Chapter 1

Why does water security matter?

Water security is about managing water risks, including risks of water shortage, excess, pollution, and risks of undermining the resilience of freshwater systems. This chapter provides the rationale and conceptual basis for a risk-based approach to water security. It argues that a risk-based approach has many advantages over current policies to manage water security and could be applied more systematically to improve water security cost-effectively.

Following a risk-based approach to water security, a risk is considered *acceptable* if the likelihood of a given hazard is low and the impact of that hazard is low. In such cases, there is no pressure to reduce acceptable risks further, unless more cost-effective measures become available. In contrast, cost-effective measures are required to reduce *tolerable* risks to an acceptable level. Due to their very high probability and/or high damage potential, *intolerable* risks require urgent action to reduce them to an acceptable level. The acceptability and tolerability judgement process enables policy makers to prioritise risk management decisions when risks exceed acceptable levels (OECD/Swiss Re/Oliver Wyman, 2009).

Achieving water security means maintaining acceptable risk levels for four water risks – see risk terminology in the glossary of terms in Annex A:

- *Risk of shortage (including droughts):* Lack of sufficient water to meet demand (in both the short- and long-run) for beneficial uses by all water users (households, businesses and the environment).
- *Risk of inadequate quality:* Lack of water of suitable quality for a particular purpose or use.
- *Risk of excess (including floods):* Overflow of the normal confines of a water system (natural or built), or the destructive accumulation of water over areas that are not normally submerged.
- *Risk of undermining the resilience of freshwater systems:* Exceeding the coping capacity of the surface and groundwater bodies and their interactions (the "system"); possibly crossing tipping points, and causing irreversible damage to the system's hydraulic and biological functions.

All four risks must be assessed at the same time as they can impact on each other given the nature of water as a hydrologically interconnected resource. Indeed, these risks are interrelated; for instance, the risks of shortage, inadequate quality and excess may all increase the risk of undermining the resilience of freshwater systems. Managing all of these water risks is central to achieving the objective of water security.

From an efficiency perspective, the management of these water risks should focus on events with the most impact. There is generally an assumption that this means focusing on extreme ("tail") events with low probability and high impact, such as extreme floods.[1] But the long-term catastrophic consequences of "normal" (low immediate impact) but recurrent or chronic threats to water security, such as competition or pollution, deserves much greater risk management attention. These concealed or dormant risks develop slowly and are thus often considered as "invisible", with their main impacts emerging only in the long term. Yet there are subtle signs that may signal risk triggers, such as slower recovery from small disturbances (known as "critical slowing down").[2]

To date, water risk management has largely focused on protecting critical assets from disasters, on emergency preparedness and short-term crisis management, and much less on long-term water security. Furthermore, risk assessment and management have been applied piecemeal to certain aspects of water management (e.g. drinking water standards, flood control) but have not covered water resource management holistically, from a risk perspective. Water resources are still not managed for risk, but for certainty (e.g. supply security, access security).

Yet, water management, at its core, is about *reducing or avoiding water risks* and about the distribution of residual water risks – who *bears the risk*. But water management decisions are often driven by imperatives such as economic constraints and opportunities, and the costs and benefits and distributional impacts of risk management are seldom expressly considered. Responses to water risks may *transfer risks* to others or defer them into the future. They may also *increase other water risks* (e.g. reducing the risk of water shortage may increase the risk of undermining the resilience of freshwater systems). Current policies often fail to recognise these unintended effects ("externalities") and to address these trade-offs between water risks (risk-risk trade-offs).

Most countries face seasonal or local water shortage problems and several have extensive arid or semi-arid regions where water is a constraint to economic development. Multiple and scattered ("diffuse") sources of water pollution are challenges in many countries and a multiplying number of water contaminants threaten freshwater quality. The population affected by flood is increasing worldwide and with it the value of assets at risk.

This report *Water Security: Managing Risks and Trade-offs: i)* calls for action to manage the risks to society and the environment of water shortage, excess and pollution and of fragile freshwater systems; and *ii)* looks for solutions to maximise expected social welfare of trade-offs to maintain an acceptable level of such water risks to all. The report focuses on OECD countries but also refers to countries outside the OECD area.

The water outlook

The outlook is not optimistic (see Annex B for more details). A 55% increase in world water use is projected between 2000 and 2050. By 2050, the *OECD Environmental Outlook* projects that more than 40% of the world population will live in river basins under severe water stress (i.e. in river basins where withdrawals exceed 40% of available resources). This means an additional 1 billion people compared with today. The projected degradation of water quality adds to uncertainty about future water availability. By 2050, flood risks are projected to affect nearly 20% of the world's population.

As the world population rises to an expected 9 billion by 2050, water risks will be exacerbated. The process of urbanisation will increase, along with the demand for food and energy, and the pressures on the environment. Water risks will also be exacerbated by the immeasurable effects of climate change, which will increase uncertainty.

OECD and non-OECD countries face different water security challenges. Even though water use and nutrient pollution are increasing at much faster pace outside the OECD area, particularly in the BRIICS, diffuse sources of pollution, seasonal or local water shortage and floods remain an issue in most OECD countries, as is financing to replace ageing infrastructure and meet increasingly stringent environmental and health standards.

Managing water demand to balance with the available supplies in a way which promotes sustainable development is a formidable global challenge. The problem will be greatest in non-OECD countries that, as a group, are expected to have much larger rates of population growth. This is particularly so in large developing countries, such as India, where the rate of increase in incomes is also expected to exceed the OECD average. By contrast, a move towards water pricing based on supply costs in urban and industrial sectors in the OECD area, together with water recycling investments and improvements in water use efficiency in agriculture, have resulted in decoupling water demand from GDP (Annex B).

Unsurprisingly, the water outlook differs significantly between OECD and non-OECD countries. Water demand is actually projected to decrease in the OECD area (from 1 000 km^3 in 2000 to 900 km^3 in 2050). The projected decrease in water demand is driven by efficiency gains and a structural shift towards service sectors that are less water intensive. It is doubtful, though, that this will be enough to address the serious regional water supply-demand issues that already exist in parts of Australia, Israel, Mexico, Spain and the United States.

In contrast, water demand is projected to increase significantly in the BRIICS (from 1 900 km^3 in 2000 to 3 200 km^3 in 2050) and to a lesser extent in the rest of the world (from 700 km^3 in 2000 to 1 300 km^3 in 2050). Most of the population in river basins expected to be under severe water stress live in the BRIICS.

Similarly, the projected increase in nutrient pollution from point and diffuses sources is more significant outside the OECD area.

Moreover, there is a massive gap in major water infrastructure between OECD and non-OECD countries, both in terms of water services, water storage capacity per capita and share of hydropower potential developed. Compounding the infrastructure gap, there is a "bad hydrology" problem. There is a strong correlation between rainfall variability and GDP (Brown and Lall, 2006). Rainfall in most rich countries is moderate and predictable, whereas many poor countries suffer more frequently from droughts and floods, face higher levels of inter-annual uncertainty and confront ever greater variability as the world climate changes. In that context, water excess and shortage risks are seen as a profound cause of underdevelopment. However, as will be explained below in the context of water stress, these global indicators mask local disparities and water security concerns.

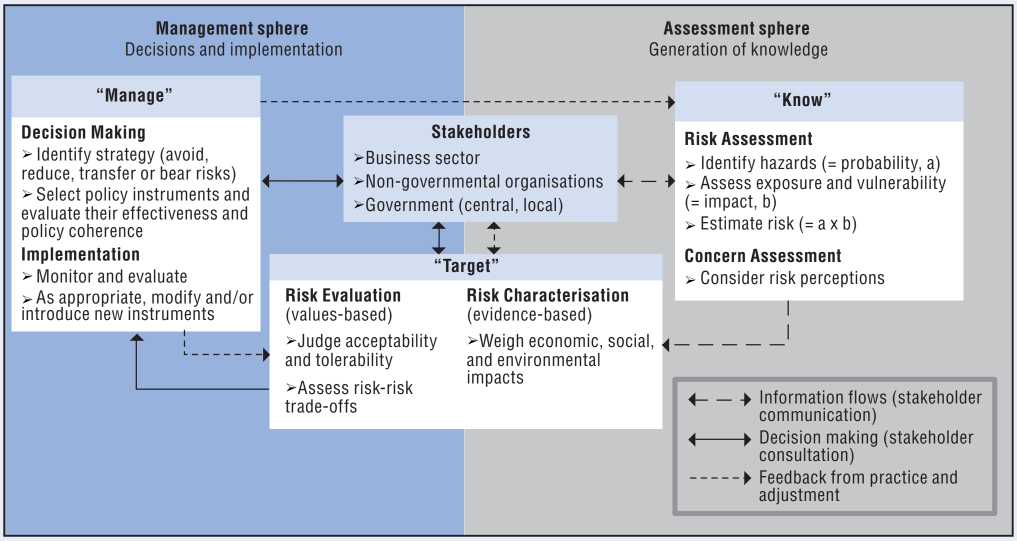
But there are still significant water security concerns in the OECD area. For example, pollution loads from diffuse agricultural and urban sources are continuing challenges in many OECD countries. Most OECD countries will probably continue to face seasonal or local water security problems and several countries have extensive arid or semi-arid regions where water could continue to be a constraint to economic development. In addition, climate "weirdness" could result in OECD countries experiencing more irregular precipitation patterns, which could have important economic impact given the strong correlation between rainfall variability and GDP. Moreover, OECD countries will need to mobilise significant financial resources in the next few decades to replace ageing infrastructure and to meet increasingly stringent environmental and health standards. As seen previously in the context of water supply, water demand, water quantity and water quality, water security is an issue in both OECD and non-OECD countries.

Applying a risk-based approach to water security: A conceptual framework

A risk-based approach to water security can be informed by a conceptual framework laying out the three steps involved in risk assessment and management, namely "know", "target" and "manage" the water risks (Box 1.1). The utility of this conceptual framework is in providing a comprehensive view of the three steps and their traits, along with a depiction of information and decision making flows and interaction with key stakeholder groups.

The framework combines the typical elements of technical risk assessment with important contextual factors, such as risk perceptions and risk evaluation. These contextual factors influence the demand for risk management and the willingness to pay

Box 1.1. **A risk-based framework for water security**



Source: Adapted from Renn and Graham (2006).

Know the water risks

Improving knowledge and reducing information asymmetry are the basis for making effective and informed risk management decisions. Yet, there is a striking lack of information on water risks and their scale (information gap), compounded as water resource management enters an era of uncertainty, greater variability and increasing risks as a result of climate change, population pressures, increasing demand to meet environmental needs and other risk drivers.

Although good science and technical expertise are needed, the understanding of risk perceptions via a *concern assessment* is a fundamental (and often overlooked) step in the risk appraisal process. It is a key element in seeking to assign roles and responsibilities for managing water risks. Indeed, individuals or businesses' perception of risk has an important influence on their decisions affecting their vulnerability to the risk and risk management strategies.

Appraising water risks means identifying areas subject to high-severity events, including "tail events" (i.e. low probability/high impact risks), but also "slow-developing catastrophic risk" areas, which are subject to low but cumulative impacts (e.g. gradual depletion of water resources; accumulation of pollutants in sediments).

Set acceptable levels (targets) for water risks

Achieving water security requires maintaining acceptable levels of risk – in terms of water shortage, excess, pollution, and freshwater system resilience – for society and the environment, today and in the future, through the effective and efficient application of water and water-related policies.

A water risk is considered *acceptable* if the likelihood of exceeding a given risk threshold (e.g. river flow, health standard, flood magnitude, tipping point of a freshwater system) is low and the impact of exceeding that threshold is low. In such cases, there is no pressure to reduce acceptable risks further, unless more cost effective measures become available. In contrast, cost effective measures are required to reduce *tolerable* risks to an acceptable level. Due to their very high probability and/or high damage potential, urgent action is needed to reduce *intolerable* risks to an acceptable level.

Box 1.1. **A risk-based framework for water security** *(cont.)*

The demand for risk reduction is influenced by factors beyond the risk profile itself determined by the severity of negative impacts and their likelihood. The (bold) claim that "acceptable" levels of risks should be determined only by scientific information about hydrology to the exclusion of any other criteria is a weak one. Although discussions of risk in water planning have traditionally been dominated by uncertainty in hydrology (increasingly so with concerns over climate change), due attention must be given to economic, social, cultural and environmental factors, which can be more important than hydrological uncertainties.

The acceptable level of water risk for society and the environment should depend upon the balance between economic, social and environmental consequences *and* cost of amelioration. Indeed, water security can be improved – but only at a *cost*. This cost may be in economic (e.g. building new or replacing old water infrastructure), social (e.g. closing water allocations to cap demand) and/or environmental terms (e.g. deterioration of freshwater systems to reduce the risk of water shortage). Depending on the existing level of water security, incremental improvements may, in some cases, be disproportionally costly. By identifying the level of acceptability of risks, a risk-based approach fosters targeted and proportional policy responses and thus cost effectiveness. As a result, targets for water risk vary between uses of water.

A tool to inform *trade-offs between policy objectives* is to document all the uses and associated values. Water use can be part of the market economy, making valuation of use relatively straight forward, or it can be non-market uses which are more challenging to value. Setting targets for water risks should thus be transparent about values and their trade-offs and consider equity between users.

Manage the water risks

Decision making about the appropriate response to water risks and the implementation of actions build on all the previous steps of the risk management process. The *risk management* strategy may be to avoid, to reduce, to transfer or to bear the risk. This can be done by altering risk drivers, limiting exposure or making populations, ecosystems and activities less vulnerable to potential harm. In cases where a policy response is considered appropriate, policy options should be assessed from an economic, environmental and equity perspective, to ensure that risk reduction is proportional, pursued at least cost and at least distributional impacts.

A risk-based approach allows for assigning risks to the actors able to manage them most efficiently in social welfare terms. For example, flood risks may be addressed more cost-efficiently through flood insurance or compensating farmers converting their land into flood plain instead of government investing in dams. Overall, the rational expectation would be that governments would only take direct action if, for instance, risks were collectively consumed on a large scale, when the potential for risk transfer was significant, where individuals had highly constrained opt-out options and where individuals or communities were deterred from making private safety provisions because they could not exclude free riders.

Maintaining acceptable levels of risk ultimately means addressing *trade-offs between policy instruments*. This requires a coherent approach between water policies and other (sectoral, environmental) policies.

for a given amount of risk reduction. The framework explicitly recognises “know”, “target” and “manage” as a process driven by both evidence-based and value-based judgements.

Know the risks

This step first entails framing the risks by identifying the main drivers impacting on the hazards, exposure and vulnerability and projecting their long-term trends. **Drivers of water risks** include socio-economic trends, natural phenomena and inadequate water and water-related policies. Demographic and socio-economic trends, such as population growth and economic activity may strain water resources via increased abstractions and pollution. Urbanisation and decisions about land-use may increase exposure to water risks, including the risk of excess water, and to hazards such as natural disasters (e.g. earthquakes). Natural climate variability and climate change generate and exacerbate weather-related hazards. Social and cultural factors are also important risk drivers as they influence risk perceptions and may exacerbate man-made disasters and crises (e.g. terrorism, conflicts).

But water policy itself is what drives water risks the most (Grafton, et al., 2012). For example, it may lead to a lack of adequate water infrastructure and technology, due to neglect, insufficient financing and/or poor management and maintenance. Water risks are also the result of spillover effects. By creating incentives towards meeting their own security objectives, sectoral (e.g. agricultural, energy) and environmental (e.g. climate, biodiversity) policies have significant spillover to water security. For example, by distorting production and trade of agricultural commodities, agricultural policy distorts the domestic demand for water.

Building an adequate information base to inform decisions about water risks then requires appraising water risks through bringing together two components – a scientific risk assessment as well as an understanding of risk perceptions by stakeholders. The aim of the **risk assessment** process is to produce a best estimate of the physical harm a water risk may cause as well as identifying the exposure and vulnerability of populations, ecosystems and activities. The outcome of a formal risk assessment is an estimation of the risk in terms of a probability distribution of the modelled consequences.

A formal risk appraisal process for water risks can be data-intensive and costly in terms of time and resources. Often, significant scientific capacity is needed. In cases where significant populations, ecosystems and activities are at risk (e.g. densely populated urban areas in flood plains) and the cost of risk reduction is significant (e.g. structural flood protection), a formal and comprehensive risk appraisal is justified. In other cases, a less formal, but still informative, qualitative assessment or rapid risk assessment may be sufficient. The depth and extent of the appraisal undertaken should be proportional to the magnitude of the risk.

Although good physical science and technical expertise are a prerequisite for sound risk management, they alone cannot be the main basis for decision making (Rees, 2002). The understanding of risk perceptions via a **concern assessment** is a fundamental step in the risk appraisal process. It is a key element in seeking to assign clear roles and responsibilities for managing risks. Indeed, individuals or businesses’ perception of risk has an important influence on their decisions affecting their vulnerability to the risk and risk management strategies. Concern assessment also helps solving the issue of “contested values”[3] that are often at the heart of conflicts over water (e.g. determining sustainable levels of use and/or pollution). The conventional risk assessment process, which typically places scientific assessment at the starting point for analysis, could even be inverted to place the human context, knowledge, needs and preferences as the first stage of appraisal. Such "inverted' risk appraisal models would appear to have a useful role to play to ensure that risk management becomes more demand responsive and more inclusive in terms of risk management options.

In appraising water risks, there will be many cases where the scientific assessment will be limited by sparse data, knowledge gaps and other sources of **uncertainty**. This is particularly acute when taking into account the impacts of climate change, for which confidence levels are often low for key climate parameters (OECD, 2013). A common distinction between risk and uncertainty derives from Knight's (1921) observation that risk is uncertainty that can be reliably measured. Thus, risk describes the likelihood and consequence of an uncertain event of which the probability of occurrence can be reliably estimated. Uncertainty describes situations where the probability of occurrence is not known and perhaps cannot be known. The difference between risk and uncertainty can be understood as a spectrum, where uncertainty is an expression of the degree to which a value or relationship is unknown.

A key step to dealing with uncertainty in risk assessment is to identify the sources of uncertainty and to be explicit about the degree of confidence experts have in the scientific knowledge base. Uncertainty can be characterised quantitatively, for example, by a range of values calculated by various models assessed with various confidence intervals; or qualitatively, by reflecting expert judgement.

The **role of the government** is first and foremost to facilitate the provision of information to improve knowledge and reduce information asymmetry as the basis for making effective and informed risk management decisions. Indeed, there is a striking lack of information on water risks. The knowledge, science and monitoring of hydrology, environmental and water resource management linkages is less well developed than have been the advances in water policies in many countries (OECD 2010). This disconnect means that decision makers are poorly informed and that policies are inadequately implemented and evaluated. These gaps in knowledge, science and monitoring are compounded as water resource management enters an era of greater uncertainty, variability and higher risks as a result of climate change, population pressures, increasing demand to meet environmental needs and other risk drivers.

Information failures are a main source of disparities in the distribution of water risks due to imperfect knowledge and information asymmetry (those exposed or vulnerable to risks lack the knowledge to make informed choices about their own welfare). Because of unequal distribution of information, information asymmetry creates risk transfer externalities.[4]

Moreover, there is critical lack of data and information on the economic aspects of water management. Furthermore, the provision of water security to one community or group of users can create the perception of relative disadvantage to other communities. The understanding of such risk perceptions is too often overlooked.

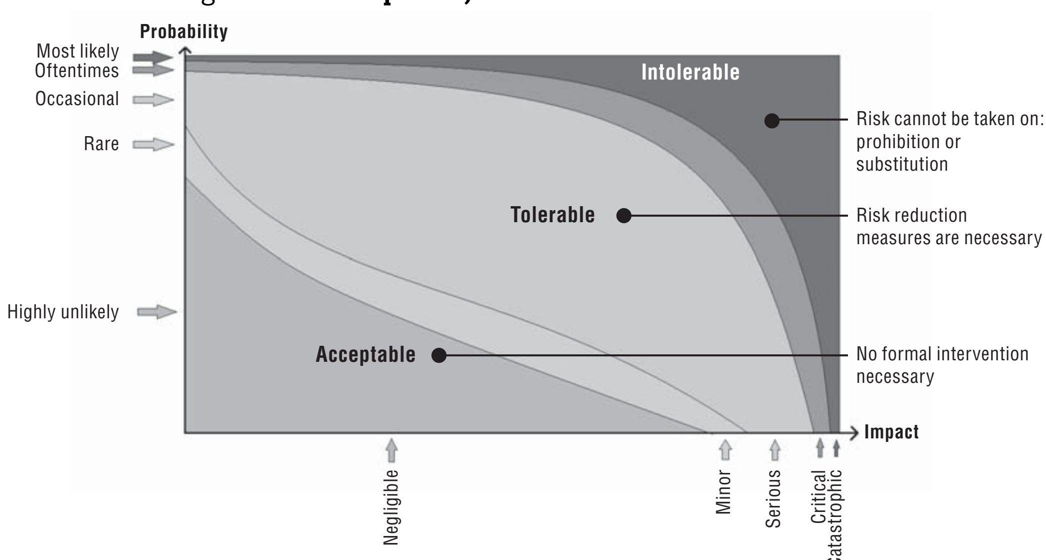
As new information on water risks develops, it may help resolve ambiguity about the way risks are shared between users and the government. For example, the risk of reduction in water availability in the Murray-Darling Basin is to be borne by users if it is due to new knowledge about the hydrological capacity of the system, and by the public if it arises from changes in public policy, such as changes in environmental policy (Quiggin, 2011). In the latter case, water users will receive compensation for such reductions in available water.

Target the risks

Based on the results of the risk appraisal, the process to determine the appropriate response begins by determining the "acceptability" of the risk. This relies on both evidence- and values-based judgements. Economic analysis has an important role to play for the evidence-based judgement, along with analysis from natural and social sciences. The overarching purpose of the **risk characterisation** process is to produce the best possible estimate of the broader economic, social and environmental implications of the risk.

The **risk evaluation** consists of making the distinction between acceptable, tolerable and intolerable risks (Figure 1.1). This is one of the most challenging and controversial tasks in the risk management process (Klinke and Renn, 2012). Indeed water security touches upon the issue of allocating water risks between residential, agricultural, industrial and environmental uses, a significant political economy question, as each will define *essential* or *adequate* in different ways.[5] For instance, much of the current policy debate in Australia's Murray-Darling Basin is about reallocating water from irrigation to sustaining the ecosystems. The reallocation of water among users can be seen, in effect, as a reallocation of water risks. In this example, the shift in allocation increases the risk of shortage to irrigators in an effort to decrease the risk to the resilience of freshwater systems.

Figure 1.1. **Acceptable, tolerable and intolerable risks**



Source: Klinke and Renn (2012).

Societies vary in the ways in which they select which problems are identified as risks, and which risks require attention and response, and what is an acceptable level of risk. Different actors within societies define risks and levels of acceptable risk in different ways. Too much or too little water can be considered a risk, depending on the level of water required.

The risk evaluation process also characterises potential **risk-risk trade-offs**. Indeed, efforts to reduce water risks for a given population, ecosystem or activity may (inadvertently or not) increase other water risks. For example, reducing the risk of water shortage through increased diversions can increase the risk of undermining the resilience of freshwater systems. Risk-risk trade-offs depend in fact on how water risks are managed. For example, should the risk of water shortage be addressed through improving efficiency of water use, this would have no effect on diversions and hence, on the risk to freshwater systems resilience. In many cases, risk-risk trade-offs will not involve choices between only two water risks, but several.

Weighing risk-risk trade-offs thus helps identify strategies that minimise the negative externalities of risk management. Risk-risk trade-off analysis helps policy makers evaluate the impact on water risks of policy intervention (or lack thereof), weigh the comparative importance of managing interrelated risks when difficult choices are required, and analyse the possibility of overall risk reduction (Graham and Wiener, 1995).

Addressing the trade-off between water risks can reduce inefficiencies and inequities. Weighing risk-risk trade-offs requires both scientific and value judgements, as illustrated in Box 1.1.[6] Criteria for making judgements about risk-risk trade-offs will likely include the magnitude of the risk, in terms of the severity of negative impacts and the probability of those impacts; the size of the populations, ecosystems and activities affected by each risk (in the case that different populations, ecosystems and activities are impacted) as well as distributional aspects related to the characteristics of the affected populations.

Government has a responsibility to facilitate stakeholders' agreement on the acceptability of water risk(s) in exposed and vulnerable areas (areas at risk). Indeed, the level of acceptable risk is a key cost driver for water security. A valuable (and unique) feature of the risk-based approach is to make this explicit and consider it in light of the costs imposed (today and in the long run).

Setting targets for water risks should be consistent with the existing legal framework (e.g. water quality standards, maximum and minimum river flow).

Governments should not aim to provide "zero" risk. Consistent with the scientific and technical understanding of the risks, where there are threats of serious damage to the water environment, it is not appropriate to use the lack of full scientific certainty about the magnitude of the impacts or causality as a reason for postponing cost-effective measures to prevent or minimise this damage.

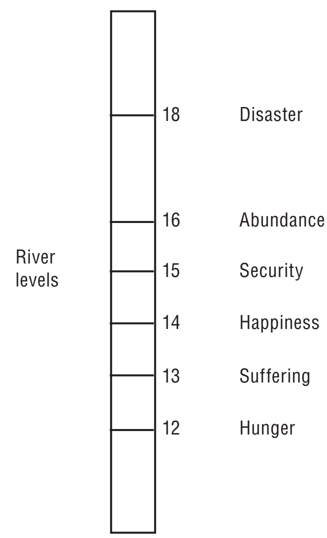
The precautionary principle (see definition in the glossary of terms in Annex A) essentially assumes the worst-case scenario, considering the downside risks without considering the potential benefits. The precautionary principle is best considered in relation to the standard prescription of normative theories of choice under uncertainty, namely, to choose the course of action that yields the highest expected (net) benefits (Quiggin, 2005). The burden of proof of safety is on those who create risks (in contrast with the distribution of costs and benefits, which places the burden of proof on regulators to identify the risks).

More attention should be paid to the systematic assessment of the costs and benefits of reducing risks across the water use sectors and to the consequent evaluation of various risk trade-off options (Rees, 2002). Information about the water risks should include the methods and costs of reducing exposure and vulnerability or of adopting loss sharing schemes.

The demand for risk reduction (or, in other words, the acceptable level of water security) is influenced by factors beyond the risk profile itself determined by the severity of negative impacts and their likelihood. The (bold) claim that "acceptable" levels of risks should be determined only by scientific information about hydrology to the exclusion of any other criteria is a weak one. Although discussions of risk in water planning have traditionally been dominated by uncertainty in hydrology (increasingly so with concerns over climate change), due attention must be given to economic, social, cultural and environmental factors, which can be more important than hydrological uncertainties.

A good example of economic factor influencing flood risk acceptability is given by agriculture along banks of the Nile in Ancient Egypt. "Moderate inundation' was defined as the key element of agricultural productivity (and related tax revenues). A lighter inundation than normal would cause famine, and too much flood water would be equally disastrous, washing away much of the infrastructure built on the flood plain (Figure 1.2).

Figure 1.2. **Interpretation of readings from the Nilometer**



Source: waterhistory.org,. *www.waterhistory.org/histories/cairo/cairo.pdf.*

An example of social (health) factor influencing quality risk acceptability is given by the level of chlorine in drinking water. Because the key objective of public policy is to improve health and because disinfection by-products that result when chlorine interacts with organic matter may contribute to increased cancer, it is legitimate to ask whether levels of chlorine used in water treatment to reduce the likely of water-borne diseases should occur at the expense of potentially increasing the risk of cancer.

The reduction of (or failure to reduce) a water risk may occur at the expense of (generate) another water risk. Such trade-offs between water risks provide a good example of environmental factors influencing the acceptable level of risk reduction.

The demand for risk reduction is also influenced by cultural factors. For instance, a community may increase its demand for flood protection because neighbouring communities have benefited from such protection, instead of as a result of increasing frequency or severity of flood events.

Regulating the public provision of water security often reinforces the demand for it. The availability of water or protection from floods can provide incentives to increase exposure and vulnerability to water risks. For instance, flood protection may provide incentives for further development of flood plains. Over time, the risk of flooding may increase, in some cases, significantly. This increased risk shifts the cost-benefit assessment of flood protection significantly, as does the continued development in the floodplain.

Manage the risks

Decision making about the appropriate response to water risks and the implementation of actions build on all the previous steps of the risk management process. The **risk management strategy** may be to avoid, to reduce, to transfer or to bear the risk. This can be done by altering risk drivers, limiting exposure or making populations, ecosystems and activities less vulnerable to potential harm. In cases where a policy response is considered appropriate, policy options should be assessed from an economic, environmental and equity perspective, to ensure that risk reduction is proportional, pursued at least cost and minimise the distributional impacts.

The periodic monitoring and evaluation (M&E) of risk management strategies and tools provides for necessary adjustments and/or introducing new risk management instruments. Besides, the M&E results should feed back into the risk management process, as part of an iterative process, and may lead to revisiting the risk appraisal and/or reconsidering the acceptable levels of water risks.

Ideally, risks should be assigned to the actors able to manage them most efficiently in social welfare terms. For example, flood risks may be addressed more cost-efficiently through flood insurance or compensating farmers converting their land into flood plain instead of government investing in dams.

Yet, the impact of water management decisions on the **distribution of water risks** is seldom expressly considered in policy decisions. Public and private decisions that significantly influence the drivers of water risks as well as the exposure and vulnerability of populations and ecosystems to those risks are often driven by other imperatives, such as economic constraints and opportunities. As a result, the distribution of water risks is often characterised by inefficiency and inequity (Rees, 2002).

The treatment of water risks is often starkly uneven. On the one hand, the cost of reducing or avoiding risks can be unacceptably high (disproportionate to the risks avoided) (e.g. oversised urban wastewater treatment plants that were built in the new German *Länder* after 1990). On the other hand, potential threats can be overlooked entirely (reflecting difficulties to set acceptable risk levels) (e.g. there are still many priority substances that have yet to be regulated under water legislation).

Responses to water risks may transfer risks to others or defer them into the future. For example, flood protection may transfer flood risk from one community to a neighbouring one. A strategy to manage the risk of water shortage by unsustainably mining groundwater may simply transfer the risk from current to future users. We often undertake actions that inadvertently increase the risk of a disaster or magnify disaster losses at a faraway location or at some point in the future. We often fail to recognise these actions, and when we do, traditional approaches only poorly control these negative externalities (Berger, 2008).

The **role of government** in managing risk can be guided by several economic characteristics specific to water risk (in part, following Rees, 2002).

First, there may be a government's role when many people are affected by a water risk at the same time ("joint consumption of risk"). For example, all flood plain dwellers are exposed to the same potential hazard (though all may not be equally vulnerable).

It is also important to look at the geographical scale of such "joint risk". The rational expectation is that national governments would adopt the subsidiarity principle for spatially confined issues. If, for example, a pollution risk was confined to one locality and provided information asymmetries have been addressed, it would be possible for the government to enable the use of market-based instruments or dialogue between the polluters and those bearing the risk, rather than employing national coercive quality standards on the discharges of all polluters in the country.

Another (distinct) factor is the possibility and ease of opting out of some or all of the risk. If vulnerable people cannot avoid the risk *at all* (too costly, not physically possible) this could also be an argument for the government having a role. It has to do with the extent to which people can affect their risk consumption by choice (e.g. by altering their land use or building dwellings on platforms or by purchasing insurance). Where opt out is possible and easy the government *should not* manage the risk – because it could create moral hazard (i.e. increase the incentives that individuals have to take risks).

Enabling individuals to make their own decisions about risk mitigation measures is only likely to be effective if it is possible to physically exclude free riders who have not contributed to the safety provision. However, this clearly has ethical and equity implications, particularly when ability to pay is a factor behind the failure to contribute (e.g. provide no assistance to those without insurance). In practice where physical excludability is possible (e.g. deny access to a clean water source), societies will need to make judgements about whether the poor should be protected.

The degree to which risks can be transferred also matters (see definition of "risk transfer' in the glossary of terms in Annex A). This could occur within the water sector or produce risks in other sectors (e.g. reduction of risks from water pollution increasing risks from air, ocean or land pollution). In either of these cases, the greater risk transfer, the less likely governments would allow private choices to operate in an unregulated way.

Where the risk for some people magnifies the risk for others (e.g. risk spread in the case of water-borne disease), risk is in this case a public "bad" which the government needs to mitigate or regulate directly.

Overall, the rational expectation would be that governments would only take direct action if, for instance, risks were collectively consumed on a large scale, when the potential for risk transfer was significant, where individuals had highly constrained opt-out options and where individuals or communities were deterred from making private safety provisions because they could not exclude free riders.

As discussed in detail in Chapter 2, a risk-based approach to water security offers a new way to approach water policy making. Enhancing water security should address first and foremost how resource and pollution-related risks should be managed in light of the costs they impose and the expected benefits from improved management. A risk-based approach has the potential to facilitate:

- A *holistic approach to water security.* First, water security means addressing all water risks at the same time because they are interrelated. Second, setting acceptable levels of water risks means addressing trade-offs between water security and other (sectoral, environmental) policy *objectives*. Third, maintaining acceptable levels of risk means addressing trade-offs between policy *instruments*.
- *The assessment of policy priorities.* Indeed there is no need to address water security everywhere, in particular where the likelihood and the impact of water risks are low. By identifying areas at risk ("weak spots"), a risk-based approach can help to prioritise policy action, focusing on where to get more value for money. It can also ensure that risk management is proportional to the risk faced. Emphasising the proportionality of action

to address risk can help to avoid taking action where the marginal cost of risk reduction exceeds the marginal expected benefits.

- *Preventive action*. A risk-based approach is a move from reactive policies (responding to pressures on water) to proactive policies (identifying where an impact might occur) based on the drivers of exposure and vulnerability to risk, which are not typically addressed in conventional approaches to hazards.
- *Dealing with uncertainty*. Uncertainty is inherent in the notion of risk. A risk-based approach allows for addressing uncertainty in a systematic and explicit way.
- *More responsive decision making*. The risk-based approach allows flexibility and responsive decision making. The acceptable or tolerable levels of water risks are not (should not be) static and will change over time, reflecting changes in risk drivers as well as in risk perceptions and water valuation. Feedback from practice is an integral part of risk appraisal and acceptability judgement, as part of an iterative process.
- *Long-term vision*. At times, solving urgent water security concerns requires short-term solutions. However, water security is not only about addressing immediate concerns but foremost to reduce risks of water insecurity over the long-term. Water security should be seen as a long-term goal.
- *Fostering equity*. By explicitly considering the distribution of water risks, a risk-based approach helps to prevent particular stakeholders to impose their own risk preferences on others or to gain benefits from risk management at the expense of others.
- *Ecosystems protection*. A risk-based approach seeks to achieve acceptable levels of water risk for society *and* the environment. The acceptable levels of water risks are set based on environmental quality objectives (e.g. water quality standards, maximum and minimum river flow).
- *Enhancing resilience*. By explicitly considering the risk of undermining the resilience of freshwater systems, a risk-based approach aims to develop water management practices that enhance such resilience.

Implementing the risk-based approach

As discussed in detail in Chapter 3, implementing a risk-based approach to water security will require governments to use a mix of policy instruments. Market-based instruments can play an important role in this policy mix as they can fundamentally alter the incentives facing water users, provide explicit signals about the likelihood and potential cost of water risks, and provide mechanisms for offsetting risks. This can be considered in the context of water supply, demand, quantity and quality.

As water risks are interlinked and the use of market-based instruments can have wider environmental and social impacts, a focus on economic efficiency by itself is not sufficient to tackle water security problems. Environmental and social goals need also to be considered. A widely accepted framework to implement this integrated approach is through integrated water resource management (IWRM), which encourages a more flexible, adaptive approach to water security management, involving greater collaboration with stakeholders and increasing the chance of sustainable outcomes to water security problems in the long term.

As discussed in detail in Chapter 4, managing water risks should be the result of well-informed trade-offs between water security and other (sectoral, environmental) *policy* *objectives*. Setting acceptable levels of water risks among stakeholders is one of the most challenging and controversial tasks in the risk management process. Indeed, allocating water risks between residential, agricultural, industrial and environmental uses raises a significant political economy question. Taking a broader view on interconnected and sometimes conflicting policy objectives, such as tensions between food security (and the willingness to secure domestic production) and water productivity (and the allocation of water to activities which add more value), trade-off choices can be improved.

Managing water risks has also to do with managing trade-offs between *policy instruments*. This requires a coherent approach between water policies (as described above) and other (sectoral, environmental) policies. Enhancing overall efficiency in water risk management entails taking account of complex links with sectoral policies, such as agriculture and energy, and other environmental policies, such as climate and nature.

By creating incentives towards meeting their own objectives, sectoral and environmental policies may have significant spillover to water security. The links between water and other related security objectives – food, energy, climate, biodiversity – are not routinely addressed or fully understood. Yet uncoordinated policy aimed at security in one area may result in less security in another: less water security as the cost of greater energy security through biofuel production, for example.

Complexity arises from the need to consider not only the direct but also the *indirect impacts* of sectoral policies on water security. The same sectors (e.g. agriculture, energy) that impact on water also impact on other components of the environment (e.g. climate, nature). Moreover, within a sector, the objectives of environmental protection and improving water management sometimes conflict with each other (e.g. subsidies to fast-growing forest plantations aimed at carbon sequestration are sometimes at the detriment of old growth natural forests that better regulate water flows).

What are the costs and impacts of inaction?

The costs of policy inaction can be considerable, not least because water insecurity can have global impacts (see Annex C). This is particularly the case where water insecurity causes disruptions in globalised businesses' supply chains. Not only are water risks directly affecting users (e.g. through the depletion of water resources), they also can result in significant additional use costs (e.g. increased abstraction costs due to groundwater subsidence). Moreover, there can be costs associated with damages to non-use values, such as the life-support function of water.

Inaction can thus lead to significant costs to society and the environment. Some costs of inaction are already reflected in household, firm and public expenditure (e.g. expenditure on health or to secure access to clean water or flood protection). Some are not, including the costs associated with biodiversity loss, though their impacts (in terms of lost welfare) can be significant. Loss of biodiversity reduces social welfare if the loss to society as a whole outweighs the gain to society (resulting from its loss), including it medium and long-term effects.

There is concern that segments of the population face greater exposure to water risks because they are more vulnerable (e.g. children), more exposed (living in areas at risk) and have more limited access to water resources and services (e.g. poorer households). In particular, microbial water pollution mostly hurts children and groundwater shortage the rural poor.

There is also a concern that disparities in water risks increase income disparities. Because they invest less in water security and are often living in areas at water risk (e.g. areas of poor water quality), lower income groups are more exposed to water insecurity and potentially "pay" a higher share of the costs of policy inaction (e.g. health costs) than higher income groups. In addition, water insecurity can marginalise those who lack access to capital (e.g. to invest in well-deepening as a result of falling water tables).

Notes

1. A tail risk is at the tail end of the risk distribution, with the least probability of occurring.
2. When a system is close to a tipping point, it can take a long time to recover from even a very small disturbance.
3. As a society, people value water highly for a range of economic, environmental, social, and cultural benefits, which at times are in conflict with each other (Bark et al., 2011).
4. Information asymmetry also hinders risk insurance initiatives.
5. Water security can be interpreted in terms of minimum levels of water risks for ensuring service provision which can be said to be "essential" (i.e. basic needs vs. "luxury" use), where one person's luxury use may be another's basic use.
6. There are techniques (e.g. stated preference or choice modelling) which allow for the expected benefits of reducing one type of risk to be weighed against both the expected costs of reducing that risk and the relative deterioration in safety from other forms of risk.

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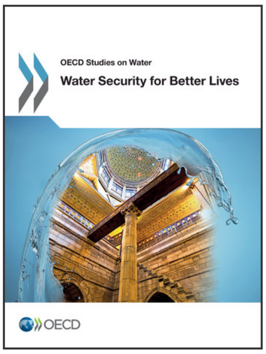

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