they import, which consumes water elsewhere. Importing food can 'release' water locally for other purposes that would otherwise be consumed by crops. Many countries already rely heavily on food imports as they do not have sufficient water resources to grow all their own food. The question arises – what are the costs of ensuring food security? Costs include the environmental (including water) effects of growing crops in exporting countries. In the UK, food imports account for nearly two-thirds of the water consumed to meet the nation's food requirements (WWF, 2008). Some of this 'virtual water' (Allan, 1998; Hoekstra & Chapagain, 2008) comes from areas where water is scarce, for example in oranges imported from Egypt (Nile River) and potatoes from Israel (Jordan River). Zeitoun (2011) describes the environmental and social problems related to exporting asparagus from the desert Ica Valley in Peru and pleads for a broad interpretation of the term water security that includes the other 'securities'.

These examples underline the importance of addressing water security and other security issues together. The extent to which this is important depends on scale. At a national level, Zeitoun (2011) presents a global 'web' to demonstrate the way in which national water security explicitly influences other securities (Figure 2).

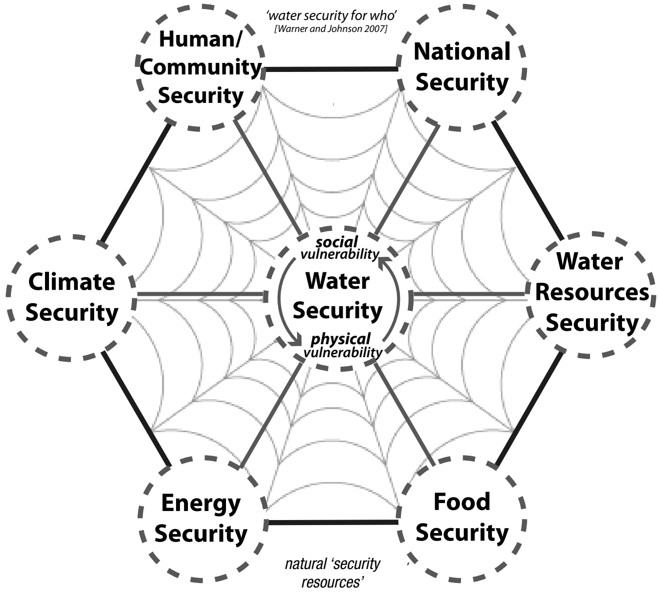


Figure 2. The global 'web' of national water security. Source: Zeitoun (2011)

This approach makes sense considering that most countries set specific targets with respect to food, energy, and WASH (water, sanitation, health). But, at the level of basins or specific regions, such targets are often not set or not applicable. Urban communities, for example, rely mostly on food imported from outside the area. Even then, in determining the water security of such area, various key dimensions have to be taken into account. These have strong relations with national securities.

In many countries the link between national security and water security is increasingly recognised. Threats from terrorist action on key water installations, for example, could seriously disrupt a nation's economy and household water security. In the USA the word 'security' is strongly linked to national security, and the safety and protection of public facilities against threats. This has led some to seek an alternative for the term 'water security' in the international discourse.

FROM IWRM TO WATER SECURITY

The concept of water security is closely aligned to integrated water resources management (IWRM) as all its principles, particularly the idea of integration, are embedded in the concept of water security. Indeed, IWRM provides an integral and important part of the pathway towards increasing water security.

IWRM origins

The origins of IWRM are now part of water resources history (Ait Kadi, 2014). The establishment of the Tennessee Valley Authority (TVA) in 1933 is an early example of bringing together the different facets of water use, such as navigation, flood control, and power production, for economic development (Snellen & Schrevel, 2004). But modern ideas about the need for integration in and across the water sector have their roots in the 1977 international water conference, which led to the Mar del Plata Action Plan. In 1992 IWRM was incorporated in what have now become known as the 'Dublin Principles', the precursor to incorporating IWRM in Agenda 21 of the United Nations Conference on Environment and Development (UNCED). This was about improving water resources management by connecting the many different water services and providing good governance, appropriate infrastructure, and sustainable financing. In 1996, GWP was founded to promote IWRM and provide a forum for dialogue among corporations, governmental agencies, water users, and environmental groups to promote stability through sustainable water resources development, management, and use. In 2002, the World Summit on Sustainable Development (UN, 2005) in Johannesburg called for the development of IWRM and all countries agreed to develop IWRM and water efficiency plans.

IWRM marked a fundamental shift away from the traditional top-down, supply-led solutions to water problems dominated by technology (McDonnell, 2008). When water was plentiful and abstractors few, the rules of water sharing in most societies were few and basic. But as water use increased, and shortages occurred, and awareness grew of the impacts this had on the environment, more complex institutions were needed to negotiate and coordinate water allocations among different users. Administrations responsible for developing and managing water resource infrastructure had to pay more attention to managing and protecting the resource (Muller & Lenton, 2009).

What integration means

An integrated approach to water resources management is a concept that few would now argue against. It is seen as the most effective way of managing limited water resources in the face of competing and often conflicting water demands. So much so that the idea of a 'silo' or fragmented approach to managing water would seem archaic today.

At first 'integration' meant bringing together water resources, engineering, and economic driven solutions. But there was an increasing realisation that the way land is managed affects water resources and vice versa, and that water quantity could not be managed in isolation from water quality. As demand for water increased it became clear that bridges were needed between human and natural systems and between the water sector and the economy. 'Vertical' bridging was also needed across levels of decision-making from local, provincial, and national to river and transnational basins. So, the idea of integration grew to include decentralised approaches to water management that were holistic, appreciated local ideas, and involved demand management (McDonnell, 2008). But, integration did not mean that everything needed to be together and managed under 'one roof' or that sectoral decision-making should be abandoned. On the contrary, these mechanisms were considered to be both undesirable and unworkable. What was clear though, was that integration meant increasing complexity and this has undoubtedly contributed to concerns about fully achieving it.

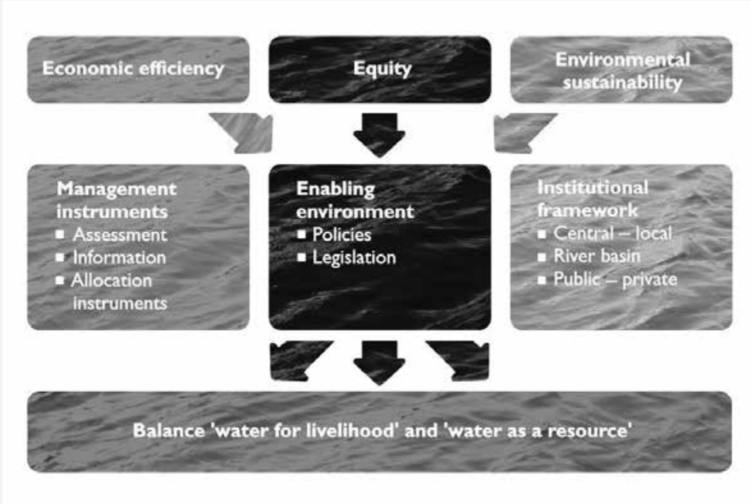
Box 7. The Global Water Partnership (2000) defined IWRM

"IWRM is a process which promotes the coordinated development and management of water, land, and related resources in order to maximise the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems."

IWRM is defined as a process; it does not offer a 'blueprint' approach to water management. Water resources are different from place to place and so too are development priorities and social and economic issues. Country or water basin planning may differ but IWRM provides a common approach and experience shows that there are features common to all. These include a strong enabling environment; sound investments in infrastructure, clear robust and comprehensive institutional roles; and effective use of available management and technical instruments. These are the practical elements of implementing IWRM (Muller & Lenton, 2009).

Cont.

Box 7. Cont.



Since its inception in 1996 GWP has driven a worldwide movement towards IWRM. It has helped countries around the world to: (1) recognise basic principles that underpin good water management; (2) develop a stronger enabling environment of policies and laws; (3) build more appropriate institutional frameworks; and (4) share, adopt and adapt management instruments and tools. (Ait Kadi & Arriens, 2012).

Since the Johannesburg commitment in 2002, many nations began to develop IWRM and water efficiency plans. Substantial evidence to support an integrated process has come from the UN status report on Integrated Approaches to Water Resources Management (UNEP, 2012) published in time for the Rio+20 Conference in 2013. Some 134 nations across the world responded to the survey carried out to determine progress towards sustainable water resources using integrated approaches measured against such practical elements as a strong enabling environment; sound investments in infrastructure, clear robust and comprehensive institutional roles; and effective use of available management and technical instruments (Muller and Lenton, 2009).

IWRM is not without its critics. They suggested it focuses too much on process (enabling environment, institutional framework, management instruments) and is not specific in what it is meant to achieve. Others say IWRM has rarely, if ever, been achieved in reality (Watson, 2007). The concept of water security overcomes these criticisms by moving the focus from process to outcomes. Thus IWRM is important but is not an objective by itself. What ultimately matters is to improve services that good water management provides, such as supplying good quality water, protecting people from droughts and floods, and providing a healthy environment for people and ecosystems. These are the end goals of an integrated approach and together they comprise the concept of water security.

The process of integrating water resources management is now reaching adulthood. It has changed the way people think about water management from a sub-sectoral approach to a cross-sectoral approach which includes water for people, food, ecosystems, and industry. IWRM is usually applied at a basin scale to include all upstream-downstream aspects. The ultimate goal is to achieve a water system which is economically efficient, socially equitable, and environmentally sustainable. Together this allows a better balance between the management of water as a service and as a resource.

Looking ahead, water management needs to respond to the worldwide movement and enthusiasm towards sustainable resource use and 'the future we want'. Societies have already become more conscious of the problems of water scarcity and how they are all closely inter-connected. The problems of climate change for example, are interlinked with the problems of water security, food security, and energy security. These interconnections are often ignored when policy-makers devise partial responses to individual problems. They call for broader public policy planning tools with the capacity to encourage legitimate public/collective clarification of the trade-offs and the assessment of the potential of multiple uses of water to facilitate development and growth.

IWRM and water security are symbiotic

IWRM and water security clearly have the same general objective – improving the conditions related to water for human wellbeing. The question arises as to whether these concepts are overlapping or to what extent they are complementary. Both take a broad view of the issues related to water and ask for an integrated approach across sectors and scales. IWRM is well established and understood in many countries while the concept of water security is still developing. One might wonder whether they are the same concept but packaged differently (Lautze & Manthrithilake, 2012)?

Absolute water security can never be achieved because conditions will change, demand for water will continue to grow, and limited financial resources will constrain what can be done. IWRM will help improve water security although improvements will depend largely on the amount and quality of resources invested in the effort. Thus, IWRM and water security are symbiotic and this is factored into the continuous IWRM planning cycle (Figure 3). An important step in the planning cycle is the 'situation analysis' in which the problems are identified and goals set. Water security quantifies those goals by identifying the dimensions of water security and specifying indicators to measure this, preferably including clear targets.

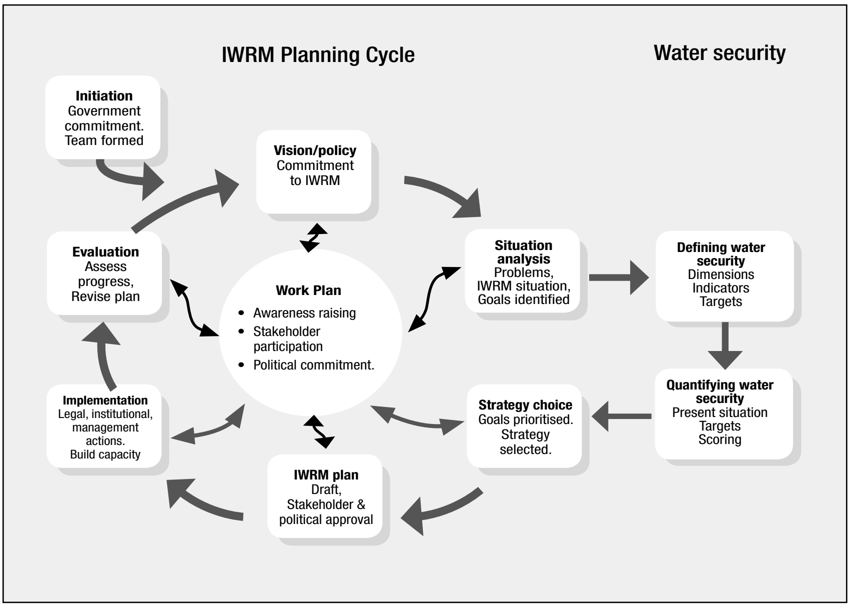


Figure 3. Factoring water security into the IWRM planning cycle

Some though are less sure about the complementarities between IWRM and water security. Bakker and Morinville (2013) reviewed several governance dimensions of water security, and suggested that IWRM does not deal with the inherent uncertainties in water management and focuses too much on river basins as planning and management units. Most of the concerns stem from rather limited view of IWRM as a rigid, water-centric paradigm. In practice, IWRM offers a framework for addressing water-related problems and issues. How this is done depends on the specific context and will, and in some cases should, include a risk-based and adaptive approach to deal with inherent uncertainties. In cases where supra-regional objectives and multi-scale links are important, IWRM should look beyond the river-basin scale. An example of this is the water-food-energy nexus. The very purpose of IWRM is to deal with multi-user and intersectoral allocation issues, manage trade-offs, and capitalise on synergies. But, to do this, water managers have to come out of the 'water box' and learn to work closely with professionals in other sectors.

Implications for governance

As water security focuses on the end goals of water management, there are implications for water governance. IWRM places the water system at the centre of planning and operational management (the 'water box') which needs to account for water balance considerations and upstream-downstream users when developing and managing water systems. This is best done at a river-basin scale. As a logical next step IWRM encourages a governance approach at river-basin scale by means of river-basin organisations, in which all key stakeholders are represented. However, outcomes, such as sufficient water for food and energy security, are not restricted to river basins but are higher level, often national-scale goals. The IWRM process accommodates these outcomes at different scales.

A risk-based approach to water security also has an important consequence for governance. As the future is uncertain, an adaptive approach to water management is needed, which in turn requires an adaptive governance structure, partly based on social learning.

Bakker and Morinville (2013) also refer to the centrality of social power in negotiating conflicts generated by tensions between the various end goals of water security. Differences in social power should be addressed in governance structures.

The governance issues in water are not new; they have frequently featured in discussions on putting IWRM into practice. Governance has been addressed before, in particular in applying IWRM at national level, such as in National IWRM Plans. However, the concept of water security does make these issues more explicit. As with IWRM, there is no 'one-size-fits-all' solution to improve governance for water security. Local conditions determine what will be the 'best' governance structure for each specific situation.

Adapting to change

The context of water security is constantly changing. Demand for water may increase as a result of population growth and economic activities. Supplies of water may decrease due to climate change. Protection from water risks may get better as people's life styles improve. Putting IWRM into practice is a process of adaptive management – a virtuous spiral of incremental progress and adaptation (UNESCO, 2009) that increases the economic, social, and environmental benefits of water resources while maintaining a balance among uses and users (Figure 4).

In any location, the water management actions of today will build on the achievements and experiences of the past. The spiral process is continuous as basin stakeholders build on their strengths and experiences, work to manage current needs, and invest to prepare their river basin (and cities in the basin) for the future. Anywhere and at anytime, stakeholders can assess their situation and options and determine the best way to proceed (keys for success), and thereby move up the spiral.

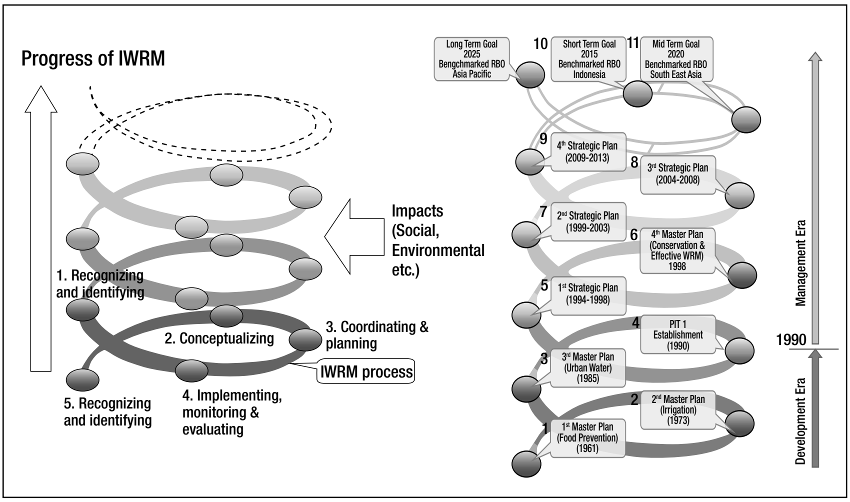


Figure 4. IWRM as a process of adaptive management – resulting in a spiral of progress (left), illustrated by the development in planning and management of the Brantas River in Indonesia (right). Source: UNESCO (2009).

The economic value of increased water security

Infrastructural and management interventions in water systems are costly and so economic analysis has to provide insight into the costs and benefits of interventions, comparing the present 'state of the world' with some planned future state. Estimating costs is the easy part. Estimating the benefits requires a sound understanding of the value of water to users, which is usually context dependent. Moreover, some water use is often not fully consumptive and so can be used again in the same basin. This makes the perspective of a State (government), on the economic value of water, different to that of households. The State should consider the value of the whole system while households only look at the direct value that water has for them. Whittington et al. (2013) provides an overview of these issues:

- water security by itself cannot be expressed in terms of economic value (What economists can provide is the economic value of moving from one level of water security to another, i.e. increased water security.)

- in determining this economic value the different perspectives of households and States should be taken into account
- a State should carefully consider users' perceptions about the economic value of water interventions as they determine how the services are being used; and the willingness of users to contribute financially to investment, operations and maintenance (cost recovery)
- individual decisions on investments should be considered as steps along a long water development path. (Each decision should be economically justified. To account for uncertainties in the future, scenario analysis should be used to explore alternative future states of the world.)

Coping capacity and water security

Increasing water security often requires a combination of technical, economic, operational, legal, and institutional interventions. The concept of water security can help to determine which measures have priority. The choice of measures depends on the conditions and on the goals. Each specific situation has its own issues and context that influence what can and should be done. Table 2 shows degrees of water stress (low or high) and financial and governance capacities to cope with water security issues (Ait Kadi & Arriens, 2012). It describes the particular water security issues that may exist under these conditions and the measures that can be taken to increase water security at the national level.

Table 2. Water security matrix at national level – what can be done under low and high water stress

Water	Coping capacity	
	LOW	HIGH
LOW	**Water security issues:** Vulnerability to floods Pollution Increasing needs for water and sanitation services (mainly to large cities) **Increasing water security through:** Development of an appropriate stock of infrastructure (storage, flood control, etc.) Proper legislation and adequate institutions Integrated and comprehensive water planning	**Water security issues:** Mitigate for past, present and future pollution Ecosystems need for water Legal frameworks ensuring access for all **Increasing water security through:** Effective legal frameworks at a range of scales Economic incentives More ethical management
HIGH	**Water security issues** Water demand growing fast Water availability falling to crisis level Overexploitation of groundwater Shortages compounded by pollution Low efficiency of irrigation Vulnerability to floods/droughts **Increasing water security through:** Optimal mix of increasing supply and managing demand Strengthening the institutional capacities and adopting a more cohesive and integrated legal framework Developing appropriate mechanisms for intersectoral water allocation	**Water security issues:** Declining water resources Pollution abatement Environmental requirements Conflicts of use **Increasing water security through:** Water conservation and reuse Sustainable policies and legal frameworks and institutions for water management and dispute prevention and resolution Strengthening waste water and pollution control through enforceable legal and institutional mechanisms

At the national level, general enabling measures should be developed and implemented. But more specific actions may be required at regional and local levels. Good governance will be required whatever the level, together with sound political, legal, and economic institutions and instruments. The higher the level of institutionalisation and governance, the more water security is likely to be increased.

Virtual water, water footprints, and water security

Increasing water security for a specific country or basin should not be at the expense of decreasing water security elsewhere. One way to increase water security is to reduce the demand for water, for example by importing foods that require substantial amounts of water from other countries. Another example would be to reduce environmental damage by closing certain polluting industries at home and importing products from abroad. Increasing water security in a country by importing 'virtual water' in this way may be at the expense of water security in the exporting countries. Bearing in mind the ultimate goal of global water security, it is desirable that such imports should not come from countries or basins that themselves have problems achieving water security. The concepts of virtual water and water foot prints provide insight into these global connections and may lead to more rational and ethical decisions on what to grow or produce, where and, if imports are considered, where to import from.

Most products used in daily life need water to produce them. Crops need water to grow. Industrial products need water for processing, washing, and cooling. Water embodied in products is referred to as 'virtual water'. Allan (1998) introduced the concept of virtual water in studies exploring the possibility of importing virtual water (as opposed to real water) as a partial solution to water scarcity in the Middle East. By consuming products we are also consuming the virtual water associated with these products. In other words, our consumption of virtual water is part of our total water footprint.

Box 8. Volume of water needed to produce

1 sheet of A4 paper:	10 litres
1 slice of bread:	40 litres
1 egg:	140 litres
1 pair of leather shoes:	8,000 litres
1 pair of blue jeans:	11,000 litres
1 kg of beef:	15,400 litres
1 car:	150,000 litres

Source: Hoekstra and Chapagain (2008)

The source of virtual water can be 'blue' or 'green' (Falkenmark, 2003). Green water refers to rainwater, while blue water refers to ground or surface water. The water footprint approach also includes 'grey' water. This takes account of water pollution from domestic sewage, industry, and agriculture and refers to the volume of freshwater needed to lower the concentration of these pollutants to acceptable levels[1]. For example, producing a pair of jeans requires about 6,000 litres of 'green' water, 3,600 litres of 'blue' water, and another 1,400 litres of freshwater to reduce the concentration of pollutants from the production process to an acceptable level.

The essential message of water foot-printing is to show the water use related to consumption while the traditional water balance approach shows water use in relation to production. Given the limited data on water availability,

[1] The term 'grey' water in virtual water terminology is different from the use of the term 'grey' water in the water industry which refers to waste-water.

analyses of water footprints are typically carried out at national level and include both water used in production (agriculture, industry) and consumption of products (internal and external). Together they provide information on virtual water flows out of the country (production minus internal consumption) or in-country (external consumption).

Water footprints help to address the question 'water security for who?' Information on water footprints helps to better identify those aspects of production responsible for water stress and makes clear how much water is 'exported'. Equally water footprint analysis shows how much water is consumed by importing products. Products may come from countries or regions where water is in short supply and so concerns about water security should not be limited to our immediate locality. Actions, such as importing food and other goods, may well increase water insecurity in the exporting country. However, 'exporting' water is not necessarily a bad thing, even in water-stressed situations, when the economic value added contributes to social wellbeing.

Economists tend to disagree about minimising water footprints (Falkenmark, 2003; Whittington et al., 2013). Intuitively, however, it makes sense to reduce water footprints in the same way that it make sense to get 'more crop per drop' when growing food crops. However, in the case of food production, water is only one factor. Other factors, such as labour availability and quality of arable land, also determine the most efficient production method. Still, the concept of water footprints helps us to understand some of the causes of water insecurity and what kinds of actions might be needed to improve the situation.

Dealing with future uncertainties through adaptation

Increasing water security requires decisions on interventions and investment. Making these decisions requires answers to questions such as – What will the future look like? How much water will be needed? How much water will be available? How will the risks of droughts and floods change?

Socio-economic developments and climate change effects are hard to predict. Witness the changes that have taken place over the past decade, none of which were predicted at the turn of the century. Potential developments need to be taken into account but uncertainties influence what needs to be done and when. We do not want to do too much or too little; and we do not want to act too early or too late. This requires us to take an adaptive approach which means that we only do what absolutely must be done now and in the near future (e.g. next 10 years). We then monitor what happens and take further action if or when the situation requires it. Nevertheless, this approach means we still need to anticipate what could happen in the more distant future (e.g. next 100 years). Techniques, such as decision trees (Sayers et al., 2012) are available to explore these distant futures, determine tipping points[2] (Kwadijk et al., 2010), and analyse pathways. Figure 5 is an example of a pathway analysis in which nine possible paths are explored, taking into account the tipping points of current (after 3 years) and possible future actions (interventions).

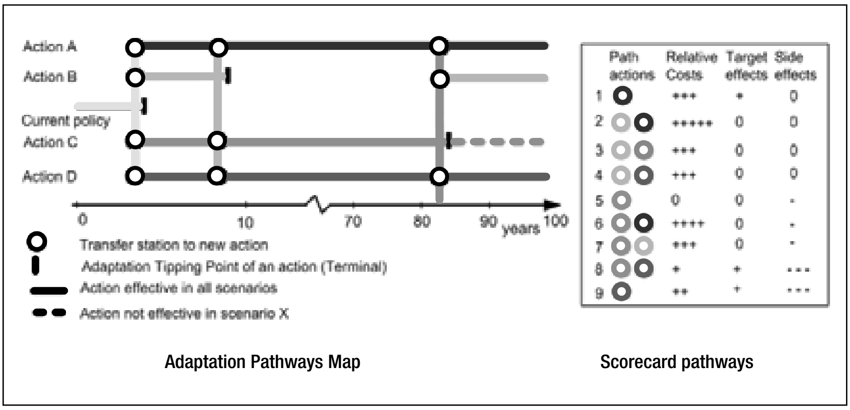


Figure 5. Example of an adaptation pathways map. Source: Haasnoot et al. (2012)

Building capacity and partnerships

The traditional approach for quantitative assessment was to mobilise groups of experts, consultants and university academics, rather than involve stakeholders. In view of the many different dimensions of water security, a more useful approach is to bring together stakeholders who are committed to measuring and learning as a basis for collaborative action.

What other new practices are needed? First, it is critical for teams of government and experts to find ways to partner with the private sector in order to lower the risks for businesses. Second, scientists need to be involved.

Scientists are the key to ensuring the best use of available data, providing sound analyses, and providing findings that have credibility with a wide range

[2] A tipping point is the condition under which the performance of a particular policy action becomes unacceptable.

of stakeholders, including the media. Third, quantitative analyses offer great opportunities for stakeholders to understand and cut through complexity, for example by preparing scorecards. Quantitative analysis involves appropriate design, data collection, analysis, and reporting. Stakeholders can then use the results to adjust actions. Integrating quantitative analyses in management can encourage joint ownership of a river-basin vision and its implementation.

River-basin organisations can play a key role in promoting and coordinating measurements relating to water security, as can city governments. By engaging scientists, businesses, civil society, and the media, the results can be disseminated widely to generate more buy-in for a wide range of investments to increase water security.

Taking the lead to increase water security

Effective water governance is central to increasing water security and to negotiating the trade-offs between the different dimensions of water security. An intersectoral and multi-disciplinary process is needed that requires leaders and leadership across sectoral boundaries to create synergies among the health, food, energy, and climate issues related to water. Leaders both inside and outside the water sector will need to take part in making decisions. The Asian Water Development Outlook 2013 recommends a diverse set of strategies that leaders can adopt (Box 9).

Box 9. Headline messages for leaders on accelerating progress towards a water-secure world

1. Make the best use of already developed water resources by investing in and incentivising ‘reduce, reuse, recycle’ systems.
2. Unlock the performance of water utilities through corporatisation.
3. Invest in better sanitation to boost health, productivity, and the economy.
4. Mobilise rural communities for equitable and just access to water and sanitation.
5. Embrace the challenge of the water–food–energy nexus.
6. Start managing groundwater as a valuable and limited resource.
7. Revitalise irrigation institutions to transform irrigation services.
8. Make integrated water resources management a priority.
9. Mobilise additional resources to clean up rivers.
10. Forewarned is forearmed.
11. Create insurance mechanisms to minimise reliance on disaster relief.
12. New problems demand institutions crafted for current challenges.

Source: AWDO (2013)

QUANTIFYING WATER SECURITY IN PRACTICE

On the basis that we cannot manage what we do not measure, measuring is a fundamental part of increasing water security. There is a growing need for practical approaches to apply metrics in national and river-basin planning and management activities. How water secure are we at this moment? Quantifying water security is important to:

- *focus* the attention of planners, stakeholders, and decision-makers on current problems and set targets for improvement
- *assess* the effect of planned measures on increasing water security, and determine an effective strategy with stakeholders
- *compare* local status of water security against benchmarks and experiences in other countries, basins, and cities, and learn lessons from good practice.

The concept of water security is relatively new and so there are, as yet, few examples of quantifying it. But there is a growing body of experience that can help users to build a framework that meets their needs.

Quantification metrics have their own terminology (Box 10).

Box 10. Quantification metrics terminology

Goal. A broad statement of a desired, usually longer-term, outcome of a programme/intervention.

Key dimensions. The main components of the goal.

Indicators. A quantitative or qualitative variable that provides a valid and reliable way to measure achievement, assess performance, or reflect changes connected to an intervention for each of the key dimensions.

Targets. The objective a programme/intervention is working towards, expressed as a measurable value; the desired value for an indicator at a particular point in time.

Monitoring. Routine tracking and reporting of priority information about a programme/project, its inputs and intended outputs, outcomes and impacts.

Building blocks for quantifying

How can we measure water security? There are several dimensions involved and so a combination of several indicators is needed. Moreover, the importance of the dimensions may differ depending on the situation and the severity of the problems. Water security may also need to be measured in different ways at national, river basin and city levels. Nevertheless, it is possible to derive a common structure that supports water managers and decision-makers to describe their specific water security issues and to help them define a set of relevant quantifying indicators.

A recommended framework has the following elements:

- *Vision/goals* – specifies the wanted outcomes of the water resource system
  - based on existing economic, social, and environmental issues
  - based on (political) priorities
- *Key dimensions* – relevant dimensions of water security
  - assign a value based on a composite scoring of specific indicators
  - to facilitate benchmarking, a common set of key dimensions are selected
  - to facilitate local improvements, relevant key dimensions are selected
  - to facilitate SDG monitoring, key dimensions are chosen to quantify the global definition of a Water SDG (Sustainable Development Goal)
- *Indicators* – the most important components of a key dimension for a specific case
  - should be quantifiable, preferably based on readily available data
  - supplemented by expert judgement where data are not available
- I*WRM criteria* – ensure indicator selection takes the IWRM pillars into account
  - social equity
  - environmental sustainability
  - economic efficiency.

Key dimensions are aggregated indicators whose value will be determined based on the values of several selected constituent indicators. If the purpose is to plan specific measures and draw up effective strategies for a particular location – a country, river basin, city or project area – key dimensions and supporting indicators can be selected to best describe the main water security issues in that location. If this is the case then it will not be possible to benchmark performance against other locations. If, however, the purpose is to compare performance and learn from experiences – between countries, river basins, and cities – a common set of key dimensions and indicators will be required.

Whatever the purpose, framing, or scale used, it is important to take account of the specific circumstances in the country, river basin, city, or project area being assessed. For example, an assessment of water security in dry areas such as Australia or the Middle East and North Africa (MENA) region would pay attention to the amount of water available. Whereas in countries with a wet climate such as the Netherlands an assessment might pay more attention to protecting against flooding.[3] Each assessment of water security should therefore describe in clear terms what dimensions are included and why, preferably by identifying specific indicators to measure the dimensions involved.

Vision/goals and key dimensions

The first two building blocks of the framework are the vision and the key dimensions, which are clearly related. The vision should address the most important outcomes from water management. The key dimensions should express the expected results of good water management that contribute to realising the vision. The vision and key dimensions will differ, depending on local conditions, and how narrowly or broadly water security is framed. The example from Java (Box 3) illustrates how an important local condition, such as erosion, which is a major problem on the island and is specifically mentioned in the water resources law as a goal, was included as a key dimension.

When a narrow framing of water security 'within the water box' is deemed appropriate, a correspondingly narrow set of key dimensions can be chosen to reflect how the public experiences basic water issues, for example:

- *Key dimension 1:* water availability (addressing water scarcity or 'too little water')
- *Key dimension 2:* flood safety (addressing flood risk or 'too much water')
- *Key dimension 3:* clean environment (addressing water pollution or 'too dirty water')
- *Key dimension 4:* water and sanitation (addressing water and sanitation needs or 'no tap or toilet').

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[3] At a policy level, the Dutch translation of water security (water veiligheid) is exclusively used to indicate protection against flooding from rivers and the sea.

Scoring on these key dimensions can be in absolute or relative terms, for example a scale from 1 (poor) to 5 (excellent), and can be based on publicly available data and expert judgement. The results can be presented in the form of a pentagram or radar plot (Figure 6).

When a broad framing of water security is required 'outside the water box', for example a water-secure society, key dimensions can be chosen to reflect this. The national water security index developed by the Asian Water Development Outlook (AWDO) team is the most elaborate example of a water security assessment to date. The methodology was used to assess water security in 49 countries in Asia and the Pacific (Table 3). Makin et al. (GWP, 2014) applied the methodology to several countries in Africa, Europe, and North and South America in a subsequent analysis. This methodology was created to support government leaders in guiding reforms and investments to increase water security. The methodology can be adapted for river basins, cities, and sub-regions.

Table 3. National Water Security Index for selected countries according to the AWDO approach

Country	KD1 Rating	KD2 Rating	KD3 Rating	KD4 Rating	KD5 Rating	Total	National Water Security Indicator	Index
Australia	5	3	4	4	5	21	4.20	4
Brazil	3	3	3	3	3	15	3.00	3
Bulgaria	5	3	2	1	3	14	2.80	3
Cambodia	1	<u>2</u>	1	2	1	7	1.40	1
Canada	5	3	3	5	5	21	4.20	4
China, People's Republic of	3	<u>3</u>	2	2	2	12	2.40	2
Egypt	4	3	2	1	3	13	2.60	2
Ethiopia	1	3	2	3	2	11	2.20	2
Georgia	3	<u>2</u>	2	2	3	12	2.40	2
Kyrgyz Republic	3	3	2	2	1	11	2.20	2
Mexico	3	3	2	2	3	13	2.60	2
Morocco	3	3	2	1	3	12	2.40	2
Mozambique	1	3	2	3	2	11	2.20	2
Nepal	1	3	1	2	3	10	2.00	2
Pakistan	1	<u>3</u>	1	1	1	7	1.40	1
Poland	5	3	2	1	3	14	2.80	3
Slovakia	5	3	2	<u>***1***</u>	3	14	2.80	3
Spain	5	3	3	1	4	16	3.20	3
Tanzania	1	4	2	3	2	12	2.40	2
Uruguay	5	3	3	3	4	18	3.60	3

Notes: KD=key dimension, KD1=Household Water Security. KD2=Economic Water Security. KD3=Urban Water Security. KD4=Environmental Water Security; KD5=Resilience, Numbers shown in <u>***underlined bold italic***</u> type indicate a rating from expert opinion (no data available), Results for KD2 shown <u>underlined</u> indicate where the assessment has changed from the earlier AWDO 2013 publication as a result of the exclusion of the resilience subindicator due to lack of comparable data for countries outside Asia and the Pacific region.

Source: GWP (2014) Assessing Water Security with Appropriate Indicators. Proceedings from the GWP Workshop.

The AWDO framework has five key dimensions: (i) household water security, (ii) economic water security, (iii) urban water security, (iv) environmental water security, and (v) resilience to water-related disasters. Scoring, from 1 to 5 in each dimension, was based on publicly available data, supplemented with expert judgement where data were not available. The resulting scores were presented visually in pentagrams.

The score for each key dimension is a composite of the scores of a number of indicators that describe the sub-elements in each key dimension. The indicators were, as far as possible, selected because data was publicly available. In summary, the purpose and indicators of the five key dimensions are as follows:

- *Key dimension 1:* household water security
  - purpose: measures domestic water security at the household level
  - indicators: piped water access (%); sanitation access (%); hygiene (DALY[4])
- *Key dimension 2:* economic water security
  - purpose: measures how countries ensure the productive use of water to sustain economic growth in food production, industry, and energy
  - indicators: productive economies in agriculture (agricultural dependency, utilisation efficiency); industry (industrial water productivity, industrial consumption); and energy (% hydropower potential developed, % hydropower dependency); with a resilience indicator added for storage and inter- and intra-annual rainfall variability
- *Key dimension 3:* urban water security
  - purpose: measures the creation of better water management and services to support vibrant and liveable water-sensitive cities
  - indicators: water supply (%), wastewater treatment (%), drainage (flood damage), with factors added for urbanisation rate and river health
- *Key dimension 4:* environmental water security
  - purpose: measures the progress of restoring rivers and ecosystems to health on a national and regional scale
  - indicators: river health, including pressures/threats to the river system; vulnerability/resilience to alterations to natural flows

[4] Age-standardised Disability-Adjusted Life Years (DALY) is a measure of the diarrheal incidence per 100,000 people.

- *Key dimension 5:* resilience to water-related disasters
  - purpose: measures the level of hazard, exposure, vulnerability, and coping capacity
  - indicators: resilience index based on the type of hazard (floods and windstorms, droughts, and storm surges and coastal flooding), measuring: exposure (e.g. population density, growth rate), basic population vulnerability (e.g. poverty rate, land use); hard coping capacities (e.g. telecommunications development level; and soft coping capacities (e.g. literacy rate).

AWDO presented the report to heads of state and government who attended the 2nd Asia-Pacific Water Summit in 2013. The report generated wide interest in and beyond Asia. The methodology is expected to stimulate countries to collect better data, which planners and decision-makers urgently need. Better data will also help to further improve indicators for the next assessment, for which preparation has already started, supported by the Asia-Pacific Center for Water Security at Tsinghua University in Beijing. Areas for improved data collection include the quality and reliability of installed water supply and sanitation services, water storage in groundwater, and small to medium-sized reservoirs, productivity in rainfed agriculture, variability in precipitation, and the use of water resources for hydropower.

Whether applying a narrow or broad framing the desired perspective of water security is achieved by focusing simultaneously on the selected key dimensions. However, analysis within each of the key dimensions can also yield valuable insights 'as building blocks'. For example, a narrower framing can be done by focusing on any of the five key dimensions used in the AWDO analysis on a stand-alone basis. The International Water Management Institute (IWMI), which was part of the AWDO team, published an advance study that focused on economic performance limited to agriculture, using a simplified framework (Lautze & Manthrithilake, 2012). The key dimensions used by IWMI were:

- key dimension 1: basic household needs
- key dimension 2: agricultural production (availability of water)
- key dimension 3: environmental flow
- key dimension 4: risk management (buffering against rain variability)
- key dimension 5: independence of external sources.

Selecting indicators

Indicators are used to express the nature of key dimensions and their selection will depend on the purpose and specific application of the assessment. AWDO used two to four indicators (and sometimes sub-indicators) for each of the five key dimensions. As the initial purpose of the AWDO assessment was to compare the water security status among countries, the same set of indicators was applied to all countries. In adapting the methodology for river basins and cities, adjustments can be made to reflect local priorities and available data sets.

Selecting good indicators is a challenge. Often, a pragmatic balance needs to be struck between 'what should be measured' and 'what can be measured' (Mason & Calow, 2012). Indicators are first of all meant to inform planning and decision-making. Data collection can be influenced more effectively once decision-makers recognise the benefit of quality information in their work. Quality data and good indicators have the following characteristics (Dunn & Bakker, 2009):

- easy to access (preferably using publicly accessible data)
- easy to understand (for stakeholders and decision-makers)
- timely (updates of data)
- relevant (for the specific issues involved, scale)
- credible, transparent, and accurate.

Indicators should reflect the preferred outcomes of improved water security. If a good indicator for an outcome is not available, or the data to determine the indicator are difficult to obtain or are not available, intermediate outcomes can be used as a substitute. Examples include access to water and sanitation as an intermediate outcome for reliable, safe, and affordable water and sanitation services; the area irrigated as an intermediate outcome for agricultural production; and 'water quality classes' as an intermediate outcome for 'ecological health'. Intermediate outcome indicators can also be used if they are easier to understand and accepted by decision-makers and stakeholders.

Other intermediate outcomes relate to governance. Good governance is a means to improve water security and not an end outcome in itself. However, it is not scientifically correct to include governance indicators when assessing water security. Nevertheless good governance is an important precondition for increasing water security, and as such it is important to consider it in evaluating progress. This can be done by treating it as a separate and cross-cutting category in addition to the key dimensions. While there is considerable interest in developing a governance index specifically for water, many aspects of good governance are not unique to the water sector. Thus, it may be sufficient to use global data sets on governance that are already available, such as the World Bank's governance index. The AWDO assessment compared water security ratings using global data sets on governance, GDP and others.

There is a wealth of literature on selecting indicators, including:

- World Water Development Report 4 (WWAP, 2012)
- UN-Water set of key water sector indicators (UN-Water[5])
- proposed indicators of the Expert Group on Indicators, Monitoring, and Databases (EG-IMD) (WWAP, 2009)
- Water Wealth Index (WWI)[6]
- Assessing Water Security with Appropriate Indicators (GWP, 2014). Proceedings from the GWP Workshop.

These sources are referred to in 'Water and sustainability: a review of targets, tools and regional cases' – a report prepared in 2012 by UNESCO's International Hydrological Programme.[7] This report provides a source and a pool of inspiration for selecting indicators for specific cases. Table 4 shows a matrix for determining a suitable mix of indicators. Not all elements of the matrix may be needed. Sometimes one indicator may be sufficient but in other cases two or more indicators may be needed. In such cases, formulae and weighting can be applied to combine the indicator scores into one score for the key dimension. Table 5 provides an example of using indices to support decision-making.

[5] http://www.unwater.org/activities/task-forces/indicators/key-indicators/en/
[6] http://www.watercentre.org/portfolio/awrf-global-indicators
[7] This report sets out the then (2012) current sustainability targets for the water sector and an overview of selected tools and approaches to assist decision-makers and to meet development targets.

Table 4. Matrix for determining indicators for a specific case

IWRM pillars / Key dimensions	Economic efficiency	Social equity	Environmental sustainability
KD1	Indicator 1 ….. Indicator 2 …..	Indicator 3 ….. Indicator 4 ….. Indicator 5 …..	Indicator 6 …..
KD2	Indicator 7….. Indicator 8 …. Indicator 9 ….	Indicator 10 ….. Indicator 11 …..	Indicator 12 …..
KD3	Indicator 13 ….. Indicator 14 …..	Indicator 15 …..	Indicator 16 …..
KD4	Indicator 17 …..	Indicator 18 …..	Indicator 19 …. Indicator 20 ….. Indicator 21 …..
KD5	Indicator 22 ….. Indicator 23 …..	Indicator 24 ….. Indicator 25 …..	Indicator 26 …..

This table illustrates a possible outcome of the process to select appropriate indicators. The number of indicators for each key dimension will depend on the situation to be assessed and the preferences of stakeholders. Some boxes in the matrix may remain empty. From the IWRM perspective it is important to balance the indicators for each of the three IWRM pillars: economic efficiency, social equity, and environmental sustainability.

Composite indices

Aggregating indicator scores into an index supports decision-making but this needs to be done with care, since the various dimensions are not necessarily comparable, and may be weighted differently. For example, the AWDO assessment aggregates indicator scores into indices for each of the key dimensions, and compiles these into a composite index for water security. All indices are expressed in five stages: 5 is rated as model, 4 effective, 3 capable, 2 engaged, and 1 hazardous. The composite index is the sum of the key dimension indices (with equal weighting) divided by 5. The key dimension indices can be conveniently shown in table form (Table 3) and graphically in pentagrams (Figure 6).

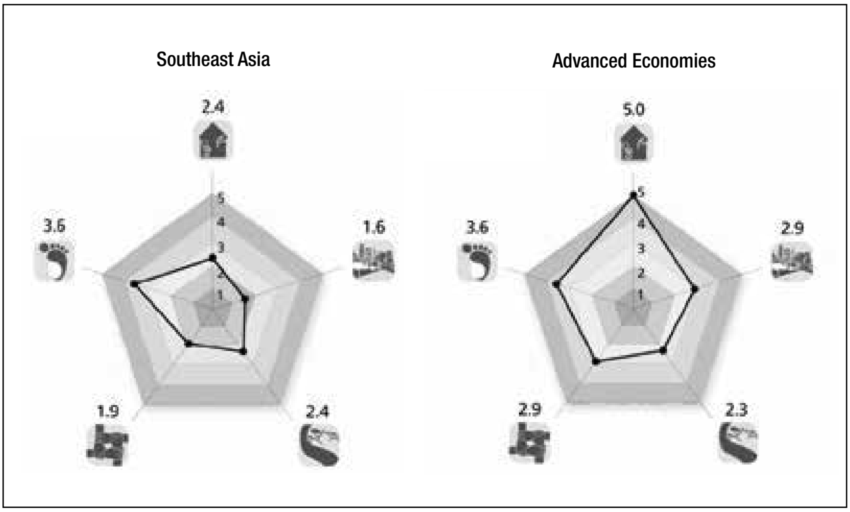

Figure 6. Key dimensions of water security shown in pentagrams for Southeast Asia and advanced economies in Asia. Source: AWDO (2013).

Composite indices can be useful, in particular for benchmarking. For informed decision-making it is advisable to present both the values of the indicators as well as their composite indices. This ensures that valuable information on specific indicators is not lost.

Assessment using a risk-based approach

This approach focuses on elements of water security with a significant risk (probability) that acceptable performance cannot be achieved or maintained. Increasing water security is reflected in achieving and maintaining acceptable levels in four areas of water-related risks OECD (2013):

- risk of *shortage* (including droughts): a lack of sufficient water for beneficial uses (households, businesses, and the environment)
- risk of *inadequate quality:* a lack of water of suitable quality for a particular purposes
- risk of *excess* (including floods): an overflow or destructive accumulation of water over areas that are not normally submerged
- risk of undermining the *resilience* of fresh water systems: exceeding the coping capacity of water systems, possibly reaching tipping points and causing irreversible damage to system functions.

This approach does not focus on elements where sustained development is needed to achieve acceptable standards, such as providing access to safe water or sanitation services. It may therefore be more relevant to OECD member countries which expect higher levels of performance in satisfying basic needs.

OECD proposes a three-step process: 'know the risk', 'target the risk', and 'manage the risk' (Figure 7).

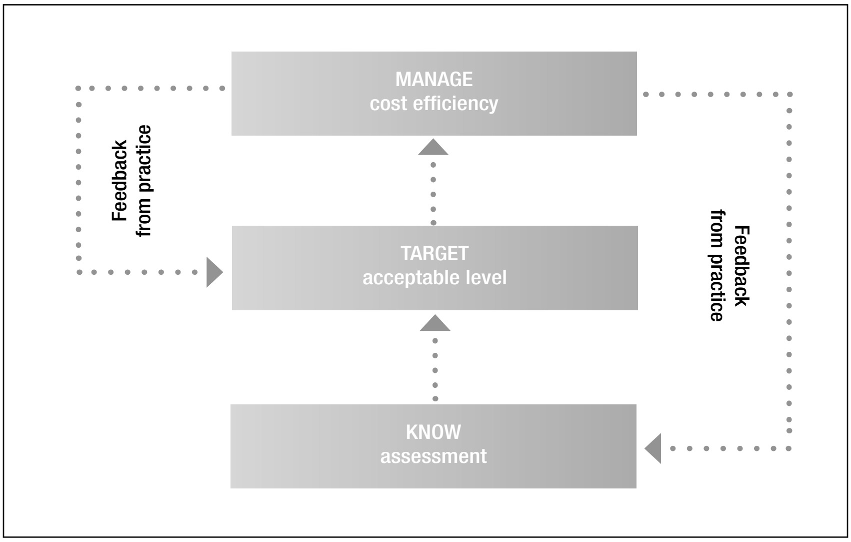

Figure 7. OECD risk-based approach to water security

Know the water risk

The first step is to identify the risks and their scale. This includes not only the scientific and technical aspects but also people's perception of risk. How important do people consider the risks? All risks should be taken into account: the normal, most visible risks; the low probability, high impact risks; and the slowly developing risks with cumulative high impacts.

Set acceptable levels (targets) for water risks

The acceptable level of water risk for society depends upon the balance among economic, social, and environmental consequences and the cost of improvement. Completely eliminating risk is, in most cases, technically impossible or too costly.

Manage the water risks

Once targets are set, measures can be identified that achieve those targets as cost-effectively as possible. Besides infrastructural measures, these may include market-based instruments and public financial support. The risk-based approach assigns the risks to the actors that are likely to be able to manage them most efficiently. Special attention is asked for the 'social dimension', including equity. A risk-based approach can help to ensure an equitable distribution of risks amongst stakeholders and prevent the imposition of one group's risk preferences on others.

Assessment using a development approach

There are three important steps to quantifying water security using a development approach (Figure 8):

- Step 1: determine the relevant key dimensions and indicators for the case;
- Step 2: assess the scores of the indicators; and
- Step 3: present the results for decision-making or comparison with other cases.

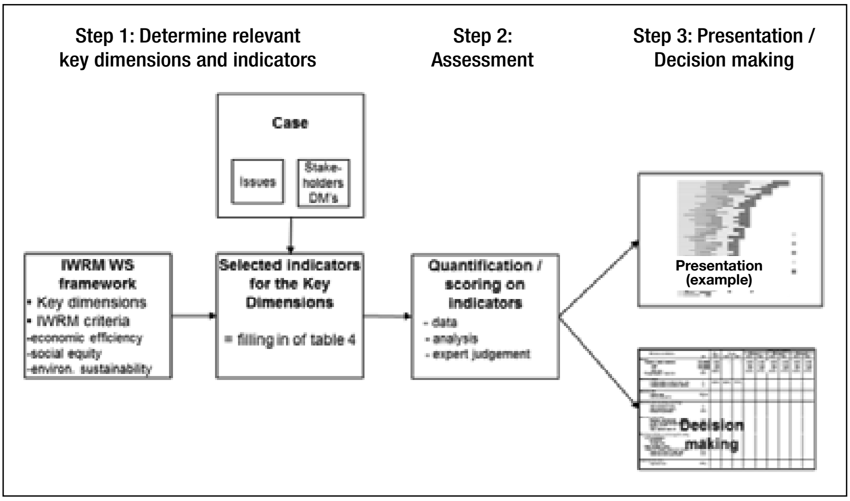

Figure 8. Three steps in the development approach to a quantitative assessment of water security

Step 1 – Determine relevant key dimensions and indicators

This step is described in previous sections. It is important to remember that key dimensions and corresponding indicators are selected which take into account specific issues and the information needs of stakeholders and decision-makers. When the assessment is used to compare countries or basins, indicators should provide a comprehensive picture of all important issues and information needs. When the assessment is made for just one basin or country, the indicators can be more specific to the issues and information needs of that basin or country.

Step 2 – Assess scores of indicators

Scores can be expressed on a nominal or an ordinal scale. Nominal scales are either real values or refer to a ratio scale, an example is the grades of an examination on a scale 1-10. Ordinal scales express the rank order of scores, examples include ++/+/o/-/--; excellent – good – indifferent – bad - extremely bad; positive – neutral – negative; and using a score of 1-5.

Preferably, scores will be based on readily available data from public databases. In many cases, some kind of analysis will be required to determine the indicator scores. When data are not available, expert judgement may be used to determine the scores.

If the purpose of an assessment is for comparison, the score would be determined for one situation only, which in most cases would be the present situation, or at least the latest situation for which data are available. If the purpose of an assessment is for making a decision about an investment, the scores should be determined for both the present and future situation with and without the investment. In making decisions on alternative strategies, the scores for these alternatives should be determined.

Step 3 – Presenting results for comparison or for decision-making

How the results are presented will depend on the purpose of the assessment. For comparative purposes, the results can be presented in tables or graphs. Figure 9 shows two examples of AWDO graphical presentations. Graph (a) compares water security in countries in the AWDO region. Graph (b) compares water security in the Brantas river basin in Indonesia (in green with lower and upper estimates) with the Indonesian national average (in red). The graphs show that the Brantas river basin has a higher than national average score on the key dimension of household water security. Presenting findings in a pentagram is particularly useful as it highlights the score for each of the five key dimensions.

Assessments carried out to support decision-making in relation to investments not only present the current situation but also the expected situation after implementing a measure or strategy. The targets for the various indicators should also be included as well as specific economic information needed for decision-making, for example on total required investments and the benefit-cost ratio. For this kind of assessment, additional studies will be needed, often requiring computer modelling. The result can be captured in a water security scorecard (Table 5). The advantage of presenting the results in this way is that decision-makers can see both water security scores, the scores of specific indicators, and the targets that apply to the specific indicators.

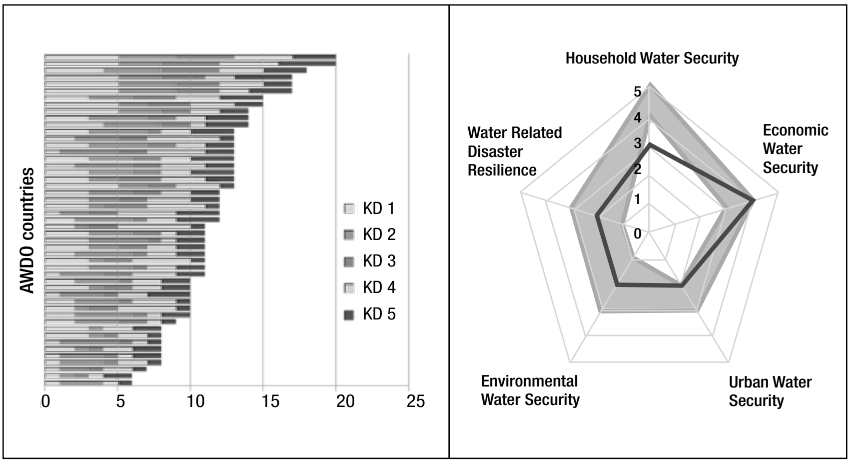

Figure 9. Examples of presentations comparing water security (a) comparing water security in countries; (b) comparing water security in a river basin (Brantas, in dark grey) with national average water security (black) in Indonesia[8]

Source: AWDO (2013) and a pilot assessment of water security in three river basins conducted by the Network of Asian River Basin Organizations (NARBO, 2012).

Selecting the most crucial indicators is particularly important. But aggregating indicators, as shown in Figure 9 and Table 5, runs the risk of 'losing' a lot of important information on water resource system performance. However, just adding more indicators may complicate the picture. Too much information can be confusing and can cloud important issues. A balance will ensure that information is both comprehensive and comprehensible to the target audience.

[8] Note that KD1, KD2 etc refer to Key Dimensions developed in AWDO (2013).

Table 5. Example of a water security decision-making scorecard[9]

Key Dimensions and Indicators	unit	Base	Targets			Alternative investment strategies					
						Strategy 1		Strategy 2		Strategy 3	
		2010	2020	2030	Perfect	2020	2030	2020	2030	2020	2030
Case Water Security Index	1-5	1,8	3,1	4,1	5,0	2,4	3,3	2,7	3,6	3,1	4,1
KD1: Water and sanitation	1-5	2,0	2,8	3,6	5,0	2,8	3,6	2,8	3,6	2,8	3,6
%people access to safe drinking water	%	50%	63%	73%	100%	63%	73%	63%	73%	63%	73%
%people access to sanitation facilities	%	30%	50%	70%	100%	50%	70%	50%	70%	50%	70%
KD2: Food Production	1-5	2,3	3,1	4,4	5,0	2,6	3,5	3,0	4,2	3,1	4,4
Irrigation area	1000 ha	24	30	35	40	26	28	28	31	30	35
# animal water points	#	300	500	900	1000	400	700	500	900	500	900
KD3: Industry and Energy	1-5	2,1	3,8	4,7	5,0	2,7	3,7	3,1	4,2	3,8	4,7
Water supplied to mining	%	30%	80%	90%	100%	40%	50%	50%	70%	80%	90%
Water supplied to industry	%	70%	80%	90%	100%	70%	90%	80%	90%	80%	90%
Hydropower generated	MWh	34	80	120	120	60	100	70	110	80	120
KD4: Environment	1-5	1,8	3,3	4,7	5,0	2,4	3,3	3,1	3,7	3,3	4,6
Protected watershed area	km^2	1200	2500	3500	3500	2000	2500	2500	3000	2500	3500
Number of springs/sources protected	#	300	600	900	900	400	600	500	700	600	850
Average class water quality rivers	I - V	II	III	IV	V	II	III	III	III	III	IV
KD5: Vulnerability	1-5	1	2,4	3,3	5,0	1,7	2,3	1,7	2,3	2,4	3,3
Vulnerability to floods - average damage	m€/yr	120	< 78	< 50	0	100	80	100	80	78	50
Vulnerability to droughts - average damage	m€/yr	200	< 50	< 30	0	120	80	80	40	50	30
Implementation information											
Required investments	m€		–	–	–	300	500	400	650	600	1200
B/C ratio economic categories (KD2, KD3)	–		> 1,3	> 1,2	–	1,4	1,3	1,3	1,2	1,2	1,1

Further development of the concept

The concept of water security, approaches to water security, and methods of quantifying water security are still developing. By quantifying water security we will improve our understanding of both the developmental and risk-based approaches. But in doing so we will have to strike a balance between what is desirable and what is doable. Although water security is complex, decision-makers and stakeholders need to be able to understand the findings. This means that methodologies, or at least presentations of the findings, must be as simple as possible.

No case of water security will be exactly the same. Hopefully, the Examples given provide guidance to a systematic framework and a three-step process for quantifying water security. Exchanging experience is valuable, such as through a community of practice supported by GWP.

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[9] In this example (a rural situation with no cities), 5 key dimensions were selected, and 2 to 3 indicators were selected for each key dimension. The base year is 2010 with two time frames for outcomes: 2020 and 2030. The example gives three alternative investment strategies for decision-makers to choose between. Water security in each key dimension is calculated as an average of the values of the selected indicators (equal weight). Equal weighting is also applied to determine the overall water security index.

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