Chapter 1
Concepts in Water Security, Natural Assurance Schemes and Nature-Based Solutions

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Highlights This chapter illustrates how nature-based solutions, operationalized in natural assurance schemes can increase water security using the readiness level concept to address barriers to implementation

- The concept of water security strategies in the context of water related hazards and mitigated by Nature-based Solutions is analyzed and conceptualized in Natural Assurance Schemes
- Operationalization of Natural Assurance Schemes are tailored to the specific regulatory context of the insurance sector and its stakeholders
- Readiness levels with respect to technology, institutions and investment are developed to address and overcome barriers to implement Nature-based Solutions and Natural Assurance Schemes.

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1.1 Introduction

In the face of the looming water crisis, the concept of water security has been positioned by many nations and international organizations as a major societal objective in recent years. But given the importance of water security, how can we define this concept? What does water security mean in practice, and how does it relate to ecosystems and nature-based solutions? In a way, water security seems to be negatively defined as the avoidance or absence of water crises, conflicts or even wars (The World Climate and Security Report 2020). However, the scientific community has proposed more elaborate definitions of this concept. Table 1.1 offers four different definitions based on four approaches to water security we have identified in the literature review.

This chapter will first introduce a brief discussion on the concept and framing of water security, then introduce the concept of assurance schemes to present the readiness approach (Fig. 1.1) adopted in our case studies and finally conclude by presenting the main questions that will be addressed in this edited book.

Table 1.1 Approaches and definitions of water security

Approach	Reference	Definition
Water availability and reduced risks	Grey and Sadoff (2007)	Water security is 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”
Sufficient, safe and efficient supply of water	Falkenmark (2013)	Water security is, therefore, essential for a society’s survival, health, and prosperity. Scarcity of water or difficulty to safeguard access, is consequently an obstacle and functions as a bottleneck in socioeconomic development.
	Rijsberman (2006)	Water security is sufficiency of water supply for humans. It exists when access is secured to sufficiently safe and affordable water to satisfy individual needs for drinking, washing, and livelihood.
Social equity and link to other types of security	Zeitoun (2011)	Sustainable water security is interpreted as a function of the degree of equitability and balance between the six related security areas (human-community security, national security, climate security, energy security, food security, water resources security), as this plays out within a web of socioeconomic and political forces at multiple spatial levels.
Governance for equitable access of people and ecosystems	Boelens and Seemann (2014)	Water security refers to people’s and ecosystems’ secure, sustainable access to water, including equitable distribution of advantages/disadvantages related to water use, safeguarding against water-based threats, and ways of *sharing decision-making power in water governance*.

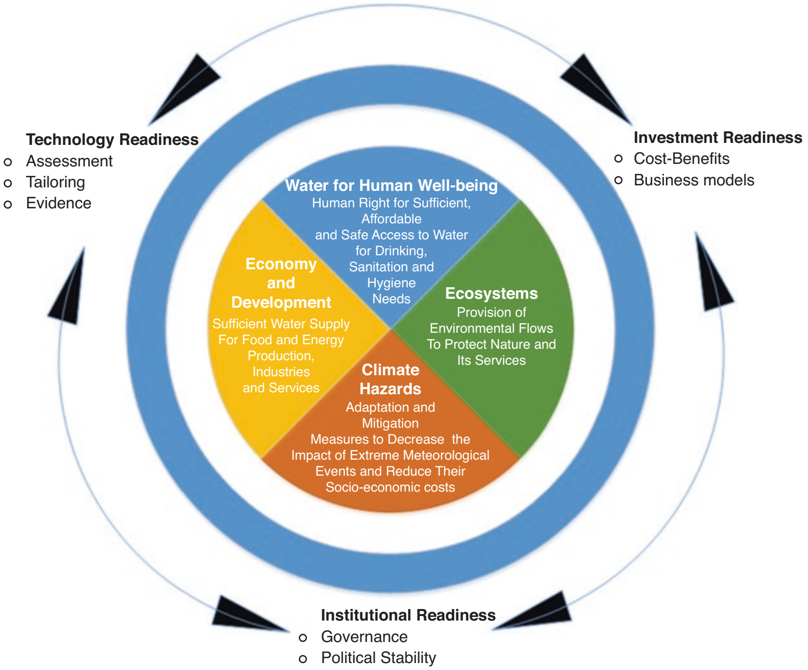

Fig. 1.1 Water security concept (modified from UN-water.org, 2013) Ecosystems-based adaptation (EbA) and Ecosystem Disaster Risk Reduction (ecoDRR) have enormous potential for reducing losses and damage from natural hazards and therefore contributes to water security

1.2 The Evolution of the Concept of Water Security

The concept of water security has evolved over the last twenty years to incorporate different aspects of, and also as an answer to, certain criticisms and shortcomings from earlier conceptualisations. Table 1.1 summarises this evolution which we discuss now to frame natural assurance schemes as part of water security and place special emphasis on environmental and social dimensions.

A first approach by Grey and Sadoff (2007) defines the concept of water security in terms of 'acceptable quantity and quality´, such approaches promote large grey infrastructure such as dams and water transfers as a vital strategy to address water scarcity, but as is demonstrated in e.g. the case study of Rotterdam (Chap. 16, this volume), nature-based solutions can complement rainwater harvesting to mitigate the effects of cloudburst generated flooding with water storage to anticipate water scarcity. A similar definition of water security is provided by UN-water.org (2013) (Fig. 1.1). Therefore, water insecurity is not a matter of scarcity of water resources, but rather the absence of storage, including green infrastructure, to increase water supply and provide water availability at certain times of the year when it is most needed, e.g. for irrigation.

Despite the criticisms of the social and environmental costs of large infrastructure (Garandeau et al. 2014; Jeuland 2010; Molle and Floch 2008; Wang et al. 2014), it is argued that some countries still need the benefits from this built infrastructure, and cannot be replaced by 'green infrastructure' if they are to support the needs of a growing population (Koutsoyiannis 2011; Muller et al. 2015), but hybrid solutions where green and grey solutions complement each other have large potential. Four categories of key challenges for water security are identified in Investing in Nature (2019): surface water quality, groundwater quality, flooding, and droughts and water scarcity.

These approaches are important in the cases studies included in this book, but can easily be extended to e.g. the region of Central America and the Caribbean (Mysiak and Calliari 2013) or elsewhere in disaster-prone regions or increasingly focus on the need to adapt throughout the world (Hare et al. 2014; Van der Keur et al. 2016). Institutional factors, including combinations of international agreements, national regulations and planning, as well as local level capacity development can facilitate substantially the adoption of ecosystems-based approaches. Notably nature-based solutions operationalized in natural assurance schemes (NAS) have value in protecting human lives and infrastructure against the effects of natural hazards while offering substantial co-benefits like biodiversity, carbon sequestration, better health. Urban and regional planning and natural resource management are important areas that can play a central role in the enhancement of ecosystem services. The positive correlation between enhanced ecosystems and poverty reduction warrants more attention as the poor are frequently the most vulnerable to the effects of disasters (Hare et al. 2014).

Ecosystems are constituting components of the natural and semi-natural environment, and a source of vital services, benefits and goods to humankind. Ecosystem services (ES) inhabit provisioning, cultural, supporting and regulating properties and embody the benefits people obtain from ecosystems that are eventually translated into valuable goods. The ES regulatory services thus include natural hazard mitigation and contribute effectively to tackling the drivers of social and economic vulnerability to natural hazards. Ecosystem services delivered by NBS are often, as illustrated in case studies in this volume, a more cost-effective way of dealing with climate extremes than 'hard infrastructure engineering solution (grey) alone and where nature-based solutions can supplement grey as hybrid solutions (e.g. Kazmierczak et al. 2020; Browder et al. 2019; Mysiak and Calliari 2013).

A second approach emphasizes that water insecurity is the result of context-specific increasing rates of population and economic growth and their relation to water utilization, consumption and availability. This approach considers a more dynamic and complex conceptualization of water insecurity by adding water crowding (number of people per million cubic meter per year) as a key indicator and linking the concept to food security. Falkenmark (2013) argues that there is an inexorable link between water scarcity and human and food security with projections to 2050 estimating a "carrying capacity overshoot in water-short countries with continuing population growth and therefore, meaning that there will be a massive dependence on food imports". Vörösmarty et al. (2010) estimated that nearly 80% of the world's population suffer high levels of water insecurity, specifically regions of intensive agriculture and dense settlements. In practice, this approach promotes two key strategies to bring about water security: vital large infrastructure as the main approach, but adding improved efficiency of water use as a key strategy, especially for agriculture.

A third approach to water security is related to the second one by emphasizing the importance of agriculture in the quantity and quality of available water. Allan (2013) criticises the apparent invisibility of the food-water relation and the pressure that is put on farmers, which in his view are 'society's water managers', to decrease their water use in favour of more productive uses often localized in cities (Molle and Berkoff 2006). However, this approach departs from the previous one by also incorporating other dimensions, such as household water security, urban water security, environmental water security, resilience to water-related disasters and economic water security (Van Beek and Arriens 2014). This approach acknowledges water as a highly complex natural resource that reaches out to other important issues and dimensions, whereby urban water security, often conceived as the main target, is just a fraction amidst the great challenges of "water for food, water for nature, sustainable use of water resources, closing water and nutrient cycles [...]" (Savenije 2002).

In the context of this book, important aspects of water security related to water related hazards and mitigation by means of nature-based solutions, are analysed, conceptualised and operationalised in natural assurance schemes. Following this idea, Zeitoun (2011) argues for the need to go beyond water, and conceive water as a web, in which food security, energy security, climate security, human/community security and national security are also included. In Chap. 7 (Basco-Carrera et al., this volume) IWRM is, in line with the third approach, elaborated for providing the guiding principles to achieve water security for all by means of strategic planning. Water security is here defined as the capacity of a population to safeguard sustainable access to adequate quantities of acceptable quality water for sustaining livelihoods, human well-being, 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 (UN-Water 2013).

The fourth approach we identified, is a social perspective on the concept of water security. Bakker and Morinville (2013) analysed the role of social power, or power relations, as another cause of water insecurity besides "poor management decisions, suboptimal processes, insufficient science, and evolving environmental pressures", and conclude that vulnerability and uneven water security emerges from the exclusion of stakeholders from decision-making processes. The approach criticizes strategies that advocate for seemingly uncontroversial desirable objectives such as increasing water efficiency by promoting controversial measures such as water utility privatizations, which have been widely promoted by international institutions like the World Bank. Some of the unintended consequences of these measures is the worsening conditions of large sections of the population once the private water utility takes over (Bakker 2013: 215). This approach brings back the political dimension of water security, when other approaches intend to depoliticize agendas that include large grey infrastructure as a vital component of water security without considering alternatives to large grey infrastructure nor the uneven distribution of costs and benefits of large grey infrastructure across different sectors of society and natural systems (Boelens and Seemann 2014; Godinez-Madrigal et al. 2020). The focus of this book is to compare such grey infrastructures to smaller green intervention measures and the protective function of green infrastructure functions and its services.

Despite the multiple socio-ecological costs associated with grey infrastructure, the discursive power of the State to 'securitize' certain agendas may close social debates and the decision space, thereby depoliticizing water problems and what to do about them (Molle 2009). This political reality is important when discussing nature-based solutions, because when decision makers consider which kind of strategies are best suited to bring about water security, they may be biased towards tried-and-true large grey infrastructure given the risk aversion of many water managers and utility managers to explore different strategies (Marlow et al. 2013). However, when considering water security as a complex multi-dimensional concept, one-size fits-all, and one function only solutions may entail multiple pitfalls in related dimensions of water security.

Figure 1.2 shows this increasing level of complexity and new dimensions added with the evolution of the concept. New transdisciplinary knowledge has lately been developed that sheds light on the importance of considering a more complex approach to water security. In natural sciences, recent research has contributed to the understanding of long-term unintended consequences of large grey infrastructure in societies such as reservoirs, drainage networks and levees. The 'reservoir effect' emerges when societies over-rely on large water transfers for their water supply, an unintended consequence of the long-term dependency of societies to reservoirs and their increasing vulnerability to hydro-climatic events (Di Baldassarre et al. 2018). The 'levee effect' emerges when levees are built to protect societies from flooding, but in turn diminishes social memory over larger periods of time by

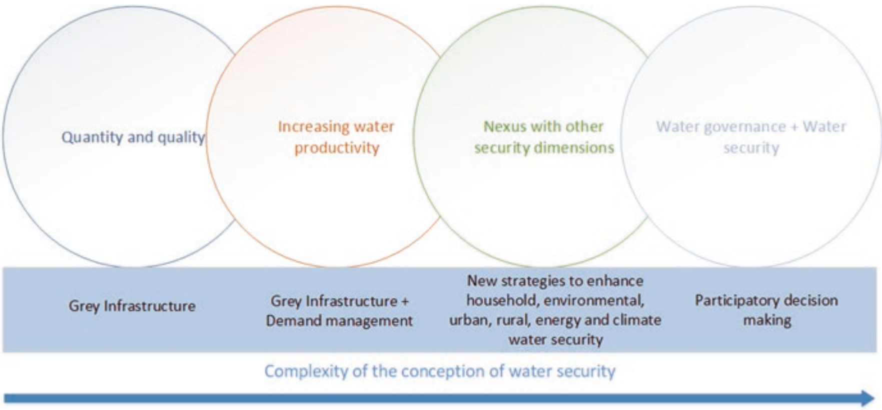

Fig. 1.2 Evolution of conceptions of water security and related strategies. (Source: authors' own)

giving a sense of unfounded sense of security that can backfire with an extreme hydro-climatic event (Di Baldassarre et al. 2013). In the social sciences, recent research shows that large infrastructure can trigger intractable social conflicts that forestalls the development of any kind of solution, while urban water systems continue to deplete groundwater with increasing socio-ecological costs (Godinez-Madrigal et al. 2020).

This knowledge may force decision makers to reconsider alternatives to large grey infrastructure. Raymond et al. (2017) argues that nature-based solutions not only have the potential for bringing about the benefits purported by grey infrastructure, but also bring about socio-ecological co-benefits along. Therefore, in the pursuit of resilient societies and urban and rural water systems, the decision space needs to include nature-based solutions as necessary components to bring about water security, understood as a complex, multi-dimensional and transdisciplinary process.

1.2.1 The Assurance and Insurance Value of Ecosystems

Ecosystems have a value based on their sustained capacity to maintain their functioning and production of benefits despite any disturbance by reducing risks to human society caused by e.g. climate change related excess precipitation, temperature or by natural disasters. In the context of NAS, the value of ecosystems is understood as the extent to which nature-based solutions operationalised in natural assurance schemes reduce water related risks from e.g. extreme events while at the same time provide co-benefits including increased health (physical and mental), increased attractiveness of living areas, especially in cities, and also benefits as improved water quality and quantity. The latter can be exemplified by e.g. re-infiltration and recharge to groundwater contributing to water quality and quantity respectively.

"Natural Assurance Schemes" (NAS) build on the potential that ecosystems have in reducing damage costs by mitigating water related risks, notably floods and drought under climate change, and increasing resilience of society. Natural assurance schemes are thus framed under the ecosystem services concept, i.e. the benefits people obtain from ecosystems, implemented as nature-based solutions for risk reduction and accompanying co-benefits. In general, ecosystem services include provisioning services such as food, water, timber and fiber; regulating services that affect climate, floods, disease, wastes, and water quality; cultural services that provide recreational, aesthetic, and spiritual benefits; and supporting services such as soil formation, photosynthesis, and nutrient cycling. Burkhard et al. (2012), define ecosystem services as the flow of materials, energy, and information from natural capital stocks, which combined with manufactured and human capital services to produce human welfare, which gives centrality to the concept of natural capital to human well-being.

1.2.2 The Concept of Natural Assurance Schemes

The underpinning concept for this edited volume is that of a natural assurance scheme or NAS. The NAS concept is itself based on the concept of natural assurance value, previously defined as the reduction of risks that natural systems can produce and associated benefits. The protective value of NAS must be economically and financially viable and include the multifunctional aspects of nature-based solutions, i.e. the primary function of mitigation and avoiding damages as well as accompanying co-benefits.

Assurance and insurance refer to a risk transfer mechanism, where a premium payment by a household, company or community to an insurer in return for having to reimburse their clients after a disaster occurs. Assurance generally applies to persistent coverage over extended periods of time or until death, whereas insurance refers to coverage over a limited amount of time. The insurance companies deal with natural hazards by modelling and pricing risks and therefore a strong knowledge on natural hazards is required by insurers to be able to face shocks and change induced by natural hazards under climate change. That compensation role is crucial for the national economy resilience. The insurance industry has a key role in protecting society from natural disasters throughout the insurance coverage providing financial support to society to reestablish itself as quick as possible, limiting damaging economic domino effects.

Natural Assurance Schemes denote a range of institutional, technological and financial mechanisms to operationalize the value of green infrastructure in the green/grey mix of mitigation against water risks. Natural assurance schemes are devised, with stakeholders, based on locally relevant but EU-wide physical, sociocultural and economic valuation and could constitute a mechanism to finance the mitigation of risks through targeted investment of a proportion of insurance revenues.

Operationalization of these natural assurance schemes for the primary benefits of risk prevention and reduction and associated co-benefits must be tailored to the specific context and regulatory settings. The insurance industry is a heavily regulated industry at national level, and marked by high competition and range from the fully solidarity based, more hybrid systems to fully private (Fig. 1.3).

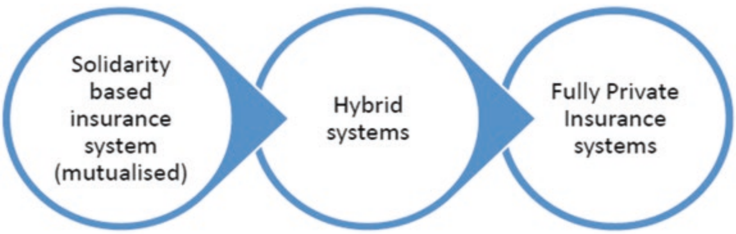

Fig. 1.3 Insurance models from fully public to fully private. (Source: authors' own)

The design of a natural assurance scheme entails a series of different steps: (i) to undertake a robust physical assessment of the hazard and exposure and subsequently identify preferred and socially acceptable nature based strategies for stakeholders including an effective and a viable business model and financing scheme; (ii) to consider the potential role of notably the insurance industry in these natural assurance schemes which may include investors, data providers and other information facilitators to focus on potentially increased risks of natural hazards as a consequence of increased exposure and vulnerability compounded by climate change.

Improved understanding of natural assurance schemes can help develop Climate Resilient Investments. A climate-resilient investment is an investment that results from a process where governments, planners and developers integrate climate change in project planning and design, including climate finance (UNFCCC 2018) from relevant sources such as the Green Climate Fund, green bonds and now under the EU Green Deal. The proper integration of climate change in the planning and design of infrastructure investments including green infrastructure and hybrid infrastructure, may considerably reduce the risk of damage to national assets.

1.3 Readiness Level Concepts to Overcome Barriers and Implement NBS and NAS

When operationalizing the value of ecosystems in natural assurance schemes, a number of barriers have to be overcome. Those barriers relate to the technical, social and economic dimensions. Nesshöver et al. (2017) identified the following key elements and drivers needed to operationalize NBS and ensure its integration in climate adaptation plans: (i) dealing with uncertainty and complexity (e.g. by adaptive management); (ii) involvement of multiple stakeholders; (iii) use of multi- and transdisciplinary knowledge; (iv) common understanding of multifunctional solutions, trade-offs and natural adaptation; and (v) evaluate and monitor for mutual learning. Moreover, in a multiple case study analysis of NBS implementation in European cities by (Frantzeskaki 2019) highlights that NBS require multiple disciplines for their design, diversity (of settings) for co-creation and recognition of the place-based transformative potential of NBS as 'superior' to grey infrastructure. In this book, we build on the concept of NBS readiness by Van Cauwenbergh et al. (2020) and frame the operationalizing of insurance value of ecosystems as a process of increasing readiness for the implementation of NBS, rather than framing it as a process of overcoming barriers, and management of uncertainty, that may hamper integration in climate adaptation plans.

Three types of readiness are considered: (1) Technology and Knowledge readiness – linked to barriers on knowledge and performance (generation of evidence) + inclusion of certain benefits such as aesthetic appeal in the design– related to setting up an appropriate level of experimentation in a context of trust; (2) Socio-Institutional readiness – linked to barriers on acceptance, trust, handling uncertainty and ambiguity, multi-functional solutions and coordination, as well as innovative regulatory frameworks to deal with the inherent uncertainty of NBS and potential liabilities; and (3) Investment readiness – linked to capturing multiple values and valorizing the multiple benefits in public-private-people partnerships.

1.3.1 Technology and Knowledge Readiness

Technology readiness levels (TRL) were developed by NASA in the 1970s, as a common way was needed to describe the maturity and state of flight readiness of technology projects for which a 9-level description in a thermometer analogy was invented. TRL is widely used in industrial sectors that want to gauge the development and prospective market value of innovative developments as well as by potential investors or users of the technology as it gives an indication of utility of reliability (Webster and Gardner 2019).

TRL are also used by funding agencies, as a guideline for researchers, developers and innovators to target technology toward higher TRL. In its Horizon 2020 and Horizon Europe research and innovation framework, the EC foresees the use of TRL for non technological development. Figure 1.4 shows the different TRL levels, based on NASA and including some additional explanation to understand the definitions.

In the context of this book technology is defined not only as bio-physical components of the NBS and interaction with the natural environment, notably the hydrological cycle and related risks. Technology is also considered as a body of knowledge and general perception of the multi-functional performance of NBS by diverse stakeholder groups, in analogy with (Arthur 2010).

1.3.2 Institutional Readiness

The concept of Institutional Readiness Level (IRL) follows Webster and Gardner (2019) as a combination of 8 categories that have to be fulfilled for readiness to be achieved: (1) demand for technology, (2) strategic focus, (3) relative need and benefit of the new technology, (4) (e)valuation processes in place, (5) IRL enacted through specific enablers within and outside of the organization, (6) receptivity, (7) adaptive capacity and (8) sustainability (see Table 1.2 below). Originally developed in the field of philanthropic studies to understand which features and characteristics are more likely to improve the 'success' of an organisation, Barnes and Brayley (2006) and Webster and Gardner (2019) applied the concept to the field of regenerative medicine. In this book it is applied to mainstream NBS as a novel technology/approach in climate adaptation.

Contrary to the TRL which uses a numerical scale, the IRL categories in Table 1.2 differ in levels of maturity expressed qualitatively. Each of the categories needs to

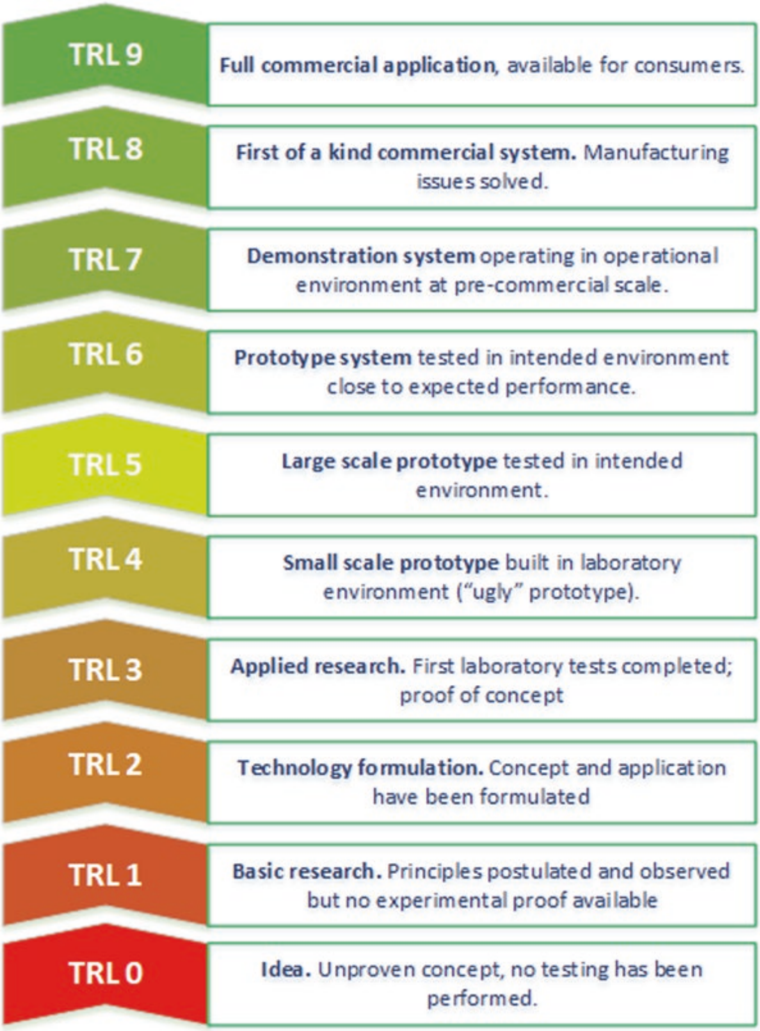

Fig. 1.4 TRL levels

be at a sufficient level of maturity or readiness for socio-institutional readiness to be achieved. At the core of IR is the existence of an effective communication between stakeholders as well as pluri- and transdisciplinary cooperation to capture the multi-functional character of NBS and translate it into a fair and sustainable distribution of its multiple benefits. This means that in order to successfully integrate NBS in water related risk strategies, substantial coordination across municipal or sectoral organizations is needed as discussed by Van Cauwenbergh et al. (2021).

Table 1.2 Key aspects of institutional readiness levels for NBS

Institutional readiness levels (IRL) category	Operational definition
Demand for NBS	Institution has key actors engaging with and identifying new NBS that meet field/organizational needs in CCA, DRR and Water Resources Planning (WRP)
Strategic focus	Institution has identified potential NBS and determined their relationship with existing technologies and grey infrastructure to achieve water-related security and resilience
Relative need and benefit of NBS	Institution has key actors assessing the capacity to take-on and develop new technologies within current and future contexts
(E)valuation processes in place	Assessment of the (diverse) values of NBS are undertaken and shared
IR enacted through specific enablers within and outside of the organization	Key individuals/groups are formally tasked to enable adoption especially with regard to meeting standards and regulatory requirements
Receptivity	Novel institutional structures are created, in anticipation of expected challenges / affordances presented by NBS. These structures reflect the need to retrain staff, the construction of new innovation spaces and new technology platforms.
Adoptive capacity	NBS aligns with institutional priorities and organisational capacities. Initial problems and unanticipated challenges/ affordances are identified and seen to be manageable
Sustainability	NBS is routinely produced/used/assessed within institutions. Current institutional arrangements and resources are sufficient for routine and ongoing production, assessment and deployment

Adapted from Webster and Gardner (2019)

1.3.3 Investment Readiness

While academia and increasingly policy makers are promoting NBS as a cost-effective way to address floods, droughts and climate change resulting in economic, social and environmental benefits, investment appetite in NBS is still low. This is largely due to the unclear return on investment, as the capturing of multiple values and benefits in a public-private-people partnership is complex and requires innovative business models.

In this book we discuss business models specifically developed for NBS and NAS and link it to the concept of investment readiness. We use the definition by Blank (2014) for investment readiness or IVRL. In analogy to TRL, eight levels of investment readiness are indicated as a simple and visual way to share a common understanding of investment readiness status (Fig. 1.5). The development of the business canvas (Chap. 8, this volume) is at the core of generating investment readiness in where the canvas is representing how lower levels of IVRL can be overcome by various ways to mobilize the funds and finance. The modified business canvas for NBS-based Natural Assurance Schemes by (Mayor et al. 2017; Chap. 8, this volume) underlies the considered IVRL and addresses the growing interest of leaders

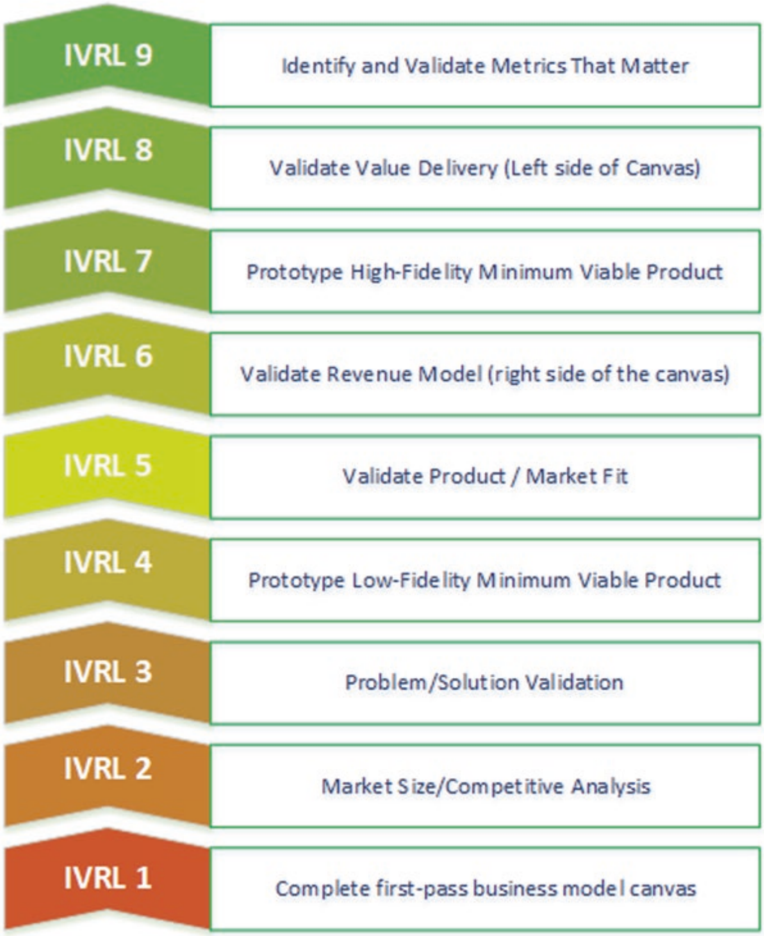

Fig. 1.5 IVRL levels

from philanthropy, development and finance to mobilise capital to effectively solve social and environmental issues (Höchstädter and Scheck 2015) (Fig. 1.5).

1.4 Main Questions to be Addressed by the Book

Nature-based solutions, as operationalised in Natural Assurance Schemes, are important to ensure water security in various ways. The leading thread in this book is to increase our understanding of NBS through a multidisciplinary approach and investigate how NBS can contribute to water security by helping mitigate water related hazards while at the same time contributing to maintaining water resources of sufficient quality and quantity. Strengthening the knowledge on NBS can help scaling up implementation of NBS in Natural Assurance Schemes in cities and basins.

The main questions addressed by the book follow the overall chapter structure of this work and help to understand how to improve readiness at the level of Technology (TRL), Institutions (IRL) and Business (IVRL) for developing and implementing NBS and NAS while increasing water security.

Essential overarching questions include:

- how to develop and apply methodologies to assess the effectiveness of NBS for different water related natural hazards, physical environments and spatial scales; how do they add to water security; (contribute to TRL)
- how can understanding and mapping stakeholder participation processes and risk perception help NAS development in the planning process; contribute to IRL
- what is the economic value of NBS and how can NBS be assessed through a cost-benefit analysis framework; (contribute to IRL and IVRL)
- What decision process can support analysing, selecting and implementing NBS with the view to reach a robust strategy that contributes to the different dimensions of water security; (contribute to TRL, IRL and IVRL)
- how to operationalise NBS and identify suitable business models and enabling environment in order to build effective NAS; (contribute to IRL and IVRL) what business models emerge from capturing the assurance value of ecosystems? Can this be insured? how would these be financed?

The leading questions are addressed and illustrated in a range of contrasting case studies in Europe both with respect to (1) varying environmental, physical conditions, spatial scale and vulnerability to water related natural hazards that require diverse NAS approaches, but also to (2) varying readiness level of technology, institutionality and investment for implementation of nature-based solutions in NAS. Illustration of how developed methodologies and strategies are applied in the case studies serve important lessons learned in the final chapters of this book.

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