Radboud Honours Academy

Urban regions in the delta

Reflections on Science 2011 – 2012

Radboud University Nijmegen

REFLECTIONS ON SCIENCE

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Radboud Honours Academy
Erasmusplein 1
P.O. Box 9103
6500 HD Nijmegen
T. +31 (0)24 361 59 55
E. honours@honours.ru.nl

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Foreword

University studies are not just about getting from A to B as fast as possible. It's often enriching to take some detours along the way, to run an extra lap, or to see how things look from the other side.

The Greek poet Konstantinos Kavafis summons us to embark on such an enriching journey in his poem *Ithaka*. This is a journey that leads to new knowledge and understanding, one that awakens your appetite for travel, because anyone who has experienced the world beyond familiar horizons will want to continue that quest.

The Honours programme *Reflections on Science* stimulates the most talented students to start the journey Kavafis suggests. It gives students who want to broaden their regular Master's programme an opportunity to look beyond the borders of their own discipline and culture.

To this end they form think tanks with students from other Master's programmes and foreign universities. This report presents the results of the research conducted by students of the Reflections on Science programme during the academic year 2011-2012.

Professor Sebastian C.J.J. (Bas) Kortmann
Rector Magnificus of Radboud University Nijmegen

Ithaka

As you set out for Ithaka
hope the voyage is a long one,
full of adventure, full of discovery.
Laistrygonians and Cyclops,
angry Poseidon – don't be afraid of them:
you'll never find things like that on your way
as long as you keep your thoughts raised high,
as long as a rare excitement
stirs your spirit and your body.
Laistrygonians and Cyclops,
wild Poseidon – you won't encounter them
unless you bring them along inside your soul,
unless your soul sets them up in front of you.

Hope the voyage is a long one.
May there be many a summer morning when,
with what pleasure, what joy,
you come into harbors seen for the first time;
may you stop at Phoenician trading stations
to buy fine things,
mother of pearl and coral, amber and ebony,
sensual perfume of every kind –
as many sensual perfumes as you can;
and may you visit many Egyptian cities
to gather stores of knowledge from their scholars.

Keep Ithaka always in your mind.
Arriving there is what you are destined for.
But do not hurry the journey at all.
Better if it lasts for years,
so you are old by the time you reach the island,
wealthy with all you have gained on the way,
not expecting Ithaka to make you rich.

Ithaka gave you the marvelous journey.
Without her you would not have set out.
She has nothing left to give you now.

And if you find her poor, Ithaka won't have fooled you.
Wise as you will have become, so full of experience,
you will have understood by then what these Ithakas mean.

K.P. Kavafis (1911)

Translated by E. Keeley and P. Sherrard (1992)

Introduction

If you wish to enrol in the Honours programme *Reflections on Science*, you must be of high calibre. The course is designed for excellent students who can work independently. It demands a degree of mastery that not every young researcher has achieved, as well as flexibility. You will need to appreciate what other scientific disciplines can offer, and you will need to be able to work in close partnership with students from other countries. There is no guarantee of a good outcome; in fact, there are plenty of obstacles along the way. The strength of this programme is that in overcoming obstacles, you open up new vistas for yourself. Clearly, this year's students have not searched in vain.

This report presents the results of the endeavours of the members of a think tank that has been working on the theme 'Urban regions in the delta' for the past year. Although the Netherlands has considerable expertise in dealing with water, there is much to be gained through joint efforts with people from other countries. The members of this think tank were drawn from several countries. Students from Radboud University Nijmegen worked with students from the University of Duisburg-Essen, the Bandung Institute of Technology, Padjadjaran University of Bandung, Portland State University and the Blekinge Institute of Technology in Sweden. The think tank was commissioned to produce a report for the Delta Alliance, an international network organization with the mission of improving the resilience of the world's deltas. The work of the think tank was supervised by Prof. Toine Smits of Radboud University Nijmegen, Prof. André Niemann of the University of Duisburg-Essen, Prof. Alan Yeakley of Portland State University and Prof. Rimbo Gunawan of Padjadjaran University in Bandung.

During the journey these students have made over the past year, they have been introduced to a new way of working, which has its own dynamics. Moreover, immersion in a think tank whose members are so diverse has enabled them to see themselves in a new light. It has been an exceptional and enriching experience, and they will benefit from it as they continue on their way.

Noortje ter Berg
Programme Director, Reflections on Science

Urban regions in the delta

Water, health, development

Khaled Abdul-Ehami
Andre Benaim
Frank Collas
Kelly Cowan
Miroslav Damyanov
Hofiya Djauhari
Jaap van Erp
Monja Froböse
Jovin Hurry
Sarah Holmen
Rutger ter Horst
Ahmad Komarulzaman
Lars Lamers
Robbert Lauret
Sandra Lohrberg
Marissa Matsler
Basra Mohammed
Anindrya Nastiti
Ludwika Nieradzik
Kathrin Oertel
Cansu Oranç
Swinda Pfau
Annisa Rahmalia
Hilde Reijers
Silvita Fitri Riswari
Jodi Schoenen
Simone Wevers
Antonia Zillman

Preface

Water is one of the most intrinsic elements of dutch identity; just take a look at a map of the Netherlands and you will immediately see that water is a defining feature of this country. The way the so-called "Low Countries" have dealt with water have long been a source of wonder to the rest of the world. However, urbanisation and climate change will bring forth new challenges and complex problems that cannot be solved by one discipline or one country.

The report you are about to read is the result of ten months thinking, discussing, writing and re-writing to address these complex problems. The project started in the summer of 2011 when the Radboud Honours Academy set up a so-called "summer school" in The Netherlands and where the interdisciplinary think tank "Urban Regions In the Delta; Water, Health and Development" came into being. This think tank comprised 25 master and PhD students from five different universities. The universities involved in this think tank were: University of Duisburg-Essen (Germany), Institute of Technology Bandung and the Padjadjaran University Bandung (Indonesia), Portland State University (USA), the Blekinge Institute of Technology (Sweden) and Radboud University Nijmegen (The Netherlands).

During summer school, the think tank was challenged by the "Delta Alliance", an international knowledge network dealing with resilient deltas. This challenge was formulated as follows:

> *"Develop a generic framework and common language that stakeholders can use to synergize various activities related to (long term) sustainable development of urban regions in the delta. Subsequently, test this generic framework by (theoretically) applying it to a river basin/delta in Indonesia".*
> (Note: which specific Indonesian river basin/delta is selected for this experiment is a choice of the think tank itself)

In the period that followed the think tank analysed various sustainability concepts for their suitability to solve the "wicked problems" of urbanized areas and that would

promote sustainable development of deltas. Finally, the think tank selected the so-called "Framework for Strategic Development" (FSSD) and the Citarum River basin in Indonesia as a challenging practical case to (theoretically) apply this framework. This exercise led to several recommendations that could help a successful application of the FSSD to deltas.

HOW TO READ THIS REPORT

This report starts with a discussion on sustainability and its definition, followed by a thorough investigation of the Framework for Strategic Sustainable Development (FSSD) and possibilities for the incorporation of other frameworks. The reader who is familiar with the FSSD can skip section 2.1. Chapter 3 describes a series of wicked problems, divided in three categories: water, health and development. In the fourth chapter the report discusses to what extent these wicked problems occur in Indonesia. The report ends with a description of all recommendations.

ACKNOWLEDGEMENTS

We would like to thank Prof. Toine Smits for supervising this process and his support, expertise, involvement and guidance he provided throughout. We are also grateful to Henk Willems, Bep Kulling, Femke Kok and Noortje ter Berg of the Radboud Honours Academy for their assistance and contributions during the course of this Honours master. Finally, we are thankful to the co-supervisors Prof. Alan Yeakley, Prof. Rimbo Gunawan, Prof. André Niemann and Yvonne Chang for bringing in their expertise and support.

On behalf of all the authors,
Robbert Lauret

Executive Summary

The "assignment" given to the radboud honours think tank by the delta alliance was to create a generic framework for sustainable development in urban regions in deltas and to apply it to the problem of water related diseases in Indonesia. Throughout the program the potentials of the "Framework for Strategic Sustainable Development" (FSSD) were analysed. Finally, the think tank formulated recommendations for a successful application of this framework to fit the specific conditions in urbanizing deltas.

To get a clear overview of urgent issues in deltas, the think tank identified various complex problems, which frequently occur in urbanized delta regions all over the world. These "wicked" problems are divided in three categories: (1) water related problems, such as flooding or water scarcity, (2) health related problems, such as water borne diseases, and (3) socio-cultural problems, such as awareness, cultural diversity, governance and law enforcement. The identification of these wicked problems enabled the think tank to figure out what a generic sustainability framework has to address in order to be qualified for use in urban regions in deltas. After an analysis of various sustainability concepts the "Framework for strategic Sustainable Development" (FSSD), was selected as the potential most suitable sustainability concept for this quest. After various workshop sessions the think tank came up with several recommendations for the application of the FSSD in urban regions in deltas, both in a general sense as well as specific for the Indonesian case (the Citarum river basin).

In general it can be concluded that the FSSD is an appropriate framework to be used for sustainable development in urban regions in deltas. However, some suggestions have been made to narrow down the focus of the FSSD to the specific problems in urbanizing deltas. For example, water related health issues should play an important role in the definition of goals. Additionally, knowledge on cultural and spiritual/religious characteristics should be taken into account and a common language should be developed in order to optimize the cooperation between stakeholders. Furthermore, an integration of the Ecosystem Services concept in the FSSD could be very helpful in valuing (monetary and monetary) the importance of sustainable use of natural resources in river basins and deltas.

When applying the FSSD in Indonesia it is crucial to take into account the cultural and spiritual/religious background, to involve all relevant stakeholders (including individuals with informal authority) in the roadmap towards sustainability and to use practical examples to explain the connection between people's needs and the importance of sustainable development.

1. What is Sustainable Development?

One of the most commonly used definitions for sustainable development is the Brundtland definition: "Development that meets the needs of the present without compromising the ability of future generations to meet their own needs".[1] It states that resource use and interventions today should not deplete the capacity of those resources for future use. Sustainable development has become increasingly important as growing populations put greater pressure on dwindling natural resources. Much current research indicates that we are on an unsustainable course.[2, 3] Our lifestyles and methods of production are consuming resources in ways that cannot be sustained. This can be described as the "sustainability challenge" and it can be represented metaphorically in the form of a funnel.[4]

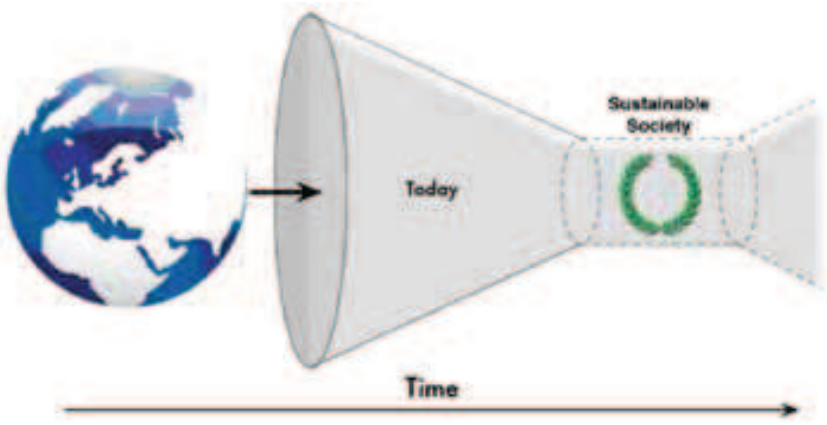

Figure 1 | The "funnel" metaphore of the FSSD. Unsustainable use of natural resources will narrow down living conditions. Sustainable use by meeting the four sustainability principles (see paragraph 2.2) will stabilize (indicated by the laurel wreath) and eventually increase the earth's resilience[4, 5].

The increasing number of people on Earth, increasing pollution and escalating resource use are putting strains on the biosphere's ability to support life, including humans. Each day these trends are reducing the potential we have to manoeuvre. We are moving towards the walls of the funnel. In order to promote sustainable development we need to restore the walls to a parallel position. But what does that mean? What is sustainable development? The Brundtland definition provides an excellent vision and value statement that can inspire us to act in order to fulfil such a goal. However, when deciding to take up such a task, how do we know we are going on the right direction? How do we determine if we are becoming more sustainable? What does sustainable development mean in practice?

To achieve sustainability, natural systems must be preserved and resources used within the carrying capacity of these systems[6]. Extraction of elements from the Earth and depletion of the natural landscape must be done in proportion to nature's ability to regenerate itself. It also means that reliance on finite resources, such as fossil fuels, phosphorus, and chemical fertilizers, should be developed in strategic and conscious ways, in order to prevent abrupt transitions or lack of substitutes. In this way, future generations will still be able to use the Earth's resources to meet their needs. Sustainable development also considers the amount of garbage, man-made waste products, and chemicals which are hardly biodegradable we release into nature. We must realize that there is no such thing as "throwing away" the things we do not want. Things we throw away are reintroduced into natural cycles and can create pollution that leads to toxic effects.

In addition to the environmental and resource side of the sustainability challenge, there is also the social aspect of human life that needs to be sustainable. Inequitable, unjust, or unstable social systems cannot be sustained. New systems must be developed that remove barriers for people to meet their needs. The development of systems that allow equitable distribution in wealth and tasks is required for any social system to be sustainable.

Thus, strategies like recycling, as well as strategic and diversified resource planning are becoming more relevant than ever. Closed resource loops, such as the "cradle to cradle" concept, are an example of one such solution7. However, while these solutions can help us build a sustainable society, they are simply solutions to one aspect of a problem. They are neither the definition nor the success criteria for sustainable development.

Therefore, sustainable development must be defined by qualitative relationships between economic, social, environmental, and cultural factors. These qualitative elements can be used as criteria for sustainable development, and they are present in two frameworks which will be examined more closely in the next chapter.

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2. Towards a Framework for Sustainable Development

2.1. SUSTAINABLE DEVELOPMENT FRAMEWORKS

Urban river deltas present a number of "wicked problems"[1] for sustainable development, as populations expand into ecologically sensitive areas, causing complex sets of tradeoffs to occur. Many frameworks exist for evaluating various aspects of sustainable development, and a number of these frameworks can be adapted to address problems in urban river deltas. A framework is a collection of tools, methods, and principles for solving specific types of problems. Models can contain multiple frameworks, or selected elements from those frameworks. Shedroff has analyzed over 30 of the most influential sustainable development frameworks created in the last 50 years and identified 11 that were considered the most integrated and actionable[2]. However, there is no easy way to choose sustainability frameworks or models, because the results will vary based on what values of interest are measured and how they are measured. Therefore, one of the first tasks in applying this research should be to agree on the concepts and values of interest, as well as the specific types of issues and wicked problems to be solved in urban river deltas.

Of the frameworks described by Shedroff, the *Natural Step or Framework for Strategic Sustainable Development* (hereafter FSSD; § 2.2) and Ecosystem Services (§ 2.3) will be further elaborated on, since they are two of the most relevant for solving some of unique challenges in delta regions: Rich biodiversity, human settlement, and economic activity, but also a high sensitivity to the impacts of many development processes[3, 4].

The FSSD is a flexible framework for engaging stakeholders to make more sustainable decisions. It has been widely tested for many types of projects. However, it is a general framework and does not specify its own metrics for issues like ecosystem vitality, or other factors involving economic, social, environmental, or cultural sustainability impacts[5, 6]. Ecosystems Services provides methods for determining such values and impacts[7, 8]. Thus, these frameworks appear to have complimentary abilities that could lead to improved decision making outcomes for sustainable development.

Therefore, this research will examine ways to create an integrated approach to using these frameworks for analyzing sustainable development problems related to water, health, and development in urban river deltas. The final methods chosen for this research represent a preferred choice among the known options, but this does not mean to imply that they will always be the best or only options for all situations.

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2.2. FRAMEWORK FOR STRATEGIC SUSTAINABLE DEVELOPMENT

2.2.1. Introduction

The Framework for Strategic Sustainable Development (FSSD) is an analytical and planning tool. It supports the development of actions that are aligned with sustainable development. The criteria supporting the Framework are scientifically derived into four principles that allow one to assess whether an action/strategy will be sustainable or not.

The FSSD was developed in a time when there was no consensus on what constituted a sustainable action. The definition by the Brundtland commission (see chapter 1) was a strong value statement and provided a clear direction for future efforts. However, it did not provide the criteria for verifying whether an action would lead to sustainability. As the causes of unsustainability were debated, climate change was still an uncertain concept in many minds. The sustainability principles were developed to answer the need for solid criteria in which one could assess plans and actions in relation to sustainable development. The FSSD consists of: a five level framework (5LF), four sustainability principles, and a backcasting method, which are implemented through a process called ABCD. Each of these are elaborated below.

The FSSD takes a generic 5-Level Framework (System, Success, Strategic, Actions, Tools) and refines it specifically for the purpose of working or planning toward sustain-ability. Through a consensus process, diverse stakeholders started to evaluate the **systems** we live in. The definition of system is the biosphere on planet earth, which is a closed system in terms of matter and open to flows of energy. Rules of science, such as the laws of thermodynamics and conservation of matter apply, as do biological and sociological rules.

From the system analysis a scientifically developed definition of **success** for sustain-ability was established, namely that:

In a sustainable society, nature is not subject to systematically increasing:
(1)…concentrations of substances extracted from the Earth's crust;
(2)…concentrations of substances produced by society;
(3)…degradation by physical means;
and in that society,
(4)…people are not subject to conditions that systematically undermine their capacity to meet their needs.

These four elements of the FSSD's definition of success are also known as the 4 Sustainability Principles (4SPs). This definition is comprehensive and complete for the biosphere and human societies that are to be sustained. The 4 SPs work as system

boundaries that allow creativity within these constraints. By setting boundaries rather than being prescriptive, the principles set the tone and allow for more creative solutions and a broad range of actions to be tailored in any context.

At a **strategic** level, the FSSD added to its structure back casting from principles. The relevance of back casting is based on the notion that no one really knows what a sustainable society will look like in today's context. It entails imagining a desired future and thinks backwards about what the necessary steps are to get there. One of the main advantages of this method is that forecasting and current resources do not limit it. This allows for flexibility in envisioning solutions that could be developed. As part of the planning approach, the following three prioritization questions are used to select actions and determine the order in which they should be implemented:

1. *Does the action move us in the right direction towards success?*
2. *Does this action provide a flexible platform on which to build future?*
3. *Does the action provide a good return on investment in terms of financial, social or ecological capital, which can be re-invested towards other actions?*

At the actions level, potential ***actions*** will have been brainstormed in a backcasting context. They will then be prioritized in accordance with the questions from the strategic level to ensure they move in the right direction for achieving the goal defined at the success level.

Different **tools** have been created to deal with sustainability issues – from management to certification criteria. The FSSD is a synergistic tool that suggests that the different tools should be used in a strategic way. In other words, it is about using and integrating them in the best way, planned and consciously, so they have the biggest impact in terms of achieving the goals of their sustainable initiatives. Therefore, any and all tools that can be brought to bear to complete the actions are fair game.

2.2.2. Application of the FSSD

When using the 5 levels of the FSSD in a regional or organizational planning context, an expanded application of the 5-level framework is done. The system boundaries definition may be adjusted to account for the subsystem in question. Likewise the definition of success can be augmented to include specific goals of the region or organization. However, the 4SPs of the FSSD must be kept to ensure planning and decision-making remain focused on achieving sustainability. Backcasting and the three prioritization question may also be augmented with additional strategic approaches applicable to the region or organization. The FSSD is used through the ABCD process, as can be seen in figure 2:

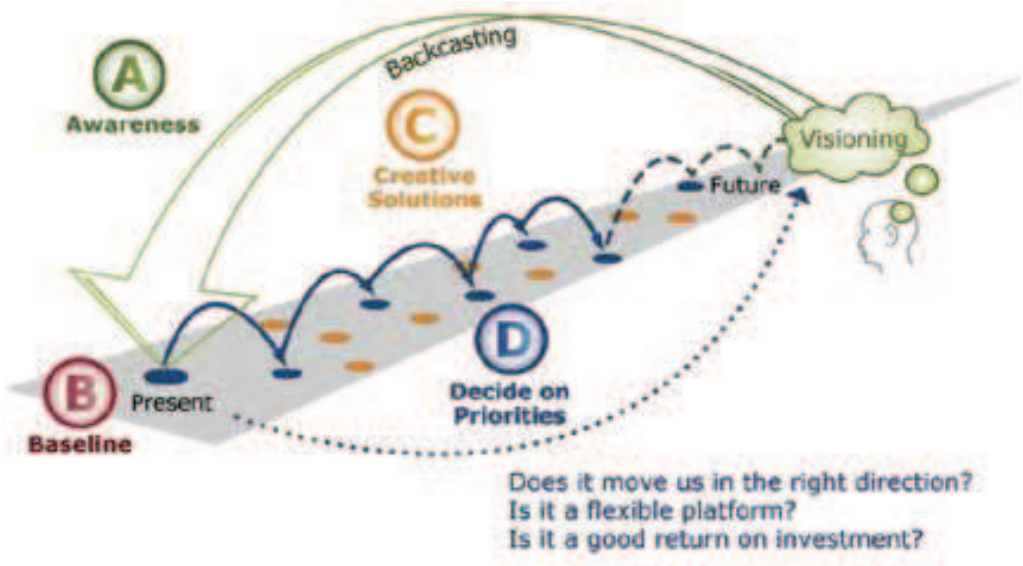

Figure 2 | Application of the FSSD through the ABCD- process.

A - Awareness of the system and success

The first step in the process is to establish and agree to a shared language describing the system, its boundaries and definition of success. What are the common vision and goals for the planning process?

B - Baseline Reality

The B step speaks to the assessment of processes and outcomes that might lead an organization to unsustainable "behavior". This assessment is made in light of the sustainability principles.

C - Creative solutions

The C step involves the development of possible changes, actions and ideas that might lead the organization to a more sustainable path.

D - Deciding on the actions

The D step speaks to deciding on possible actions, developing a plan, and caring it out. Most likely not all the actions developed on the C step will be taken. A strategic decision-making process is relevant at this stage in order to agree on short to long-term action. The three prioritization questions mentioned earlier are utilized here, as part of the strategic approach to prioritizing which actions to take and when.

The Framework, as an analytical tool, can be used as a checklist. In this case, the different elements are used to explore the distinct levels and its connection to sustainability. However, attempts to use it as a planning tool require a more complex and dynamic approach in order to use the framework as an actual "frame-work". On the one hand, an analytical tool can be used to explore the different levels and see how they inform us, while on the other hand applying it as a framework, we use the different levels as categories to frame our thoughts, i.e., they are areas to pay attention to in planning the work to be done. Additionally, the FSSD is a collaborative tool. It does not exclude or aim to replace other tools, yet aims to provide a planning structure in which these tools can be used in a strategic manner.

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2.3. ECOSYSTEM SERVICES CONCEPT

Ecosystem Services (ES) is a conceptual framework that provides a cross-disciplinary language to describe the services provided to humans by ecosystems. These services include direct services such as food, fiber, and water, as well as indirectly employed services such as nutrient cycling, water filtration, and climate regulation (Figure 3). A growing literature has been dedicated to defining the concept and refining the ES framework.[1-6]

Figure 3 | Nested Systems. All components of the Environment, Society & Economy need to be considered when developing sustainable solutions because they are interdependent on each other.

Ecosystems provide the biophysical environment for many fundamental processes and functions that provide the goods and services utilized by humans. It is important to recognize the multidimensional web of ecological and social interactions humans depend on for their well-being[3]. The ES framework is one way to conceptualize these interactions. The ES framework is composed of four service categories as laid out in the Millennium Ecosystem Assessment 1 including: supporting (e.g., nutrient cycling, soil formation, primary productivity), regulating (e.g., climate, flooding, water), provisioning (e.g., food, clean water, wood and fiber), and cultural services (e.g., aesthetic, spiritual, recreational). These can be seen in Figure 4.

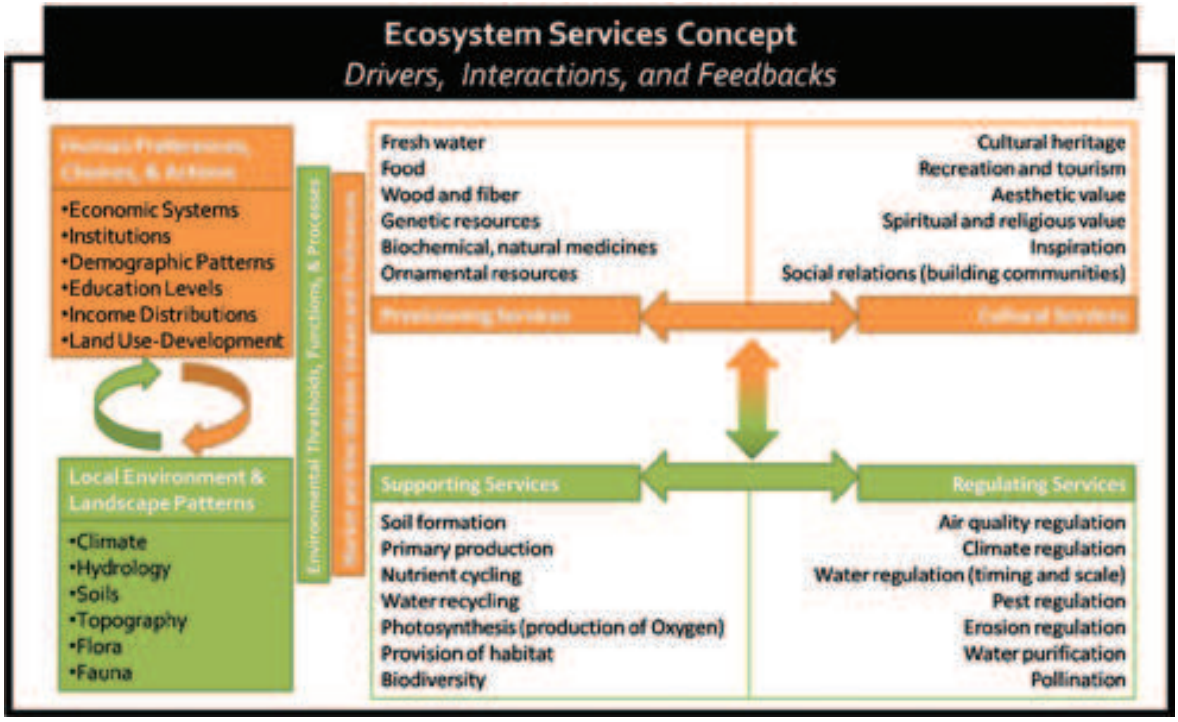

Figure 4 | The ecosystem services concept shown coupled with the biophysical and socio-economic drivers (interactions & feedbacks) of environmental change (thresholds, processes, functions) and ecosystem service demand and valuation. Figure concepts adapted from the Millennium Ecosystem Assessment 1 and Carpenter *et al.*[7].

In some cases these ecosystem services can be directly linked to our current market system; for example the provisioning of food through agriculture and the provisioning of wood through timber harvest. Both food and timber products are traded in market systems and have monetized benefits associated with them through this trade. However, other ecosystem services such as climate regulation, nutrient cycling, and spiritual/religious relations do not have direct market connections and their benefits cannot be valued in the same fashion. Adding to the complexity, non-market regulating and supporting services work in concert to provide an ecological (biophysical) foundation that produces both provisioning services (direct market) and cultural services (non-market). All of these services have the capacity to influence one another[1,7]. Their value and utilization are directly tied to human preferences, choices, and actions[1]. Ignoring impacts that are difficult to evaluate (such as non-market ecosystem services) could lead to poor decision making resulting in the irreversible degradation of essential natural and social capital stocks[8]. For example, impacts of urbanization are both direct (i.e. affecting provisioning services) and indirect (i.e. impacting regulating, supporting, and cultural services).

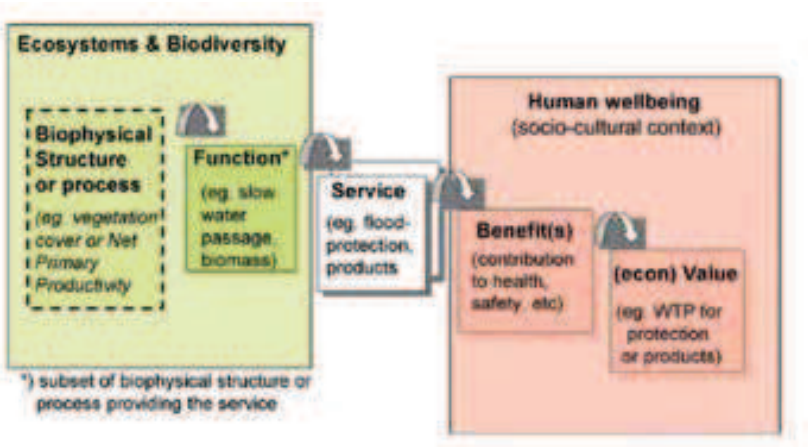

Figure 5 | Ecosystem Services flow-chart describing the relationship between biophysical structure and economic valuation[3].

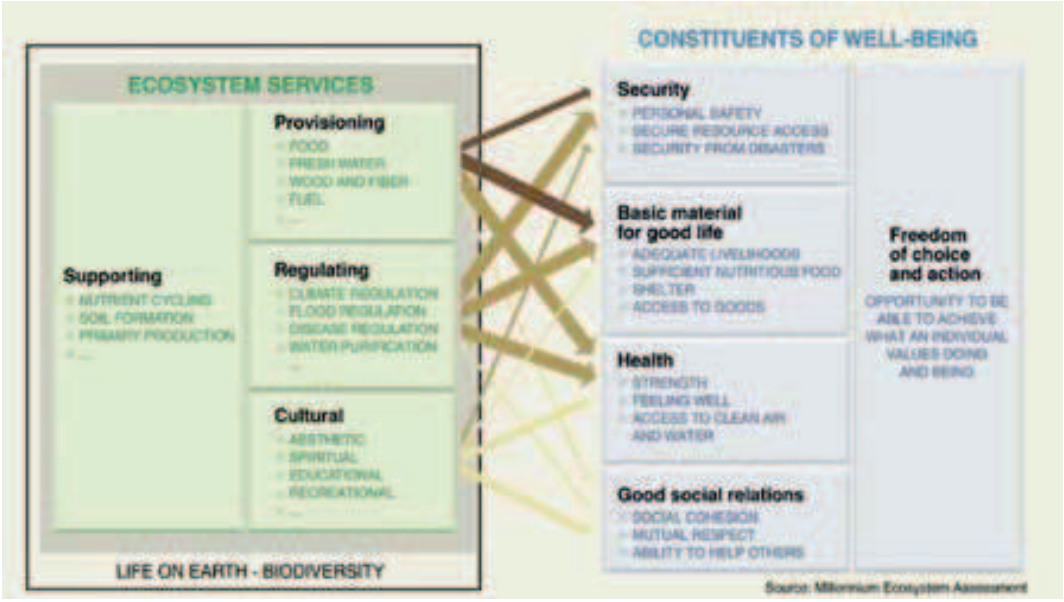

Figure 6 | The connections between ecological structure and function and social/cultural well-being, beyond economic valuation (from the Millennium Ecosystem Assessment[1]).

Focusing on direct use provisioning impacts may not reveal the true costs incurred by urban development. Ecological functioning, health, and resilience have important implications for human welfare[1, 8]. Identifying the impacts of urbanization on these ecosystem services is key to creating sustainable regulation and management strategies. As a conceptual framework, ES does not include explicit valuation or prioritization of services. ES measurement schemes are emerging and still debated. Payment for Ecosystem Services (PES) is one popular use of the ES framework. Figure 5 displays a succinct visualization of the relationship between ecosystem structure/function and economic valuation. There is hope that PES will integrate currently undervalued ecological services into the market, and a number of PES pilot programs are testing this use of ES throughout the world. Additionally, non-monetary valuation techniques are another important aspect of the ES framework also being experimentally employed in participatory planning processes globally. Figure 6 displays the connections between ecosystem services and social and cultural values that are often difficult to capture using PES techniques. Again, the ES framework provides a holistic summary of trade-offs, but does not include a mechanism to ensure the equitable distribution of these services.

ES is an emerging framework, which continues to be refined by a variety of disciplinary perspectives[5,6,9]. One of the framework's benefits is its ability to create a common language across multiple scientific disciplines[4], improving the opportunity to develop comprehensive sustainable solutions. Complementing this ecological and system-orientation of ES with the well-developed decision-making process of FSSD, creates a powerful tool that can be applied to the wicked problems facing urban river deltas worldwide.

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3. Wicked problems in Delta Areas

When considering sustainable (economic) development in ecologically sensitive and strategically important areas, such as urban river deltas, many issues arise. Complex system problems, or "wicked problems," may develop that are difficult or impossible to solve because of complicated interdependencies1. These problems are of such a high complexity that they cannot be tackled by a sectoral approach in which problems are defined, analysed and solved in sequential steps. In addition, efforts to solve one aspect of the problem may lead to new problems. In the following sections, we discuss a variety of wicked problems that generally occur in delta regions worldwide and that should be addressed when striving for sustainable development. These are divided into three topics: Water, Health and Development.

3.1. WATER

A watershed or river basin encompasses all the land in which rivers drain together. Landscape topography determines watershed boundaries, which result in the region draining to a river, river system, body of water, or delta. A delta can be defined as the part of the river basin, which flows into an ocean, sea, or lake. Deltas often contain estuaries where fresh and salt water mix. These brackish mixing zones are amongst the most productive ecosystems in the world.

As water flows from mountaintops through valleys to the ocean, it interacts with natural and anthropogenic processes. These rivers, streams, lakes, wetlands, and their connecting groundwater can be seen as the "sinks" into which adjacent landscapes drain[1,2]. Deltas, therefore, become repositories of a culmination of activities across a watershed. River ecosystems are dynamic systems which are regulated by five key drivers in space and time: (1) the flow pattern of the river system; (2) sediment and organic matter inputs; (3) temperature and light characteristics; (4) chemical and nutrient conditions; and (5) the plant and animal assemblages present in and adjacent to the river systems[1]. In naturally functioning freshwater systems, these five drivers vary within defined ranges throughout the year.

An integral component of river systems is the transitional zone between the water channel and the upland terrestrial environment, which is called the riparian area[3]. A high groundwater table, shallow inundation during the growing season and emergent hydrophytic plant species[3] characterize riparian areas. Riparian areas are some of the most biologically productive and diverse ecosystems on earth and are a fundamental component of both the riverine and terrestrial ecosystems[4-7]. They contain valuable water resources, diverse and productive plant communities, and provide habitat for both resident and migrating aquatic and terrestrial biota[4,6]. They provide essential riverine ecological services such as water filtration, nutrient cycling, detritus input, erosion control and hydrologic regulation[4-7].

3.1.1. Degraded riverine ecosystems

This section will focus on the ecological degradation and impairment of riverine systems, which can result from development and urbanization in these regions. The socioeconomic and cultural impacts from these activities will not be addressed here, as they are considered in greater detail in Section 3.3.

Rivers and streams are under significant stress globally, primarily due to intensive human uses, and are presently among the most endangered freshwater habitats[8]. Similarly, riparian wetlands are heavily impacted by humans and commonly suffer degradation from river regulation, farming, livestock grazing, development, pollution and invasive species[6,9,10-16]. These anthropogenic exploitations of riparian wetlands have degraded the ecological integrity of riverine systems throughout the world[6,10,15-18]. The destruction of these important habitats and ecological services has been linked to drastic declines in fishery and wildlife populations[6,9,10,17,19-21]. Recognition of the importance of these habitats has resulted in large scale efforts to restore and protect riparian areas[6,9,19-22]. The process of land use change, land use intensification, and flood management in urban areas often degrades riverine and estuarine ecosystems. This degradation compromises many of the life-support functions that delta ecosystems provide to humans, from flood mitigation and food provision, to climate regulation and water filtration. Urban Stream Syndrome (USS) is a phenomenon specific to urban development and is used to describe the alterations that the process of urbanization inflicts on rivers and streams around the world[23]. The USS is caused primarily by two land-characteristic changes ubiquitous to the urbanization process:

1. an increase in the area of impervious surfaces (i.e. parking lots, roads, buildings, etc) and
2. the reduction and fragmentation of vegetation along riverbanks (riparian areas) and in floodplains.

These land-characteristic changes alter physical, chemical and biological aspects of river and estuarine ecosystems, leading to significantly degraded ecosystem quality and negative outcomes for humans (Table 1). For clarity, these three aspects will be discussed separately in the following sections. However, physical, chemical, and biological characteristics of ecosystems are intimately connected and work in concert to create ecosystem function.

Table 1: A number of changes symptomatic of degraded urban rivers and a few of the resulting negative outcome for humans living in urban areas.

SYMPTOMS	HUMAN CONSEQUENCES
'Flashy' hydrograph (higher peak storm flows)	Urban flooding
Elevated concentrations of nutrients and contaminants	Reduced fresh-water fisheries and recreation opportunities
Altered channel geomorphology	Reduced property values and threatened building foundations
Reduced biotic richness/Biodiversity	Reduced property values; reduced life-support capacity from climate regulation to water filtration
Increased dominance of tolerant invasive species	Reduction or elimination of economically and culturally significant plant and animal species; reduced life-support capacity from air filtration to soil formation
Reduced nutrient uptake	Eutrophication of estuaries can greatly reduced fisheries and recreation opportunities

3.1.1.1. Physical alterations

Impervious surfaces, such as concrete or asphalt, do not allow rainwater to infiltrate into the ground. Instead, rainwater runs-off these surfaces, directly into rivers and streams. Water is moving much faster, and is present in much larger quantities, than it is during storm events in a more pervious river ecosystem that allows infiltration. The force of this increased quantity and speed leads to erosion of riverbanks and deeper river channels. It can also cause flooding in urban areas.

Estuaries are typically areas where water flow slows as river channels open into wider areas and intersect the ocean. Increased water quantity can also lead to scour and erosion of delta sandbanks and other physical landforms that can change the ecological function of these ecosystems.

3.1.1.2. Chemical alterations

Poor water quality in urban rivers results from stormwater run-off, carrying a variety of pollutants, flowing directly into rivers and streams without being filtered through the ground. This happens in urban areas because impervious surfaces prohibit the infiltration of rainwater into the ground, as well prevent evapotranspiration of water through vegetation, and instead sheet water off into storm drains.

In many cases, stormwater run-off reaches estuaries with very minimal filtration. Pollutants to estuaries and deltas include: polychlorinated byphenols (PCBs), heavy metals, radionuclides, hydrocarbons and a range of man-made chemicals (e.g. synthetic products which act as endocrine disrupters). Polluted sediments from urban surfaces are deposited into these brackish areas where they interact with a variety of juvenile species that mature in estuarine systems. Some pollutants, such as hydrocarbons, adhere to fine sediments and settle to the bottom of estuaries or deltas. Consequently, depending on the conditions in the estuary, certain pollutants can become buried in the mud only to be released again back into the water, with human activities such as dredging for ship channels. Long-lived pollutants in aquatic systems continue to degrade wetland and estuarine biota for many years or decades.

3.1.1.3. Biological alterations

Invasive species dominate many urban streams. The physical and chemical alterations described above often create conditions in which native species (of plants and animals) cannot survive. This results in open space where urban tolerant, invasive species (of plants and animals) can colonize. Over time, this can create monocultures that decrease the ecological resilience and productivity of deltas.

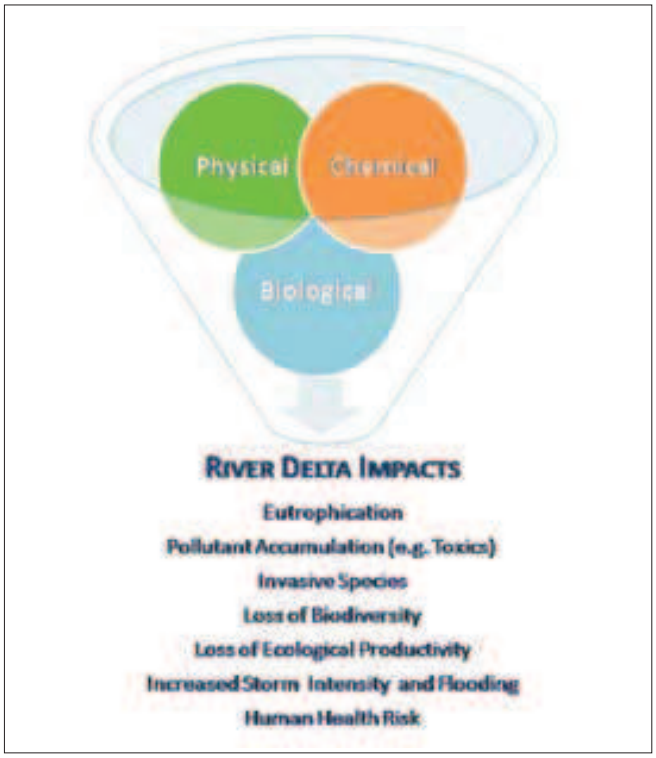

Figure 7 | Urban alteration interactions and resultant impacts to fluvial systems

3.1.1.4. Mitigation Techniques - Conclusions

Green infrastructure has been introduced in cities around the world as a comprehensive strategy to mitigate the physical, chemical, and biological impacts of urbanization described above. Green infrastructure consists of a planned network of managed green spaces such as natural, restored and constructed riparian and wetlands, public parks, green roofs, street trees, and rain gardens[24]. This network of green infrastructure components aims to:

- mitigate storm water flows
- filter out pollution and sediments
- regulate hydrology
- reduce water temperature
- create habitat and connectivity for wildlife and foster biodiversity

The ability of greens paces to slow water down, through infiltration and evapotranspiration of stormwater, keeps storm events from overwhelming centralized water treatment facilities and ameliorates flooding. This infrastructure provides not only ecological benefits but has been shown to provide spill-over social and economic benefits as well[24-26]. Low Impact Development (LID) incorporates green infrastructure elements into private and public development projects. Urban LID projects link human behavior with ecological impacts, planning ecologically sensitive water management into urban development as an integral component rather than an add-on or end-of-pipe solution downstream[23]. Green infrastructure and LID techniques are currently evolving as larger and more comprehensive networks are formed in urban areas around the world. Continued development, improvement, and integration of these approaches are necessary for achieving sustainable solutions to the ecological degradation of urban delta regions throughout the world.

3.1.2. Increased flood risks

The definition of a 'flood' is the temporary covering of land by water, which is normally not covered by water[27]. A flood event occurring in a delta region can lead to severe problems for ecology and society. However, due to the good economic perspectives of deltas, people accept (or ignore) the flood risks. One to ten people in the world now live in areas with an increased flood risk (see Fig. 8)[28], and judging by the on-going rapid growth of delta regions around the world the threat of floods does not slow down the urbanisation process.

Floods do not only have a disruptive force, destroying buildings and killing people (Fig. 9), they also trigger outbreaks of a number of water related diseases.

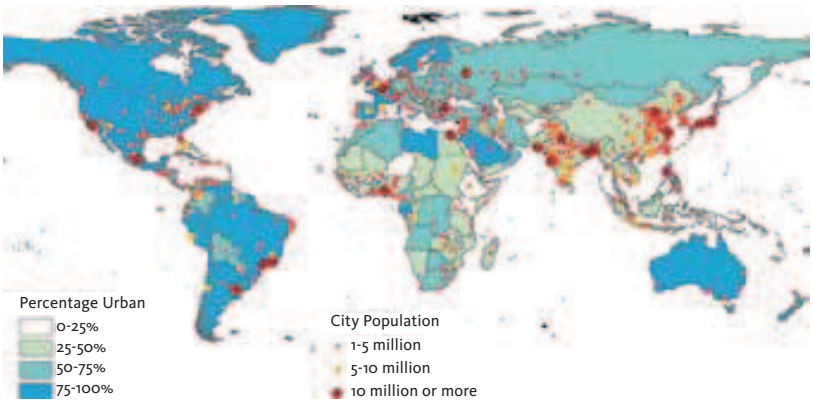

Figure 8 | City population in the world [29]

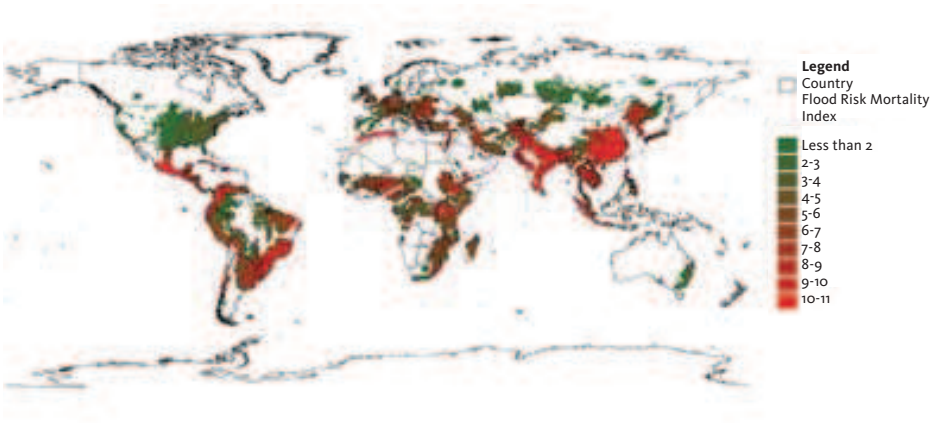

Figure 9 | Flood risk mortality worldwide [30]

Frequently, the flood proneness of deltas is man induced. Continuous water drainage (e.g. The Netherlands, New Orleans, USA), freshwater withdrawal (e.g. Jakarta, Indonesia, Mexico City[31], Mexico) and severe river regulations (e.g Rhine, Germany) increase the risk for flood disasters.

All these changes in land use and water and river management measures, which are directed at eliminating or ignoring the hydromorphodynamic proceses of deltas, lead to a vicious circle resulting in steadily worsening conditions. The challenge for the future is to break this cycle, especially when the problems related to the effects of climate change are taken into consideration; rising sea levels, for instance, can only worsen the situation regarding flood risks. In order to realise a sustainable development of deltas more attention should be paid to the adaptation of land use (e.g. floating

houses, construction of mounds) to the dynamic conditions instead of striving towards an elimination of dynamic processes, which are inherently linked to deltas. Therefore, the generic challenge is to produce a sound flood protection program which addresses address three themes in a well balanced way: flood risk analysis, flood preparedness and prevention/mitigation (land use adaptation)[32].

3.1.3. Water scarcity in river basins

The World Water Development Report of the United Nations, which was released in March 2012, states that more than one billion people do not have access to water of sufficient quality and that this number is increasing, especially in cities[35]. This increase in water scarcity is due to an increasing demand of freshwater, low water use efficiency in agriculture and climate change. As an effect of climate change the annual discharge of many river systems in the Mediterranean region, southern Africa, southern North America, and Central America tend to decrease[33] or perform more extremes in both high and low water discharges[34].

The lower river discharges are a direct threat to the available amount of water as well as indirectly influencing this quantity through the threat they pose to the quality of the water. This threat comes from the negative effects these lower river discharges have on the water quality, as they increase the concentration of substances already present in the water, like chloride in the Rhine river[36]. Extreme low river water discharges have already led to temporary stops of the intake of drinking water in the Netherlands. Additionally, low water discharges enhance the negative effects on water quality of "emerging substances"[37], "detrimental bacteria"[38], the increase of the water temperature and salt intrusion[39-41].

Extreme fluctuations in water discharge and freshwater availability form a wicked problem in deltas. Only through a system approach and comprehensive land use change on the mid and long term the resilience of river basins can be increased. The ultimate goal is to design and realise land use plans in river basins that one hand are less flood prone and on the other hand can withhold and release water in a gradual way.

From that perspective some far-reaching measures such as the "South-to-North Water Diversion" project which connects the Yangzte with the (dry) Yellow River basin (China) could be questioned. It would be an intriguing exercise to apply the FSSD on the water scarcity problems in China and find out if the result also would justify this major intervention.

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3.2. HEALTH

Contaminated water and increased flood risk, as described in paragraph 3.1.2, have a major influence on the spread of pathogens among the human population. In the following paragraph we will discuss the biological pathways of waterborne and water-related pathogens as well as the impact on human health.

During the last decades, there has been an increase in the occurrence of waterborne and water-related diseases, particularly in developing countries. In addition, some delta areas suffer from water pollution, which of course also has a negative effect on human health. This particular problem will be dealt with in paragraph 4.2.2.2. For waterborne and water-related diseases the increase is mainly due to delta areas becoming ever more densely populated[1,2,3], enhancing the transmission of diseases (e.g. lack of water and sanitation)[2,3,4,5]. The limited availability of clean water form the basis of many diseases. Approximately 12 per cent of the human population lacks access to potable water resulting in c. 3.5 million deaths per year[6, 7]. In many less developed countries the high exposure to animal and human faeces, as well as rodents, promotes the spreading of diseases. Furthermore, deltas in moist and warm climates around the equator are more susceptible to diseases since many of their hosts thrive in moist and warm climates[8]. Another factor that enhanced the occurrence of transmittable diseases is the combination of climate change and globalization[1,2,9,10,11,12]. Climate change can lead to an increase in potential habitats for various hosts, allowing the diseases to travel further with their carriers. Thus, a prerequisite for sustainable development in delta areas is the containment of diseases, but the varied nature of these organisms makes it difficult to find good preventive measures. The diseases in delta areas can be caused by a variety of pathogens of which the most important groups are viruses, bacteria and parasites[13].

During the 20th century, especially in the last 30 years, there has been both an increase of new diseases caused by viruses and a revival of known viral diseases[2, 13]. The majority of the viral diseases in revival are arboviruses like Yellow fever, West Nile and Dengue. Different arboviruses share a couple of lifecycle characteristics; in order to complete their life cycle they need both a blood-sucking arthropod vector, like mosquitoes and ticks[14], and a vertebrate host, like birds and rodents[14]. The arboviruses that have the biggest impact on public health belong to the *Flaviviridae, Togaviridae* and *Bunyaviridae families*[2]. One of these viruses is dengue fever, which has evolved so it no longer needs birds and rodents to complete its lifecycle, but instead it can spread through humans in a mosquito-human-mosquito cycle.

Dengue is the most rapidly spreading mosquito-borne viral disease in the world, with a 30-fold incidence increase over the past 50 years, expanding to new countries and a shifting from rural to urban areas. Worldwide more than 2.5 billion people live in dengue endemic countries, with 70% (1.8 billion people) of this population living in the

South-East Region and the Western Pacific Region. Even though mortality rates for this disease vary greatly from one country to another, they can be as high as 10-15%[15,16].

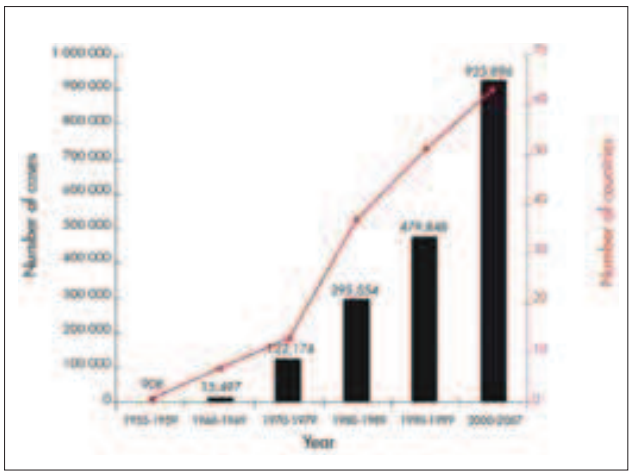

Figure 10 | Average annual number of Dengue Fever (DF) and Dengue Haemorrhagic Fever (DHF) cases reported to WHO 1995-2007[6].

The biggest group of pathogens is bacteria. Within bacteria a distinction can be made between two groups: conditionally pathogenic and intracellular. Conditionally pathogenic bacteria are only pathogenic under certain circumstances, for instance when someone has a decreased immune function or a wound. The second group, the intracellular pathogenic bacteria, always cause diseases in humans and are dependent on human cells to grow and reproduce. Since there are such a wide variety of pathogenic bacteria, leptospirosis will be used as an example for explaining the underlying mechanisms of getting infected. The most important hosts of leptospirosis are rats and mice, but it has also been found in other species like rabbits, dogs and deer[15]. The bacterium is transmitted through the urine of the host and is only contagious when the urine is wet. Most of the time it is not transmitted through human-human contact[17].

Leptospirosis is a zoonotic bacterial infection, most commonly found in tropical and sub-tropical countries[7]. It is a biphasic disease that begins with flu-like symptoms, followed by a brief symptom-free period. The second phase is characterized by meningitis, liver damage and renal failure. Due to this wide variety of symptoms, leptospirosis is often difficult to diagnose clinically. Annually, the estimated incidence of leptospirosis is about 500.000 severe human cases, but this burden of disease is probably an underestimation as not all cases are reported[18]. As many domestic and farm animals are infected by leptospirosis, this disease has a serious economic impact on food producing animals. In addition, costs paid for treatment for both diseases mentioned above might lead to an economic burden as well.

The third group of pathogens is the parasites. Within the parasites a distinction can be made between three groups: helminthes, protozoa and ectoparasites[19]. The helminthes are multicellular organisms that can be further divided into the flatworms, thorny headed worms and the roundworms. They depend on their hosts for nutrition, but, unlike the second group, they still reproduce outside the host's body[20]. This second

group, the protozoa, are unicellular eukaryotic organisms that do reproduce within the human body[21], and they can be further divided into two categories based on the way in which they infect other hosts; through faeces coming into contact with the human mouth via contaminated water, food, or other humans, or through vectors infecting the new host (e.g. when a mosquito draws blood form an infected person thus spreading the parasite to the next human they bite).[21] The last group of parasites is the ectoparasite[19], which consists of multicellular organisms like lice, fleas and ticks. They live on human blood so they need human begins to survive.

Several reports have been written[22,23] showing that an increased access to safe water, in combination with adequate sanitation will have a positive effect in reducing the spread of these diseases. Additionally, improving access to public health care and giving medical education to local people and health care practitioners will contribute to healthier communities in developing countries. It is important to focus on the different aspects to improve health quality in developing countries.

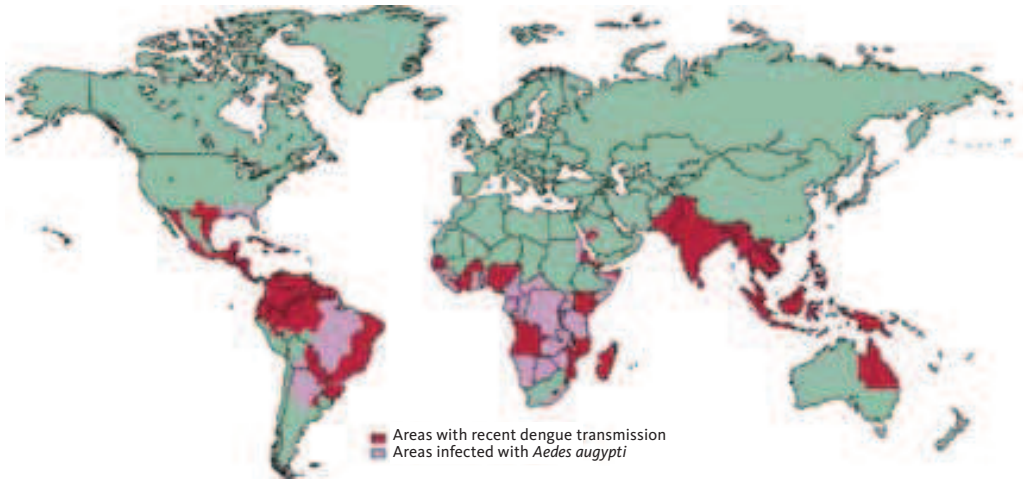

Figure 11 | Approximately global distribution of dengue and Aedes Aegypti in 2005 [3]

There are several methods that can be used to intervene and contain the spreading of the disease[24,25]. One of the easiest ways to do this is to enhance the public awareness through education. In the case of dengue, education about the habits and habitat of the host, *Aedes aegypti,* may, for instance, help people realize that they have to decrease the availability of stagnant freshwater. Another method would be to set up infectious disease control panels. These panels in their turn can help set up appropriate training for people working in the health care sector, such as local medical personnel. Besides

informing the population affected by the disease, it is also possible to prevent humans from getting sick in the first place or to help them to get better by administering vaccines and antibiotics. However, since many of the diseases are caused by rapidly evolving species it is necessary to continuously invest in research into new vaccines and antibiotics[26-29]. In addition it would be beneficial to develop economically viable, safe and reliable diagnostic methods. Another measure that could be taken to control the spread of the disease focuses on intervening at the infection source by disrupting the transmission route. An example of this would be reducing the amount of stagnant water, as this makes it more difficult for the hosts to reproduce. However, this also affects other components of the delta's ecosystem. A fascinating new development in this area, however, focuses on infecting the *Aedes aegypti* with *Wolbachia bacteria*, which makes it impossible for the dengue virus to infect the mosquitoes. This methodology offers a great new perspective on approaching the containment of other viral diseases as well[30]. From a sustainability point of view these techniques are worthwhile to consider in more detail.

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3.3. DEVELOPMENT

The following section deals with several different issues, that all fall under the broader concept of development. The structure of the section is shown in figure 12. As can be seen from the figure, six topics are discussed, that fall into two categories.

Figure 12 | Overview of the paragraph

The first three topics focus on individuals and the society they live in. It is essential that decision makers take into account the needs of the population that is affected by their decisions. Furthermore, for implementation of sustainability projects to be successful, individuals should be willing and able to change their behaviour accordingly. Therefore, this section will first describe the role of culture (3.3.1), subsequently we will discuss how awareness can be created (3.3.2) and after that how pro-environmental behaviour can be stimulated (3.3.3).

The second group of three topics discuss some of the issues that may arise at an organizational level. Firstly, some tools and methods are discussed for working towards a sustainable economy (3.3.4). Secondly, we describe some of the issues that should be taken into account when decision makers operate in groups (3.3.5). Lastly, we give an overview of some of the challenges that may arise at the level of international law and governance (3.3.6).

3.3.1. Culture

When dealing with delta areas, it is unavoidable to look across borders. Next to the specific geographical differences between delta regions, the societies of the countries they find themselves in vary enormously as well. People living together in the same place

generally share common values, whereas in other delta areas a completely different set of values may hold. These cultural differences become wicked problems when decisions that affect a group of people are made without adapting the decision-making process to their values, preferences and needs (for a detailed description of culture, see Kroeber and Parsons[1]). Therefore, the way of communicating in each delta area needs to be adapted to the prevailing culture.

Cultures can be characterized in various ways. One of the most widely used strategies to catalogue the way in which societies differ is Hofstede's principles with their four dimensions[2]. First of all there is the difference in power distance (1), which is the extent to which the less powerful members of society expect power to be distributed unequally. The second difference concerns collectivism vs. individualism (2), which represents the degree to which individuals are integrated into groups. Next there is the dimension describing how societal attitudes may range from social and caring to more competitive, which Hofstede described as masculinity vs. femininity (3)[3]. Finally, the dimension of uncertainty avoidance (4) represents the tolerance towards uncertain situations. Together, these dimensions define which leadership styles will most likely succeed within a particular society.

To ensure that development planning for urbanizing delta regions is sustainable, all cultural dimensions and values of that society should be incorporated in the planning process[4]. Research has shown that societies scoring low on power distance prefer egalitarian and participative leadership[5, 6], while societies scoring high on uncertainty avoidance value stability, rules and regulations[5, 7]. Collectivist societies, on the other hand, identify themselves with their leader's goals while individualistic societies need individual consequences to be depicted[8, 9]. Finally, in masculine societies people prefer a direct and assertive leader, who is unambiguous in expressing himself [10-13].
When implementing a framework for sustainability, it would be advisable to use Hofstede's four dimensions to investigate the prevailing culture in the area, and adapt the way of communicating to the values and needs of that particular society[14], as can be seen in figure 13. For a more detailed description of the cultural dimensions and the leadership styles, see Hofstede[2] and Dickson, Den Hartog, and Mitchelson[5].

3.3.2. Awareness

Public awareness is a prerequisite for sustainable development, since the success and implementation of a framework depend on the acceptance and support of as many people as possible. People need to be aware of the present problems and potential dangers in the future.

According to a literature review[15] an effective sustainability project includes the five basic factors of (1) social awareness and concern about the problem, (2) knowledge

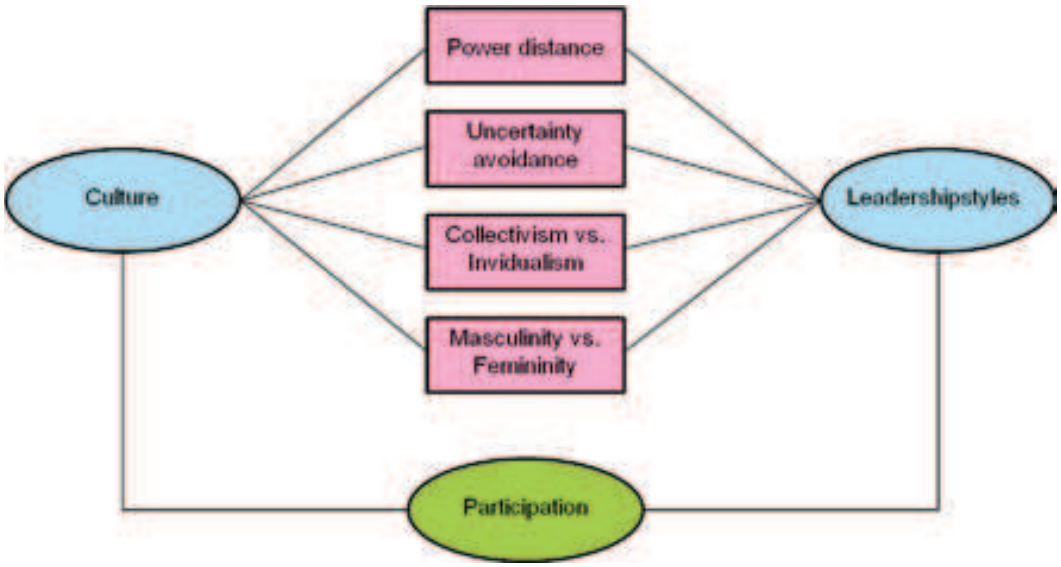

Figure 13 | Relationship between culture, leadership styles and participation

about and motivation to engage in solution(s), (3) memory or situational prompts to make the motivation salient, (4) opportunities to follow through with the behaviour(s) and (5) skills/ perceived competence to implement the behaviour(s) correctly. Thus it is important to create a general public awareness for sustainability.

Communication must be utilized as a tool to increase public awareness and the willingness to cooperate. News reports and publicity events can increase awareness of problems and can create a common social level of knowledge. Moreover, this information needs to be adjusted to individual needs[16]. Surveys can be conducted to identify the reasons why people are not motivated to change their behaviours towards more sustainable approaches. Furthermore, people need a leader with whom they can identify themselves, who they can ask questions and who can make them enthusiastic. A so-called 'block leader', a 'leader' in a particular neighbourhood who is similar to the population and familiar with the problems they encounter, might be a good option to fill such a role. People will respect this person as (s)he is one of them as well as a mediator between the public and higher agencies, which are difficult to reach. In this way, a bidirectional line of communication is established and group cohesion and enthusiasm can be maintained.

In the Netherlands a campaign was set up in 2003 that addresses the topic of public awareness, which is used here as a case study. The project is a cooperative work of numerous governmental agencies, municipalities and other organizations. By using a combination of various mass-media tools, they aim to enhance the public awareness of water-related problems. Advertisements and commercials are broadcast on TV, radio,

the internet and in newspapers, as well as cartoons designed to approach and get through to the Dutch population. Research conducted in 2009, however, showed that the majority of participants were not yet aware of the fact that traditional measures cannot prevent water-related problems in the future and that the strategy of giving room to the river might be a more sustainable solutionThe final goal of the awareness campaign is to reach acceptance in the Dutch population, for which they use a strategy to get the public maximally involved in the process. The campaign is characterized by a creative and flexible approach, which includes open dialogs between leaders, neighbours and other stakeholders. A long-term goal of the campaign is to "ensure active co-operation, in which all stakeholders accept their own responsibility"[17].

3.3.3. Pro-environmental Behaviour Change

Everyday human behaviour can increase threats to sustainable development as well as manage them; By understanding and changing relevant behaviours, their environmental impact can be reduced while simultaneously encouraging sustainable development[18]. A framework for sustainable development should therefore address relevant determinants of behaviour as well as possible approaches to influence that behaviour.

The Theory of Planned Behaviour (TPB) states that the most proximal predictors of pro-environmental behaviour are intentions, which are shaped by attitudes toward behaviour, subjective norms, and perceived behavioural control[19]. As the TPB involves developing and acquiring knowledge, problem-solving skills, values, morals, attitudes, and norms, it offers opportunities for practical applications in environmental education[20].

Social norms and personal norms that are transmitted within a particular culture go a long way towards explaining environmental behaviours[21-23]. Therefore, it is worth examining the implicit and explicit rules of approved, disapproved, and ritual practices within a particular culture. These norms can then be included in the FSSD to avoid ethnocentrism when it comes to achieving behavioural change. Research has shown that injunctive social norms (perception of what ought to be done or not to be done within a culture) are a more powerful social influence toward pro-environmental behaviour than descriptive social norms (perception of what is done within a culture)[21, 24]. Therefore, information and reminders that communicate these injunctive social norms to the public need to be present to encourage positive behaviour change (Focus Theory of Normative Conduct)[25,26]. Moreover, when personal norms (internalized values, guilt anticipation and feelings of obligation) are added to the TPB constructs, they can enhance intentions and behaviours toward sustainable environment[22,27].

Behaviours toward sustainable environment are also associated with place identity (cognitive bond between individuals and their environment) and place attachment

(affective and symbolic bond between individuals and their environment)[28]. Time (collective history) and embodied experience deepen the individual-environment relationship; place dependence (i.e. understanding all levels and thresholds of ecosystem services) enhances the individual-environment bond and as such influences pro-sustainable behaviours[29-31]. Furthermore, engaging in place-based education (PBE) early in life increases the chance that people will develop a strong bond with their environment, get involved in community projects and become aware of the ecosystem services[32].

By having a good overview of the aforementioned behaviour determinants and by providing a community with basic means towards sustainability, psychological tools may be handed to individuals to help turn pro-environmental intentions into action. Implementation intentions (if-then plans) can then replace well-established contagious and undesirable habits with new pro-environmental behaviour on a micro level[33-35]. Compared to TPB, this is a more efficient way of translating intention into behaviour.

3.3.4. Sustainable Economy

Due to abundant natural resources and access to waterways, river deltas are typically rich in biodiversity, as well as attractive sites for urban settlement and economic activity. An increasing trend toward economic development in delta regions has led to rapid urbanization, which can have strong effects on sensitive ecosystems in the area. Many deltas in less developed parts of the world are now going through a transition process. One example is the Pearl River Delta in China, which is currently thought to be one of the most polluted river areas in the world. Expansion into such delta regions creates environmental changes that have become a cause for concern. These include, but are not limited to, high sedimentation, sea water intrusion, land subsidence, land use and land cover change, river and sea pollution. Rural areas around delta regions are also changing through socioeconomic transformation and regional development. This is often followed by industrial restructuring. Large-scale industrial investments exert powerful influences on land-use change. To counteract this, a comprehensive land use and industry development policy must be developed that both meets goals for alleviating poverty and achieving environmental sustainability objectives.

Economic development is important to address the needs of a growing population, but wicked problems can occur when development is undertaken in ways that do not consider existing ecosystems and the services they provide. It is therefore essential to move towards sustainable economic development, which is the concept of using resources in ways that meet human needs without diminishing the capacity of those resources to be used in the future, and without degrading the environment in the process. This follows

the often-cited definition used by the Brundtland Commission[36]. Another way of expressing this is economic development that occurs in equilibrium with the carrying capacity of ecological support systems[37]. Non-depletion of resources is particularly important if those resources are irreplaceable or non-substitutable[38].

Ecological Economics[39-41] addresses the issue of whether natural resources are interchangeable and replaceable with human created capital. *Weak Sustainability* maintains that human created capital can replace all types of natural capital, while *Strong Sustainability* contends that certain natural resources and ecological services are irreplaceable[42]. Under strong sustainability, some resource substitution is possible, as long as certain thresholds can be established that are not exceeded.

If the need for some development is assumed, it is important to be able to measure how that development occurs and the extent to which it contributes to or detracts from sustainability goals. One metric that has evolved for this is triple bottom line accounting, which extends the common idea of a financial balance sheet to also include balance sheets for social and environmental performance[43]. One problem with this approach is that not all balance sheets can be expressed in the same units of measurement. A concept that tries to address this problem is called Integrated Bottom Line, which suggests methods for combining measurements across all three categories[44]. However, there currently are not standards for how to account for these measures, and many organizations may not even track all the data necessary for such measures.

Another tool that can be used to help plan economic development in more sustainable ways is the assessment of ecosystem services in delta regions (see paragraph 2.1 for an overview of ecosystem services). To achieve sustainability, provisioning resources that are used should be renewable, such as biomass, solar energy, wind power and water power. When these renewable ecosystem services are used wisely, according to the four sustainability principles, economic develop can be done sustainably[46]. Awareness is increasing about the possible use of ecosystem services for sustainable development, but more case studies are needed to show how this can be incorporated into planning processes.

Furthermore, best practices can be used to create awareness, since this helps to show satisfying results from the beginning of the process. If an application, method, process, or activity has proven effective in the past, it should be used as an example for other partners, such as stakeholders and specialists. Ideally, this will result in a project being implemented with fewer problems, fewer unforeseen complications, and better end results[46]. The Millennium Ecosystem Assessment describes some promising ideas in the freshwater sector, including willingness to develop water markets, water pricing methods, and payments for ecosystem services provided by watersheds[47, 48].

3.3.5. Group Decision Making

Decisions about adopting new projects or monitoring and evaluating ongoing projects are often not made by individuals, but by groups. This is because groups are said to possess more information than any individual and to be able ton take different perspectives in looking at the issue at hand[49]. This is especially true for interdisciplinary groups, where group members may have very different backgrounds. It is therefore important to look at how such groups reach decisions and to describe some of the pitfalls that could threaten optimal decision making.

Research has consistently shown that the information available to groups is often not combined in an optimal way[49-51]. Information that is known to many of the group members beforehand (shared information) has an exceptionally large impact on the eventual outcome, at the expense of information that only few members have access to (unique or unshared information). This tendency to ignore unique information can be countered by creating a so-called "transactive memory"[52]. This entails that group members are aware of each other's expertise and knowledge, and thus of the unique information each individual could hold.

Furthermore, it is essential that group members have a shared task representation[53], which refers to a representation of what the task entails, what the roles of individual group members are, and what kind of solution the group is looking for[51, 54]. The creation of a transactive memory and a shared task representation is an important task for group leaders.

A field of study called Decision Theory has developed to help decision makers use systematic, reasoned processes for making key decisions[55,56]. Decision Analysis is the application of normative decision models, which attempt to determine the best or maximal course of action in a decision making context[57,58]. Decision Analysis is widely used in Economics and Management Science, where Multi-Criteria Decision Analysis models are often constructed to determine the optimal course of action in extremely complex situations[59].

However, while multi-criteria decision models are extremely useful for analysing cases with many variables and large data sets that would be difficult to consider through less formal or more intuitive methods, Decision Theory also has a number of limitations. Real life has more variables and uncertainty than artificial models. Therefore decision modellers must be careful to avoid the "ludic fallacy", which involves the misuse of simplified models to explain complex, real life situations.[60] Thus, there has been renewed interest in understanding people's actual decision making behaviour.

Behavioural Decision Theory is one such attempt to examine how decisions are really made, including the fact that decision makers do not always have perfect

information, are not able to calculate decisions with perfect accuracy, and do not always behave in fully rational ways[61].

Another approach to actual decision making comes from Prospect Theory, claiming that people are often unconsciously influenced by factors that are, objectively speaking, irrelevant to the decision. Nonetheless, these factors can have a great impact on a decision and may lead to suboptimal solutions[62-65]. Firstly, the exact same decision problem can be evaluated differently when described in terms of gains or losses, called the "framing effect". Framing a decision problem differently can even lead to a reversal in preference[66]. Secondly, people have a tendency to prefer the status quo (the situation they are currently in) to change, even if that change can lead to positive results[67, 68]. This can lead to the "sunk-cost effect", whereby people fail to ignore irretrievable investments and continue carrying out an unsuccessful project, even if that will cost more than quitting.[69]

These tendencies can partly be countered by making people aware of their existence and asking them to explicitly justify their choices or think about the consequences of their decisions.[70, 71] However, to date no single technique exists to completely counter the tendencies described. Experts tend to be less susceptible to such errors and biases, but only in their field of expertise.[72, 73] It is thus essential to be aware of the boundaries of the experts' knowledge, in order to know how and when to value their opinions.

3.3.6. Organizational context

Because cause-effect relations in a river basin easily exceed national state boundaries, several issues emerge at geographical scales that do not coincide with political borders.[74] Problem solving in delta regions therefore takes place on several different levels. Decision making on the international level, which concerns the states through which the river flows, is linked to intranational decision-making processes on the strategies to be used in the international negotiations or on the implementation of international policies.[75]

As a result of the international character of decision-making in delta areas, the actors involved are embedded in different institutional environments. The organization of water management differs not only between states, but within states as well, especially in the larger and decentralized ones where different water-management policies and different decision-making cultures can be found, which may complicate the processes involved.[76]

Relationships between states are governed by international law and international cooperation. Whereas in national law the relation between the state and its subjects is hierarchical, international law is characterized by equality of parties and the absence of a central higher authority.[77] International law is therefore always based on consensus and the voluntary abandoning of sovereignty.[78] Furthermore, whereas in the national

context law is always binding and enforceable, this is not the case for international law, where many regulations consist only of principles or general norms.[79]

When it comes to deltas, relations between states are often organized along upstream-downstream lines. The calculation of the power ratio among riparian states involves three elements: First the states' overall political, military and economic power levels, secondly their technological power to disrupt or alter the river basin and the delta, and thirdly their geographical power reflected in a more advantageous upstream or less advantageous downstream position with respect to the river.[80] These last two elements frequently interrelate with one another in enhancing power asymmetries. As a consequence, for such issues the upstream basin states do have a relative power advantage and are able to exert influence on downstream basin states. This does not mean that upstream states are always ahead in the game. Upstream basin states may depend on downstream states for the management of navigation channels in the river or the upstream migration of fish. In many cases, several issues emerge simultaneously and basin states or other organizational structures within deltas are mutually dependent.

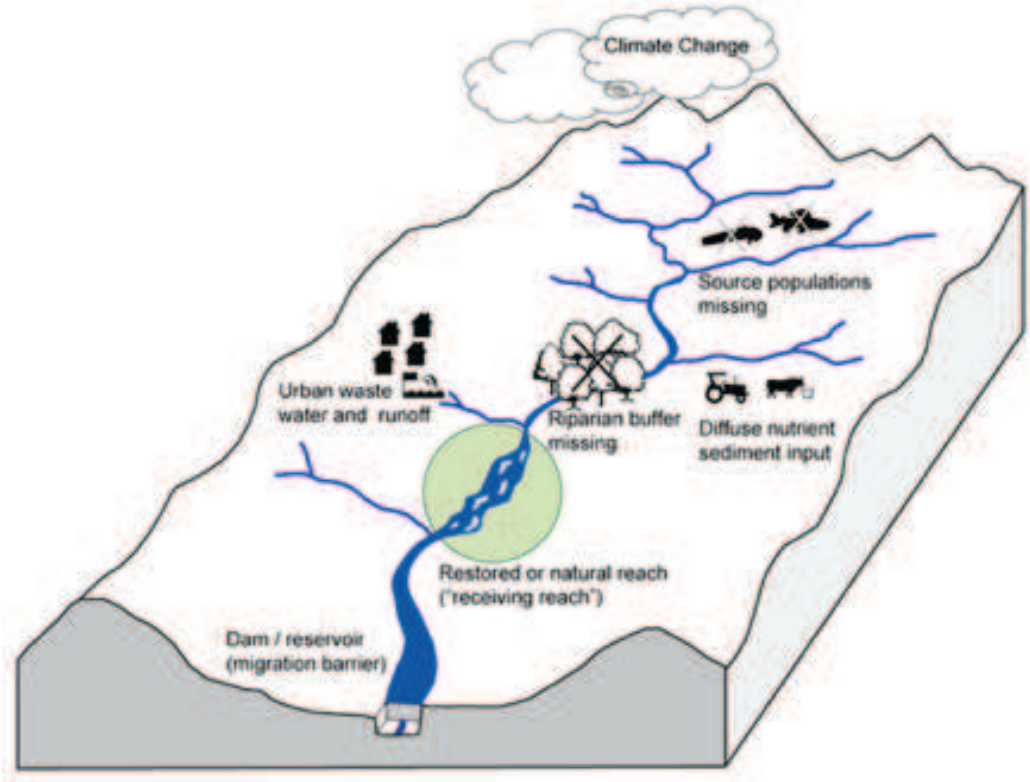

Figure 14 | Upstream and downstream basin states are often mutually dependent[81].

In order to regulate these issues between States, international cooperation is essential. The United Nations Environmental Programme (UNEP) plays an important role in the development of international environmental law, by, amongst other activities, organizing international environmental conventions, formulating concept texts of treaties, and assisting individual states with the implementation of their legal obligations under international environmental law. Cooperation between states is further aided by the development of several principles of international environmental law. These principles are often not binding, but they can be taken as guidelines to see what is considered just or fair and to determine a distribution of responsibilities.[82] Some of the most important of these are the *principle of State sovereignty and the responsibility to protect* (Stockholm Declaration 1972, Rio Declaration 1992), *the principle of intergenerational equity* (Declaration on the Responsibilities of the Present Generations Toward Future Generations, 1997), and the *principle of common but differentiated responsibilities* (Rio Declaration 1992, UNFCCC 1997).

Even when agreements exist, conflicts may still arise between basin states. The formal equality between states makes resolving such conflicts a difficult issue, as there is no prosecuting entity and no single way of disputing a resolution. In order to enforce a regulation, a state requires either enough power to undertake action itself, or a ruling by an international court that can be backed up by the international community, for example in the form of political pressure. Several such international courts exist, but they differ in membership and in jurisdiction (the topics and the subjects that the court is allowed to rule on), so that many disputes cannot be settled by a court. Additionally, environmental issues are often technically complex, and courts are not equipped to deal with such specific problems. For an international court to be effective, it is essential that it is specialized in the matter it is ruling on and that all parties can be persuaded into joining the court.

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4. Application of the FSSD in Indonesia

The Framework for Strategic Sustainable Development (FSSD) provides a science based definition of sustainability. The four sustainability principles are the core and can be used as a beacon to develop a road map towards a sustainable delta or river basin. The five levels of the FSSD helps us to create order in complex chaotic processes and problems and secure that we address the system level first before focusing on actions and tools that address specific sides of the (wicked) problem involved.

In this chapter we deal with the results that came forth from the so-called "Portland springschool (April 2012) where we discussed with the Indonesian fellows the suitability of the FSSD to two specific Indonesian cases; the Citarum river basin and the Ciliwung delta. The framework was tested on the three main topics of wicked problems belonging to the Water, Health and Development domain and the results of the discussions are summarized in the Recommendations chapter (Chapter 5). Before we go into the recommendations the "Water, Health and Development aspects of Indonesia and the two cases will be briefly introduced.

4.1. INTRODUCTION

Indonesia is an archipelago consisting of nearly 17,000 islands. It is one of the most densely populated states in the world and it is undergoing steadily increasing urbanization. For the last 30 years, natural resources have been the basis of macro-economic development in Indonesia. Unfortunately, natural resources are not managed in sustainable and leads to over-exploitation and depletion. Environmental quality degradation affects life quality and results to national economic loss.

4.1.1. Citarum river basin

The Citarum River is the largest and longest river in West Java Province, Indonesia. It originates in Mount Wayang (elevation 2,200 metre) and travels northwest for about 270 km until it empties into the Java Sea a few kilometres east of Jakarta. It consists of 17 sub watersheds that spread across three provinces: Banten, DKI Jakarta and West Java.[1] There are 14 administrative regions within its basin area of 12,000 km^2. The Citarum

River serves around 10 million inhabitants; half of whom are urban dwellers[1]. The Citarum irrigates 240,000 hectares of agricultural land and supplies 80% raw water for drinking in Jakarta[1]. Three hydroelectric dams supplying 1400 MW of electrical power located at the upper section of the basin. Of the total basin area, 56% is used for agriculture, 7.9% for industry, 7.4% for human settlements, 1.3% fishery, 24.7% are forest area and 5.7% for other uses[2].

As a strategic national river there are numerous stakeholders involved in its research, development and management at national, provincial, and district/municipal level. The government established BBWS Citarum (Center of Citarum Watersheds) under Directorate General of Water Resources to centrally manage the river. Prior to 2004, water resources in Indonesia were managed in sectorial perspective; agricultural, domestic water supply, industrial water supply, hydropower, environment, and flood management. In 2004, water resource policy reform is stated in Act No 7 2004 regarding Water Resources[3] that creates a basis for Integrated Water Resources Management. This Act provides a framework in planning, implementation, monitoring and evaluation of conservation and utilization of water resources, as well as control of water damage capacity based on three pillars: social, economy, and environment. This Act also regulates the right of water utilization for domestic and agriculture and of water utilization for commercial purposes (water vending and industry)[3].

4.1.2. The Ciliwung Delta

The Ciliwung River[4] is located on West Java in Indonesia, with a main stream of 97 km long and a catchment area of 476 km^2. Its source and headwaters lie in the mountain regions to the southeast of Bogor, from where it flows mainly in a south–north direction and discharges into the Jakarta Bay. The river flows through three large urban areas: Bogor, Depok and Jakarta, and it supplies water to big parts of the immense Jakarta Metropolitan Region "Jabotabek". In 2000 a total of four million people lived in the catchment area of the Ciliwung river[4-9]. The land use in the catchment area is dominated by agriculture (48.0%) and urban areas (32.8%), but there are also forest areas (9.8%) and paddy fields (9.4%)[4].

There are some cultural aspects on Java Island that triggered land use changes. Rapid population growth and an ever larger number of people moving from rural to urban areas resulted in increased urbanization in the downstream parts, which decreased the availability of fertile land for agriculture in the lowlands. As a result the land use in the uplands became more focussed on agriculture. Furthermore, an intensification of land use occurred, which increased the pressure on land and aquatic ecosystems and consequently on the quality of living in the densely populated delta[10]. During the

economic crisis between 1997 and 1999 farmers started clearing more forest area for agricultural purposes to secure future incomes for themselves[11]. The land use changes induced by these cultural factors resulted in an increased pressure on the delta areas on Java Island, including the Ciliwung Delta.

The river water and different groundwater bodies form the water supply for the huge urban areas in the Ciliwung Delta. Important recharge areas for groundwater bodies lie in the south of Jakarta. Due to urbanization the recharge capacity has decreased, resulting in over-exploitation of the groundwater bodies and an increased discharge of surface waters. Combined with high rainfalls, this creates a high flood risk for Jakarta[4,7]. Most of the citizens of Jakarta are not connected to a public water supply or a wastewater treatment system and have to rely on bore wells as the main source for extracting ground water[12]. Yet water is needed for household purposes and drinking water, for industrial use (process and cooling water), for irrigation and for salinity control in aquacultures near the shore.[13] In the downstream parts, however, the water of the Ciliwung River is too polluted to be used even for washing up or doing laundry[12].

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4.2. WICKED PROBLEMS IN INDONESIA

4.2.1. Water

4.2.1.1. Ecosystem degradation

The Citarum River

Population growth and urbanization has been putting pressures on riverine ecosystem in Indonesia's deltas. Citarum is known as one of the most polluted rivers in the world as a result of increasing volume and poor management of domestic and industrial wastewater. The other problems in the Citarum River are water scarcity that is translated into flood disasters and low water accessibility.

Environmental degradation and the change in land use and land use pattern deteriorate upper watershed area, and the decreasing quantity of stable run-off in hydrologic cycle, resulting in increased non-stable run-off therefore posing downstream community to flood risk. Moreover, it is predicted that the rain season in Indonesia will shorten in duration but increase in intensity due to climate change[1]. Urbanization, that relates to increase in building coverage ratio and reduced rainwater retention area, causes failure of natural drainage[2]. The situation is worsened with inadequate and poorly-planned drainage infrastructure and clogging of drainage and sewage system, while well-designed and maintained drainage systems limit water accumulation that causes flood.

The problems in both the upper (Bandung Basin) and lower (Karawang) parts of Citarum are rooted from change of land use pattern along its watershed, indicated by high pace of deforestation and urbanization. From 1983 to 2002, there was an increase in open area, plantation, urban, sub-urban, public facility and industrial land use while paddy fields and forest area decreased[3]. With the pace of erosion of more than 60 tonnes/ha/year, primary forest in Citarum upper watershed declined from 35,000 ha in 1992 to 19,000 ha in 2001, most of which turned into upland farming area. The remaining forests covers only about 10.2% – 100,600 ha of primary forest, and 34,800 of secondary forest – far less than the 30% mandated in the Indonesian Forestry Law[4].

Flood in Citarum commonly occurs as an effect of past re-alignment/straightening of the Citarum River (through cut-offs) which, while alleviating flooding upstream, increase peak flows downstream; localized land subsidence due to groundwater over-pumping that impair drainage; and clogging of drainage canals and streams by garbage[4].

In Indonesia, approximately 50% of urban population has access to piped water system, which is the most economical way to get clean water[5]. Households without connection to centralized water supply must look for alternative water sources for domestic use such as dug well, borehole, public tap, and community-based deep groundwater well and water treatment plant. Some urban dwellers buy water in jerry

cans from vendors or catch rainwater, and store the water into tanks or vessels. Many households have water tubs to store clean water from pipe with faucets. In Indonesia, boiling water is the by far the most commonly used option of point-of-use disinfection methods at household level.

Urban community which lack access to piped water are not the sole extractor of groundwater. Industries often extract groundwater beyond permitted volume even though permit is required for extraction. This misuse of essential groundwater remains underreported. In fact, water scarcity problems in Indonesia, particularly in Bandung Basin at the upper part of Citarum have a lot to do with excessive groundwater extraction. One study concluded that there is a strong correlation between groundwater extraction and land level lowering in Citarum River Basin[6]. Significant land subsidence is found near clusters of textile industries, which require large amount of water in their industrial processes[6]. In the meantime, the water scarcity problem in the Citarum is worsening by the impact of climate variability. Variations in stream flow are known to worsen drought for several areas in the basin[7].

The Ciliwung Delta

Urbanization causes three types of alterations to riverine ecosystems: *physical*, *chemical* and *biological alterations*. An important physical alteration is the increase of impervious surfaces, which prevent rainwater from infiltrating into the ground, thus impairing the recharge of groundwater systems. In the Ciliwung Delta this mainly had negative effects on the water supply system that depends strongly on groundwater resources. Resulting problems are over-exploitation of the groundwater bodies, intrusion of seawater, pollution of groundwater wells, and subsidence of the city[8-13]. The increase of impervious surfaces also leads to a higher run-off, higher erosion rates and an increased risk of flooding. In Jakarta, canalization of parts of the Ciliwung River and solid waste deposition in the channels further add to this problem[12,13]. Widespread flooding occurred in Jakarta in 1996, 2002 and 2007. The 2007 flood was the worst in the city's history, affecting almost 60% of the urban area and a total of 400,000 people, of whom 80 were killed. Urbanization was recognized as being one of the main causes for the severe nature of the flood[8,13]. During and after flood events the spread of diseases is enhanced due to worsened hygienic conditions and spread of pathogens via water, reaching wider parts of the city. Furthermore, drinking water sources can get contaminated and non-functional pumps force people to use dirty water. During the flood of 2007 health problems occurred that were directly related to the event, which included diarrhoea, acute respiratory infections, fever, itching skin, and dengue fever[10,13]. Furthermore, urbanization of coastal areas leads to a degradation of different ecosystems, resulting in the decrease of coastal protection and fish populations[14].

Chemical alterations pose a huge problem in the Ciliwung Delta. Less than 2% of the households are connected to a public sewer system and surface waters are polluted with organic nutrients, toxic materials and pathogens. Contamination caused by heavy metals such as Cu, Pb, Cd, Zn and Hg is described as a result of the inlet of untreated industrial and household wastewater, and polychlorinated byphenol (PCB) concentrations are high as well. Consequently, the water quality ranges from poor to very poor. Contamination and nutrient enrichment are catastrophic to riverine ecosystems and also lead to the degradation of marine ecosystems, resulting in loss of biodiversity and ecosystem services. Furthermore, pathogens spread more easily under these conditions, and a huge number of agents responsible for causing disease have been found in surface waters and shallow groundwater wells[11,12,14,15,16,17].

It is unclear whether *biological alterations* have occurred in the Ciliwung Delta. No surveys of invasive, alien or non-indigenous aquatic animal species have been done in either the Ciliwung River, Jakarta or on Java. Five important invasive aquatic plant species have been identified on Java: *Eichhornia Crassipes, Hydrilla Verticillata, Mimosa Pigra, Pistia Stratiotes* and *Salvinia Molesta*[18].

4.2.1.2. Flood risk

Out of every 100 km of the Indonesian coastal regions 96% is populated[19]. Approximately 60% of the total population (around 246 million) live there[20,21] and are affected by flood events which are intensified by land subsidence[22]. The different "types" of floods in Indonesia include tidal floods caused by seawater intrusion[23,24], floods due to river discharge, and increased precipitation, e.g. between December and January when the monsoon pattern reaches its maximum rainfall[25]. After a monsoon flood event in 2006, the WHO reported 236 killed, 56 injured and[28],505 people who were affected in some way, which included 670 people who had become homeless. Similar data is available for the years of 2003 and 2007[26].

GPS-analysis performed between 1997 and 2005 indicate subsidence rates of 1-10 cm/year in the Jakarta region[27] and up to 18 cm/year in areas closer to the coastline[28]. As a consequence, 40% of Jakarta now lies below sea level[29]. Similar problems have been observed in Bandung[30] and Semarang[21], and further analysis showed that these rates correlate with groundwater extraction for drinking purposes. Since most of the people in Indonesia live in coastal regions, the weight of buildings and constructions needed for every-day life promotes the compaction of soil, in other words land subsidence. Surveys conducted in Semarang showed that 65% of the households that participated stay in this tidal flood affected urban area on the coast due to a lack of capital, while 25% also appreciated the accessibility to the city centre[23].

Subsided areas are also affected more severely by seawater intrusion[24], due to sea levels rising at an average rate of 1.8 mm/year between 1961 and 2003 as a result of global climate change[31]. In Semarang an additional problem has been observed in the form of increased coastal flooding caused by the river mouth getting clogged up by sediment transported from the hill areas[21], while the region around Jakarta faces flooding due to the discharge of eleven minor rivers into the Jakarta Bay. Since there is no fully developed sewerage system, these streams contain storm water, waste and pollutants[29]. When areas surrounding these contaminated waters are submerged during a flood event, all of these components are distributed further afield and partly percolate into the soil.

The damage to housing and the losses incurred by industries are the most costly effects of floods[32]. An unexpected flash flood in West Sumatra destroyed 11 bridges, 3 kilometres of road and 120 hectares of rice fields in addition to razing 123 homes to the ground[33]. As a consequence of the pollution caused by rivers being used a substitute for proper sewerage systems, flood-related diseases like diarrhoea can spread more easily[34], while diseases like dengue fever increase as well due to flood events offering larger breeding spaces for the mosquitoes that transmit it[35]. Next to these health issues, the fertility of the soil can also decrease in the case of tidal floods allowing salt water to percolate into the ground.

4.2.1.3. Water scarcity

As Indonesia is located along the equator, it has relatively stable year-round temperatures and the country's seasonal variations are driven by monsoons. According to predictions, climate change threatens to disrupt the periods of rain and arid dryness. The dry season may become more arid, driving up the demand for water. Managing water scarcity is therefore a critical challenge for Indonesia and for many nations in Southeast Asia with similar climates[36]. In combination with this the scarcity in Indonesia (in particular periods) is enhanced by the overexploitation of their water resources.[37] Low river discharges are an expected consequence of these dry periods, enhancing the wicked problems mentioned in paragraph 3.1.2.

4.2.2. Health

4.2.2.1. Diseases

As described in the chapter on health there are numerous possibilities to counteract the spreading of diseases. A distinction can be made between two methods; the first consists of stopping the infection of hosts (e.g. humans) and vectors (e.g. rodents), the second focuses on the ecotope level of the vector. Measures generally operate on the principle that when the vector is not able to reproduce the infection is stopped. A clear example

of how this can be achieved in practice are the steps that are being taken to decrease the spread of the vector responsible for spreading dengue fever. The number of dengue cases in Indonesia is increasing every year, and the management of the vector control is not effective to combat the disease[38]. The most densely populated and urbanized area of West Java, Bandung, has a particularly high incidence of dengue[39]. The incidence of dengue hemorrhagic fever was the highest in the river watershed compared to other areas[40]. The vector, *Aedes aegypti*, uses stagnant water to lay its eggs and thus reproduce, so efforts are now being made to reduce the availability of such waters in areas where dengue is present. As *Aedes aegypti* has two life cylces, one in the natural system and one near humans, the decrease in the availability of stagnant water (e.g. in containers) will result in a decrease in the spread of dengue. However, since there are numerous other mosquito species that are capable of spreading dengue, this method is only useful in the short term and does not represent a sustainable solution to the problem. One of the other species capable of carrying dengue is *Aedes mediovittatus* which is found in Puerto Rico[41], while the *Aedes albopictu* mosquito thrives in forests. Incidentally, this is the species responsible for causing outbreaks of dengue in Fuzhan City (People's Republic of China), Houston (United States of America) and in South Cameroon[42-44].

Recently two new methods have been found that contribute to containing the dengue virus by keeping it from infecting vectors and hosts. The first method was already described in the chapter on health: infecting the *Aedes aegypti* with the *Wolbachia* bacteria, which prevent the dengue virus from transferring to the mosquitos[45]. Research by Hoffman et al (2011) showed that a population of *Aedes aegypti* infected with the *Wolbachia* bacteria were perfectly capable of maintaining themselves in natural surroundings. Furthermore, the frequency with which the mosquitoes were infected by the bacteria went up even after the infected *Aedes aegypti* were no longer introduced into the area, there were also indications that spread over a long distance was possible[46]. The second advancement which was discovered only recently is the use of chemicals that interfere with the locating senses of mosquitoes, thereby reducing the chance of humans getting infected with the virus[47]. In the near future this technique may be used to attract mosquitoes to an apparatus instead of humans. Within the health context, then, the most sustainable method of controlling the spread of the dengue virus would be a combination of the Wolbachia infection tactic and the use of chemical odours to distract the mosquitoes from their human targets. In an ideal situation, measures would be taken to reduce the population of vectors through decreasing the availability of stagnant water as well, but as these are usually quite expensive methods, their implementation is restricted to public places.

There are also some methods that do not concern themselves with stopping the host from getting infected. The government of Indonesia, for instance, uses chemicals

to outright kill the mosquitoes rather than stopping the virus from spreading amongst the mosquito population. In order for this measure to be effective, the chemical should be used for seven days in a row to get rid of all the mosquitoes. The Indonesian government, however, only uses it for one day, and neglect to alert the inhabitants of the area that they should open their windows to let the chemicals in. Additionally, people are not aware of the correct method to control the vector's spreading. They do not understand why it is necessary to clean the water storage tanks once a week, or why they should fill them all the way to the top. This has to do with mosquitoes laying their eggs just above water level, which also means the storage tanks should stay closed at all times. There is a fish that can be used to kill the mosquitoes as well, but this is not a feasible measure on such a small scale.

In the case of leptospirosis, a zoonotic bacterial infection, the main vectors are rodents, while local mammal species act as a reservoir for the leptospirosis bacteria as well. The incidence of leptospirosis cases in Indonesia fluctuated, but an increasing trend is visible, particularly in the flood plains[47]. The bacteria are spread through the urine of both vectors and reservoir species, and humans get the disease through contact with this infected urine. Flooding has a direct effect on this disease spreading in humans, as demonstrated by the case of a Danish man contracting leptospirosis when he was cleaning up a cellar flooded with contaminated sewage water[48]. A good sewage system with enough capacity to deal with heavy rainfall would have significantly reduced the chances of this man getting infected, and cases like these demonstrate the necessity of having such provisions in place. Other methods to contain the disease include decreasing the availability of stagnant water as leptospirosis cannot survive in dry conditions, or reducing the vector population through control programs for rats and other rodents[49]. Fewer rats mean fewer mammals get infected, thereby decreasing the leptospirosis reservoir and reducing the chances of it spreading to humans.

There are also several possibilities for improvements on a legislative level. A number of countries in the world, for example, already require mammals, like cattle and dogs, to be tested for leptospirosis. However, the specimens are only tested on the leptospirosis variations known to occur in the country importing the animals when it would be better to test the animals on the variations that can be found in the country exporting them[49]. Aside from more stringent testing regulations, more countries should adhere to these import and export requirements as well.

In Indonesia there is only one place where people can get tested for leptospirosis, and there are many cases of people being misdiagnosed as the disease can easily be mistaken for dengue. Neither does the government have active surveillance programmes for leptospirosis in place, which leads to them underestimating the number of leptospirosis infections. People working with sewage water or working in flooded areas run a higher

risk of getting the disease, and even the recreational use of water can increase the chances of contracting it. Those working in the military are at more risk from leptospirosis due to poor working conditions, which also counts for people working with animals or those zooming into contact with more than five rats a day. Bad personal hygiene and wounds on the skin can also increase the chances of getting the disease.

There are several methods of preventing leptospirosis: the immunization of domestic animals and rodent control, using antiseptic materials to treat wounds, and providing antibiotics to people participating in high risk activities. However, the most important method of prevention is draining contaminated waters, increasing water management, and improving the quality of living.

4.2.2.2. Water pollution

In developing countries, the supply of clean water is still a major problem. Drinking water is derived from two basic sources: surface waters, such as rivers and reservoirs, and groundwater[50]. Pollutant sources predominantly consist of: 1) industry, 2) domestic, 3) agriculture, and 4) livestock[51]. There are two types of pollution: point source (such as effluents from factories) and non-point source pollution, which includes run-off from the fields and the emission of chemicals into the atmosphere. Groundwater, for instance, might be contaminated through seepage from non-point source pollutants as well as from point sources such as leaking chemical storage tanks. Surface water, on the other hand, is often contaminated by industrial and domestic effluents released directly into lakes and rivers, and by pesticide run-off from fields[52].

In Jakarta, Indonesia, clean water supply is one of the major problems experiences on a daily basis as a result of severe shortcomings in efficient management and a lack of appropriate technology. Currently, PAM (Perusahaan Air Minum) Jaya (Jakarta Drinking Water Company) has a production rate of 1.7 million m^3/day of a low quality (e.g turbidity, odor, color) water supply, which only takes care of an estimated 40% of the demand for water in Jakarta.[53] About 40% of residents in urban areas and less than 30% of people in rural regions are connected to the drinking water network (PAM) in Jakarta[54], but the tap water is not drinking water (potable water) and should be cooked before used. For urban residents who are not served by a network of water pipes, drinking water comes from ground water, bottled water, or from itinerant water sellers.

The quality of drinking water from rivers in Indonesia, and especially those in West Java, has been much affected by pollution from the organic waste derived from domestic and industrial waste. Only about 2% of the waste water in Jakarta flows to the waste water processing installation, which generally only serves office buildings and housing. Even so, approximately 39% of Jakarta residents have a septic tank, and 20% use a latrine.[55]

Across the Citarum River, the Saguling, Cirata and Jatiluhur reservoirs are not eligible as a source of raw water for drinking water due to the concentration of Biological Oxygen Demand (BOD) being above 6 mg/L. This would raise the costs of processing the raw water, which would give rise to a situation where the community has to pay for the pollution in the river.[56]

In terms of biological parameters, such as the presence of faecal coli and total coliform, the majority of rivers located in densely populated cities tend to have higher levels of contamination from bacteria, such as the Progo River (Central Java and Yogyakarta), the Ciliwung River (Jakarta), and River Citarum (West Java). Coliform bacteria are an indicator of faecal pollution from domestic sewage, including human and livestock faeces, which can cause diarrheal disease.

Another problem is the run-off from farmed hillside areas, which introduces massive amounts of plant nutrients (nitrogen and phosphorus) into the water responsible for inducing eutrophication in the reservoirs. The resulting algal blooms and their subsequent decay have been blamed for the regular occurrence of fish kills and for the considerable damage done to the floating fish cage industry. In turn, the uncontrolled expansion of fish cage operations is exacerbating the effects of polluted water coming into the reservoirs, as improper fish feeding adds to the waste load in the form of unconsumed food accumulating on the reservoir bed. When these organic deposits are disturbed and resuspended oxygen demand becomes excessive. This is thought to be a key factor in the cause of perennial fish kills.[57]

Lack of proper solid waste management contributes to both pollution and flooding. Garbage deposited along canals and riverbanks contribute to the high BOD. They also clog drains and accumulate on riverbeds reducing discharge capacity. According to the PD Kebersihan of Bandung City, average daily solid waste generation is 6,500 m^3/day, of which an estimated 1,500 m^3/day is not collected and properly disposed. Thus the annual uncollected garbage that invariably ends up accumulating in the drainage system and rivers amounts to 500,000 m^3. According to the Saguling Dam office, the estimate inflow of solid waste into the reservoir is 250,000 m^3 per year.[57]

Along the West Tarum Canal, reduction in conveyance capacity is due both to sediment deposits and the prolific growth of aquatic plants (which create friction in water flow). Apart from contributing to the bottom detritus, aquatic plants trap silt and accelerate canal shallowing. Plant growth is promoted by the use of the canal as toilet and bathing/washing area for residents, which adds substantial quantities of plant nutrients in the water.

As the Citarum River, an important surface water source in West-Java, is showing signs of being contaminated, people are starting to look for ways to create a sustainable water supply. One of the first steps was to initiate a water quality monitoring

programme in 2004 that measures the quality of water in 30 provinces in Indonesia twice a year. In the case of the Citarum River, the results indicated that the levels of the parameters DO, BOD, COD, faecal coil and total coliform majority did not meet the criteria for water quality class I according to the PP 82 of 2001[50]. The conservation of resources of water is also mentioned in the PP 82 of 2001, and focuses on water quality management by controlling the pollution in reservoirs and other bodies of water like rivers and lakes through the use of dams and groundwater aquifers.[55]

There are many ways to assess the water quality status of a water source, some of which are presented in the KepMen LH No. 115/2003 on Guidelines for Determination Satus of Water Quality as the Storet and Index Pollution method. It is also possible to use the water class that refers to the PP 82 of 2001. Technical studies were carried out in 2004 by the Natural Resources Research and Development Center as part of preparing an overview of the environmental status of Indonesia (SLHI).

4.2.3. Development

4.2.3.1. Culture and communication

Cultural elements were shown to be a crucial factor in explaining the differences in public participation in water management practices, as mentioned in paragraph 3.3.1.[58] Hofstede dimensions can be used as a tool to understand a culture better in order to ensure the sustainability of the frameworks that are developed and implemented.

Considering Indonesia's scores along the four Hofstede dimensions[59,60], the following conclusions can be drawn: Indonesian society expects authority from the power-holders, respects their power and respond to top-down guidance. It is also a highly collectivist society, meaning that they hold society and family values in high regard. Moreover, Indonesian culture has both masculine (e.g. dignifying achievement and success) and feminine characteristics (e.g. dignifying intangible values). Last but not least, Indonesians have a high tendency to avoid uncertainty in their futures, which they find threatening, and tend to take actions in order to resolve any potential unknown situations. Scores of Indonesia in comparison to the Netherlands can be seen in Fig. 15.

Based on these findings, it can be generalized that the Indonesian culture cherishes both power and social values. Taking this information into account, it can be concluded that a top-down approach rather than bottom-up one would be a more successful strategy for applying a water framework in Indonesia, especially if this is combined with authoritative leadership and guidance. Furthermore, agencies like the government should provide stable projects for a long period of time in order to minimize risks, and they should state their goals explicitly to the urban delta societies to get them behind the projects. When authorized institutions come up with a definite, comprehensive and

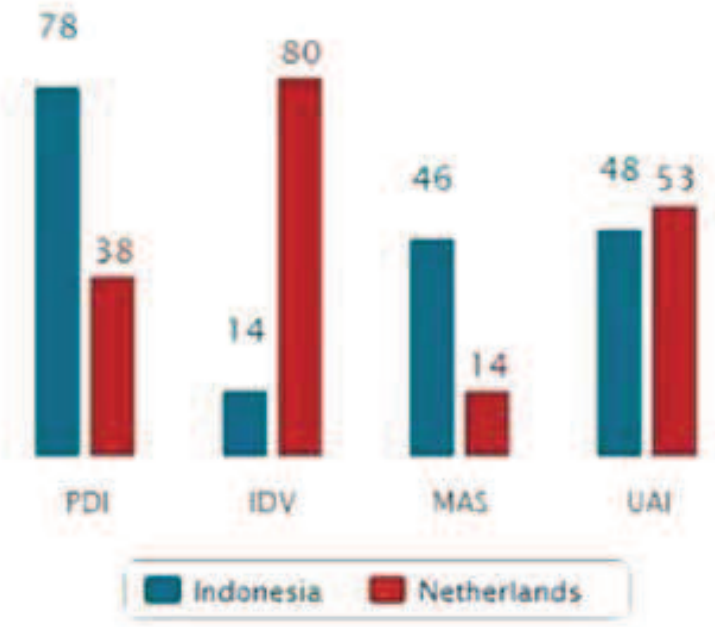

Figure 15 | Hofstede dimension scores of Indonesia in comparison with Netherlands.

not entirely innovative plan for the future and skilfully guide the public, they are more likely to be successful in putting a sustainable framework into practice. Thus, authorized persons (e.g. governors, ministries etc.) should have a thorough plan ready in advance and they should implement it using their authority while always taking the society's values and traditions into account.

4.2.3.2. Awareness

Ensuring the sustainability of a water-management project requires the active participation of the local Indonesian community.[61] A preliminary study was conducted in Manado, a coastal city in Indonesia where waste water management had to be improved.[62] NGO's and other intermediate agencies were found to be an efficient way to promote community participation, which then function as the intermediate leaders mentioned in chapter 3.3.2. Also, the degree of knowledge about the environment and pollution amongst the population was found to be low to average, which researchers partly attributed to a lack of terminology. Therefore, it is important to first ensure there is a shared language when raising awareness.

A pilot study (N=13) was conducted to investigate the awareness of water-related issues amongst the population in both the Ciliwung and the Citarum delta in Indonesia.

The results show that the population perceives four major problems, three of which are related to water (flooding, polluted water, storm water and security). Almost two thirds take precautions or measures to control the water related issues, which consist mainly of boiling or filtering the water before usage. It is remarkable that most participants thought that other people are more affected by these water difficulties than they are themselves. However, only 50% of the participants think that the government is aware of these difficulties. For example, one statement was: *"Somehow the people in the government have different set of priorities that could be different from the population"*. An even higher number of participants (75%) claim there is not enough communication between government and population. Contrary to findings mentioned above, 58% of the participants say that governmental agencies take precautions. However, they commented that those measures were neither effective nor sufficient. Finally, all participants agreed that water will create problems for the future and think that other precautions should be taken.

It can be concluded from the pilot study that the population in the Ciliwung and the Citarum delta in Indonesia seems to be aware of water related issues, especially those related to the future. They are also willing to take more precautions or measures to prevent future disasters. However, sufficient and efficient actions are still lacking. This problem could be tackled by increasing the communication between government and population, and using one shared language would make people more knowledgeable and active. Also, intermediate agencies or 'bock leaders' could be used to make people more pro-active. Careful investigation should determine who could fulfil this role. Examples are community leaders, sportsmen, elderly or religious people who are respected by the community. For a more detailed description of actions that can be taken to increase awareness and active participation, see Werner.[63]

4.2.3.3. Governance

As the two Indonesian cases do not concern other States, it would be superfluous to talk about international conflict and cooperation. Nonetheless, within Indonesia the problems concerning policy and regulation of water issues are very much present. Instead of divided responsibilities between countries, Indonesia suffers from divided responsibilities between ministries concerning the water and sanitation sector. The Ministry of Health is responsible for water quality related aspects, but the responsibility for the urban sector is shared between the Ministry of Home Affairs and the Ministry of Public Works, while the regulation of bottled water is transferred to the Ministry of Industry and Trade. This fragmentation results in high communication costs and low efficiency.[64] Due to the decentralization in Indonesia in 2001 after the fall of Suharto, most of the powers were transferred to local governments, which caused an even bigger

fragmentation of responsibilities.[65] This is mainly due to inadequate channelling of funds to carry out this responsibility.[66]

In urban areas, the provision of water services is the responsibility of PDAM's (Perusahaan Daerah Air Minum), Local Government Owned Water Utilities. There are 319 PDAM's in Indonesia.[66] Institutional responsibilities for wastewater and sewerage lie at the district government level; departmental responsibility varies between districts. Water management differs between urban areas and rural areas, where community-managed water supply services have a long history. However, community capacities to sustain water systems over long periods have tended to be limited. Because of a lack of funding, communities were not able to invest enough to be able to implement, operate and maintain adequate services.[65] Rural consumers have not consistently been offered voice and choice in decisions related to establishing and managing services and paying for them. Services have often been provided in a top-down manner by agencies external to the community, using public sector or donor funds and contractors answerable to government agencies rather than to the users of services. This has led to mismatches between what the users want and get, to a lack of community ownership of rural water supply and sanitation facilities, and to unclear responsibilities for maintenance.[65]

The Citarum River Delta is situated on Java, so two provinces are concerned here; Jakarta and West-Java. Furthermore, at least 10 cities and municipalities are at stake. At the moment they are not cooperating on any level, partly because since the process of decentralization was completed, responsibilities for each administrative entity became more unclear.[66]

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4.3. WORKSHOP – APPLICATION TO THE CITARUM DELTA

On Tuesday, April 3rd, 2012 the taskforce convened in a workshop session, applying the FSSD framework to the Case Study of the Citarum Delta, as introduced in chapter 4.1. In this session the ABCD planning process as described in chapter 2 was used as a road-map to discover whether this framework could be applied in Indonesia. The participation of the Indonesian group members played an essential role in this. Throughout the process they explained their appraisal of whether steps of the approach where applicable or not, and what specific characteristics of Indonesia and the Citarum Delta would have to be taken into account. Furthermore the rest of the taskforce commented on their insights about the wicked problems playing a role in the Citarum Delta and how these should be addressed within the application of the FSSD framework. The workshop led to interesting discussions and provided a variety of recommendations, which will be addressed in chapter 5.

5. Recommendations

In this chapter recommendations will be presented for the application of the FSSD to urban regions in deltas. They represent the results of the taskforce's efforts throughout the program, but in particular the work done during the Radboud Honours "Spring School" in Portland (USA) in April 2012, as most of the recommendations were finalized there. In a series of three workshops, possibilities for implementing the FSSD in urban delta regions were analysed and discussed. The first session focused on applying the FSSD framework to the Indonesian Citarum river basin as introduced in chapter 4.3. In the second workshop the taskforce members discussed recommendations for possible applications of the framework to urban delta regions in general, based on the conclusions drawn from the elaboration of a possible integration of the FSSD with other sustainability frameworks (described in chapter 2) and the wicked problems that occur regularly in urban regions in deltas (described in chapter 3). Experts from various disciplines gave feedback on the work done so far in the third workshop. They were invited to participate in the session on Friday, April 6 2012. The recommendations presented in chapter 5.1 (urban regions in deltas in general) and 5.2 (urban regions in deltas in Indonesia) are based on the conclusions drawn from these three workshops.

The authors of the current report are aware of the fact that the extended framework described is most likely neither complete nor perfect. The conclusions drawn and the recommendations described are based on the specific knowledge and expertise of the taskforce members, and will therefore not cover all possible issues that may arise in delta regions. There might very well be wicked problems or alternative solutions that have not been addressed or taken into account. This report should therefore be seen as a first attempt at capturing a broad range of issues associated with sustainable development in delta regions that is subject to an iterative process of improvement. Further research from other disciplines and fields of expertise is required to address additional complex problems that generally occur in urban regions in deltas.

5.1. RECOMMENDATIONS FOR THE APPLICATION OF THE FSSD IN URBAN REGIONS IN DELTAS

In general, it can be concluded that the FSSD is an appropriate framework to be used as a basis for sustainable development in urban regions in deltas. However, in order to address some of the more specific issues in delta regions, the taskforce suggests some recommendations to sharpen and customize the FSSD.

To create true sustainable development in urban delta regions, measures must be taken to protect sensitive ecosystems from urban pressures, to prevent deterioration of ecosystem services where urban inhabitants rely on. The FSSD, being a framework, does not provide specific guidelines that enables us to address ecosystem health and its connection with ecosystem services in a river basin or delta. We suggest that the Ecosystem Services concept can be a useful way of analysing and addressing this issue. The Ecosystem Services concept can be used as an "operational language", increasing the understanding of the immense importance of ecosystem services for society. Furthermore, the concept can be used to demonstrate to policy makers and entrepreneurs the potential benefits of sustainable development projects that preserve ecosystems and the services they provide. Summarized in a statement:

> *Use the Ecosystem Services concept within the fssd as an "operational language" to increase understanding of the importance of ecosystems for communities living in urbanized delta regions. The ES concept helps to value (monetary and non-monetary) the potential benefits of sustainable development.*

Experiences from other projects have shown that one of the biggest challenges is to get stakeholders working together and communicating effectively. It is also critically important to keep them motivated and committed to a joint vision after the initial phase of the project. These issues do not appear to be explicitly addressed in the FSSD. Participatory theories and techniques to encourage co-learning, trust building, and communication can be used to solve these problems. A good monitoring and evaluation system should be established for every step of the way, so that success can be measured and stakeholders can be held accountable for their performance during project implementation.

> *Identify and make use of communicating techniques to keep participants informed, cooperating and motivated.*

Based on the wicked problems described in chapter 3.1, it is recommended that awareness is created about the factors that lead to problems that affect inhabitants of urban river deltas, such as increased flood risk, water scarcity and ecosystem degradation.

> *Create awareness of the factors that lead to increased flood risk, water scarcity, and ecosystem degradation, which affect the wellbeing of delta inhabitants.*

Health issues and waterborne and water-related diseases in particular, play a huge role in urban delta regions. In the FSSD framework, however, the connection between the four sustainability principles and health needs explicit attention. Since this issue is of particular importance in deltas, it is recommended that the role "health" plays at the "Success Level" of the FSSD is mentioned needs to be elaborated. An understanding of the close relationships between health issues and other typical problems in river basins and deltas is essential (e.g. diseases are often caused by or spread because of bad water management and land use).

> *Define health issues as an important part of the Success Level, taking into account that it is interwoven with many primary system conditions.*

Water pollution is a critical problem in many urban delta regions, especially in developing countries. To tackle this problem, a behavioural change is required from many stakeholders, including the local population. It is therefore recommended that these issues are addressed specifically at the Action Level of the FSSD application. On a governance level, it is essential to make the decrease of pollution a common goal. Effective monitoring of pollution and mitigation measures are important tools for creating awareness and achieving these goals.

> *Make the decrease of water pollution a common goal among stakeholders, addressing behavioural changes and appropriate legislation on the Action Level.*

To achieve sustainable development it is crucial to look across borders, not only geographically, but also in terms of society. Cultural variety is one of the most important factors to be considered during the baseline analysis of the FSSD, in order for communication and leadership styles to be adapted accordingly. The so-called "Hofstede principles", described in section 3.3.1, are a convenient method of characterizing cultures along several dimensions. This tool facilitates understanding of the current situation and can help to predict future behaviours, so that implementation strategies can be

adapted accordingly. Besides taking into account the culture and communication style within a society, it is also important to incorporate the awareness for sustainability at the Success Level, as individuals need to be aware of the importance of sustainability before implementing a sustainability framework. Different strategies can be utilized to raise awareness.

> *Make use of knowledge about various cultural characteristics, such as the Hofstede principles, to analyse cultural and social traits in the study area and adapt communication and leadership styles.*

As the FSSD is a very generic framework, it does not go into detail about norms and social characteristics. Nonetheless, this does play an important role during the implementation of sustainable development projects in urban river deltas, and is an essential part of the application of the proposed framework. Since individual human behaviour is partly determined by social norms, information about these norms can be useful when attempting to create a shift in attitude towards sustainable development. Therefore, it is recommended to identify the social norms within the study area in the System Level so that they can be used to facilitate behavioural changes on the Strategy Level.

> *Address social norms on the System Level and make use of them in the Strategic Level.*

Deltas provide an abundance of resources for human inhabitants, but they are very vulnerable at the same time. In such delicate systems it is especially important to use natural resources responsibly and within the carrying capacities of natural systems. The FSSD extensively addresses sustainable use of natural resources and provides details about keeping economic development within the bounds of the sustainability principles, but it does not provide methods for measuring the value of ecosystems and their functions. Fortunatley, concepts like "Ecosystem Services" can be easily integrated as a tool within the FSSD to measure such values. Environmental accounting can then help to further bring these concepts together by expressing to stakeholders the multi-dimensional return on investment that will be achieved through this process.

> *Use multidimensional return on investment to explain sustainable development for stakeholders in urban delta regions.*

Even though working together with different stakeholders is an essential part of the FSSD framework, it does not specifically address practical issues of complex group

decision making. It is essential that all information that is available to the group is shared between its members. To achieve this, groups should actively investigate what information individual members hold and develop a common language and understanding of the problems and the goals of the task at hand. This exploratory work may take some time and effort in the beginning, but will aid the decision-making process in the end.

To bridge the gap between, on the one hand, stakeholders trying to push forward their own interest and, on the other hand, a common goal, it is necessary to develop trust between group members, encouraging them to switch from a prisoners' dilemma situation towards an assurance game. In order to develop this trust, it is crucial for stakeholders to meet on a regular basis at with a transparent agenda. This way, a basin-wide cooperation can be developed, that can later lead to legislation and enforceable rules. Principles of environmental law can be used as tools within the FSSD framework to arrange a division of responsibilities.

Develop a common level of knowledge and a common language and understanding of problems and goals within groups.

Have stakeholders meet and cooperate on a regular basis so that trust can evolve and be maintained.

5.2. RECOMMENDATIONS FOR THE APPLICATION OF THE FSSD IN INDONESIA

On April 3rd, 2012, taskforce members from all universities convened in a workshop session in Portland (USA), applying the FSSD framework to the case study of the Citarum Delta, as introduced in paragraph 4.1. In this session the so-called "ABCD" planning process as described in paragraph 2.2 was used as a roadmap to discover whether this framework could be applied in Indonesia. The participation of the Indonesian group members played an essential role in this exercise. Throughout the process they explained their appraisal or whether steps of the approach were applicable or not, and what specific characteristics of Indonesia and the Citarum Delta should be taken into account. Furthermore, the rest of the taskforce commented on their insights about the wicked problems playing a role in the Citarum Delta and how these should be addressed within the application of the FSSD framework. The workshop has led to interesting discussions and provided a variety of recommendations, which will be addressed below.

In order to be able to apply the FSSD framework in a useful manner, all relevant stakeholders need to be involved in the process. A tremendous amount of governmental, institutional, public, and private stakeholders are present in the Citarum river basin,

who should all be invited to directly or indirectly participate. The first recommendation is, therefore, to include in the discussion all parties who have already worked on river management, natural resources management and governance. This way, their experiences can be used to help the process along and create trust by showing them that the application of the FSSD is not aimed at substituting their work but at integrating it. Another recommendation is to use examples to help people visualize the possibilities of the framework. For instance, an introductory workshop could be organized where case studies are presented in the form of "best practices".

Invite parties who have been involved in river management in the past.

To define the Success Level in the FSSD, it is necessary to first create a joint vision of success among the different stakeholders. The FSSD makes use of the sustainability principles to define the success level, but for application in Indonesia it is recommended that the language used is not too technical or abstract. According to our Indonesian fellows the sustainability principles have to be "translated" to an easier "language", to make them understandable and clear to individuals from a wide variety of (cultural and spiritual) backgrounds. Making use of local and regional examples of sustainable solutions can make the message more relevant as well. Practical, regional examples from people's daily lives can help them visualize the connection between the problems they are experiencing and the benefits that can come from sustainable development. The concept of Ecosystem Services can be used to further explain these issues by showing the linkage between functioning ecosystems and the services they provide to humans. This can help explain the importance of ecosystems and thus facilitate incentives for sustainable development. By pointing out potential benefits of sustainable development, in monetary or other terms, policy makers can be reached as well. It should be pointed out that many Indonesian officials may be eager to maintain their status, so engaging them in this process by illustrating what is in it for them could be an important success factor of this project.

Use examples of successful application of the FSSD, e.g. "best practice" case studies.

Use practical, regional examples of sustainability during the formulation of a joint vision.

Use the Ecosystem Services concept to facilitate incentives for sustainable development.

The analysis of the Hofstede principles in section 4.3.1 shows that Indonesians value power and authority. Therefore, the effect of "bottom-up" or "grass root" initiatives solely will be limited. Creating awareness on a governmental level might be a more effective strategy, but the real hierarchical structure is often different than it seems. Local community members, or block leaders, are highly respected and trusted, and are therefore more likely able to motivate or influence the people than many elected officials. It is therefore recommended that these people are identified and brought on board for sustainable development projects. Besides these block leaders, local celebrities or religious leaders might be important individuals to invite to lend their support to the project. They too might be helpful for motivating and facilitating implementation. Thus, in order to solve issues of implementation and public support, and taking into account the specific characteristics of Indonesian society, individuals with an informal authority should be invited to participate, since they are respected and trusted by the locals.

Identify and invite people with informal authority.

An important basis for the definition of the Success Level and formulation of goals is an investigation into people's needs. In the case of Indonesia, it has to be taken into account that many people may not initially see sustainable development as an important need. They are probably much more aware of problems in their daily lives, like hunger or disease. However, most of these problems are directly linked to sustainability issues, or to loss of ecosystem services. Therefore, explaining the connection could help prioritize steps towards a desired outcome. It is recommended to first investigate the people's needs, then show them that they are not being told what they need from an outside perspective, and finally work on the most important problems that people are experiencing, by explaining the connection between sustainable development and the problems in their daily lives.

Identify and respect people's needs, and explain the connection between their problems and sustainable development.

The think tank

Urban regions in the delta

Think tank

Khaled Abdul-Ehami
Strategic Leadership towards Sustainability
Blekinge Institute of Technology, Sweden

Andre Benaim
Strategic Leadership towards Sustainability
Blekinge Institute of Technology, Sweden

Frank Collas
Biology
Radboud University Nijmegen

Kelly Cowan
Engineering and Technology Management
Portland State University

Hofiya Djauhari
Biology
Bandung Institute of Technology

Monja Froböse
Cognitive Neuroscience
Radboud University Nijmegen

Miroslav Damyanov
Behavioural Science
Radboud University Nijmegen

Jaap van Erp
Environmental Sciences
Radboud University Nijmegen

Sarah Holmen
Ecosystem Services for
Urbanizing Regions
Portland State University

Ahmad Komarulzaman
Economy
Padjadjaran University
Bandung




Jovin Hurry
Strategic Leadership
towards Sustainability
Blekinge Institute of
Technology, Sweden

Rutger ter Horst
Medicine
Radboud University
Nijmegen

Robbert Lauret
Political Science
Radboud University
Nijmegen

Marissa Matsler
Urban Studies
Portland State University




Lars Lamers
Environmental Sciences
Radboud University
Nijmegen

Sandra Lohrberg
Civil Engineering
University of
Duisburg-Essen

Anindrya Nastiti
Environmental Sciences
Bandung Institute of Technology

Kathrin Oertel
Civil Engineering
University of Duisburg-Essen

Basra Mohammed
Environmental Science and Management
Blekinge Institute of Portland State University

Ludwika Nieradzik
Civil Engineering
University of Duisburg-Essen

Swinda Pfau
Environmental Sciences
Radboud University
Nijmegen

Hilde Reijers
Behavioural Science
Radboud University
Nijmegen

Cansu Oranç
Behavioural Science
Radboud University
Nijmegen

Annisa Rahmalia
Health Management
Padjadjaran University
Bandung

Jodi Schoenen
International Agriculture
and Rural Development
Portland State University

Antonia Zillman
Civil Engineering
University of
Duisburg-Essen

Silvita Fitri Riswari
Medicine
Padjadjaran University
Bandung

Simone Wevers
Behavioural Science
and Criminal Law
Radboud University
Nijmegen

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