CLIMATE CHANGE ADAPTATION IN THE WATER AND SANITATION SECTOR IN VIETNAM

by

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iv. Abstract

Vietnam is among the countries most heavily affected by the consequences of climate change, and the WASH sector is one of the most vulnerable ones. This research dissertation analyses the current situation in the sector and how climate change is expected to affect the country. Using CAM methodology, a vulnerability analysis is carried out, analysing the levels of exposure, sensitivity, impact, adaptive capacity and vulnerability of the different types of WASH infrastructures with respect to climate change.

The research analyses the international practice on climate change adaptation, and makes specific recommendations for the WASH sector. The options are compiled in three groups: at policy level, structural options, and non-structural options.

In comparison with other countries, Vietnam has accumulated a number of good cases on climate change adaptation in WASH, and has a solid policy development that allows them to be quickly scaled up countrywide.

Key words

Climate change, Vietnam, Resilience, WASH, Adaptation

v. Executive Summary

Over the last three decades, Vietnam has experienced a remarkable socio-economic development. Starting from 1986, the Đổi Mới (renovation) introduced a "socialist-oriented market economy" that liberalised the economy and modernised the country.

During that period, the country has made remarkable progress in increasing the coverage of water and sanitation infrastructure. Since 1990, the coverage of improved water supply has increased from 90% to 99% in 2015; and in rural areas has increased from 56% to 97% (WHO/UNICEF JMP, 2015).

Sanitation coverage has also increased from 69% to 99% in urban areas, and from 31% to 74% in rural areas (WHO/UNICEF JMP, 2015). Open defecation has dropped from 43% in 1990 to 1% in 2015 and is mostly practiced by ethnic minorities.

However, climate change threatens that positive trend, especially in lowland areas that are more vulnerable to floods and sea level rise (SLR) and mountainous areas affected by flash floods.

Vietnam is among the countries most heavily affected by the consequences of climate change. Of the 84 coastal developing countries investigated by the World Bank in terms of sea level rise (SLR), Vietnam ranks first in terms of impact on population, GDP, urban extent, and wetland areas, and ranks second in terms of impact on land area (behind the Bahamas) and agriculture (behind Egypt) (WB, 2007). The authors state that the consequences of SLR for Vietnam are "potentially catastrophic" and demand "intermediate planning for adaptation".

Climate change is a big concern for Vietnamese political leaders, and thus the country has developed a strong institutional and policy framework. The Socio-Economic Development Strategy for 1991-2000 adopted at the 7th National Congress of the Communist Party of Vietnam (CPV) emphasizes that "Economic growth must go hand in glove with social progress and equity, cultural development, and environmental protection" (GoV, 2012)

Vietnam signed the United Nations Framework Convention on Climate Change (UNFCCC) in June 1992 and ratified the Kyoto protocol in September 2002. The Ministry of Natural Resources and Environment (MONRE) is the national focal point and represents the country's interests in international conferences such as the Conference of Parties (COP) that takes place annually.

Apart from the National Target Programme to Respond to Climate Change (NTP-RCC), Vietnam has developed several climate change adaptation strategies and master plans, at national, regional, provincial, and even at city level. Most of their ministries, including the three ministries involved in the water and sanitation sector, have approved strategies to address the challenges of climate change. At the end of the document (annex 3) there is a description of the main documents that regulate climate change adaptation in general and the water and sanitation sector in particular.

People interviewed during the fieldwork agreed that in recent years there has been positive progress in the institutional arrangement and management of WASH services. However, there are still some obstacles that limit the full potential of the systems put in place.

In that sense, this research aims to contribute to improved climate change adaptation in the WASH sector in Vietnam by addressing the following research objectives: (i) To

identify the main risks and vulnerabilities that the water and sanitation sector is facing with respect to climate change; (ii) to identify lessons from the international practise in climate change adaptation in WASH which can be applicable for the Vietnamese context; (iii) to identify and analyse possible options for climate change adaptation in the WASH sector in Vietnam; and (iv) to provide some recommendations to decision makers on the priorities and potential climate change adaptation options.

In order to address the first research objective, the author has carried out a vulnerability assessment of the different components of water supply and sanitation infrastructures, both in rural and urban areas, and in both coastal and interior areas.

CAM (Climate Change Adaptation Methodology) has been used to analyse the exposure, sensitivity, impact, adaptive capacity and overall vulnerability of a variety of assets. Those assets, or components of water and sanitation infrastructures, are susceptible to be impacted by different climate change-related threats such as floods, droughts, typhoons, heat waves or sea level rise-.

Some interesting conclusions can be extracted from that exercise. In general terms, floods and sea level rise (SLR) are the main hazards to water and sanitation infrastructures. Floods affect significantly ("high" or "very-high") to almost all types of infrastructures, in terms of exposure and sensitivity; which leads to a "high" to "very-high" impact levels and contributes to "high" to "very-high" overall vulnerabilities.

Similar results are obtained in some water infrastructures located in coastal areas, such as surface water intakes from rivers, groundwater and treatment plants. However, in those areas the adaptive capacity, in general terms, is, higher than in other geographical regions, due to the higher concern of climate change and sea level rise that lead to higher investments.

The levels of exposure, sensitivity and impact are quite high in general for most of the assets analysed, with "low" and "very low" adaptive capacities. The combination of relatively high impact with low coping mechanisms contribute to increase vulnerability of most of the types of infrastructure analysed.

The results of this vulnerability analysis of water and sanitation infrastructures present an interesting finding, as they highlight the Mekong delta and low land areas affected by SLR and floods as the most vulnerable areas to climate change. This is also the perception of most of people interviewed. This perception, however, differs from other (general) vulnerability assessments carried out in the past (e.g. Wilderspin & Le Dang, 2013), which tend to highlight the Northern Mountainous provinces and the Central Highlands, where poverty levels are higher, as the most vulnerable areas to climate change.

The second research objective was to identify lessons from the international practise in climate change adaptation in WASH and what can be applicable to the Vietnamese context. In that sense, an interesting finding is the observation that, in comparison with other middle-income countries, Vietnam is in the vanguard in climate change adaptation.

Vietnam shares challenges and commonalities with the rest of the world. In particular, all countries are struggling with high levels of uncertainty that might deter some decision makers and that oblige them to manage risks and scenarios in a very flexible way.

Climate change is a process that has implications in the mid to long term, and therefore the climate change adaptation process has to be considered in the long term. However, most experts agree that it is important to start now in order to make future risk avoidance more affordable and to minimize the damage of climate impacts on society. This is particularly important for water and sanitation infrastructures that are being designed now and that are expected to last for several decades.

Climate change adaptation requires a crosscutting prospective with multidisciplinary actions. This is relevant when developing IWRM strategies, land planning or urban development. The problem is global, but solutions have to be contextualized and adapted. For instance in most countries, groundwater resources are more resilient to the effects of climate change than surface water, however in the Mekong delta, due to salinity intrusion, the recommendation made by experts consist of the opposite: look for fresh water upstream in the rivers.

Most countries are starting with no-regret, low-regret and win-win measures. No-regret are defined as actions that will pay off immediately under the current climate conditions; low-regret can potentially have large benefits; and win-win are actions that tackle several risks/benefits at once. Those types of solutions are very relevant in middle-income countries like Vietnam, which do not have the resources to invest large amounts of money in the prevention of uncertain future scenarios.

All countries are facing similar constraints and almost all of them recognise that they are slow in the operationalization of CCA into strategies, plans and projects. Vietnam can be considered among the countries that have more seriously considered the threat of climate change, and are discussing CCA at the highest level. However, as is the case with the majority of countries in the world, it still lacks substantial and practical implementation of CCA actions, especially in the WASH sector.

In that sense, the third research question aims to provide some practical examples and options that can be promoted in the country. Those options are organized in three groups: proposed options at policy level, structural options and non-structural options.

The identification of these options has been done based on interviews with key resource people at national level, a review of national and international literature, and also based on the experience of the author in the country.

At policy level, one of the most critical elements identified is the need to ensure proper mechanisms for Integrated Water Resources Management (IWRM) and the development of river basin authorities. Surprisingly, Vietnam is still lagging behind other middle-income countries with respect to IWRM, and lacks functional river basin authorities countrywide.

That limits the possibilities of better coordination for management of floods, even if the country has a centralised department of storm and flood control. This research provides some discussions about the decentralisation process and the need to keep decisions for some water management aspects at a higher level (river basin instead of provincial level).

Setting up water-efficiency and water-conservation measures, and regulating water uses, especially from agriculture, can be a no-regret climate change adaptation (CCA) option.

The development of capacities on CC, and the need to improve knowledge and dissemination of good practices on practical CCA are among the options to respond to climate change at the policy level.

At the infrastructure level, better design parameters are required, starting with the revision and upgrade of construction codes, a task that is just in its preliminary steps in Vietnam. Return periods and lifespan of infrastructures have to be better considered, and infrastructures should be designed with increased margins of safety to be more climate-resilient.

Increasing storage capacity (in reservoirs, ponds, rainharvesting and underground) are frequent CCA measures. Large scale coastal protection ditches to prevent sea level rise, have been proposed in most coastal provinces of Vietnam. However, those types of solutions imply significant costs that have to be properly estimated in terms of cost-efficiency and cost-benefit.

As several mid and small-size Vietnamese towns still lack any drainage or sewerage network, the government has a golden opportunity to design efficient systems from the ground up. In Vietnam there have been a lot of discussions about separated vs. combined sewerage solutions. These solutions have to be further discussed, and consideration must be given to the impact of climate change as well.

Structural solutions also include small-scale systems, such as on-site latrines in areas affected by floods or sea level rise. In most cases, the technological solutions are already available in the country, but there is need to further promote those options.

Beyond “grey” infrastructure solutions, non-structural solutions tend to be a less costly alternative. Poverty reduction is a powerful instrument to adapt to climate change, as vulnerable communities have limited coping mechanisms.

In that sense, the predictions of increased water-borne and water-related diseases as a consequence of climate change, and more suitable conditions for vector dissemination, are more positive than expected (WHO, 2014). WHO anticipates only 5% of global malaria cases will be attributable to climate change in 2030. Improved hygiene practices and socio-economic development in the coming decades are expected to reduce the negative impact of CC in vector dissemination.

Another area of improvement for Vietnam is on the Early Warning Systems (EWS) both at national and sub-national levels. In addition, there is need for the improvement of Water Safety Plans (WSP) and Operation and Maintenance (O&M) of infrastructures. Lifespan of rural infrastructures is relatively limited due to substandard O&M investments. Low tariffs in urban water and sanitation limit the potential to expand or provide better services.

Perhaps one of the most promising areas is on Community Based Disaster Risk Reduction (CBDRR). The Vietnamese government has adopted this successful model from NGOs. This has the potential to integrate CCA concepts in rural areas, raising awareness and contributing to increase resiliency of the water and sanitation infrastructures.

The challenges to adapt to climate change in Vietnam are big, considering the high vulnerability and exposure, but the government has demonstrated a strong commitment to set up a solid policy framework.

The next steps will be to “walk the talk” and to effectively invest in climate-proof options, by promoting some of the options that have been pointed out within this document. The author expects that the document will contribute to the debate within the water and sanitation sector, and will bring some ideas on how to address one of the biggest challenges of the 21st century.

vi. Table of contents

vii. Glossary of terms[1]

Adaptation: In human systems, the process of adjustment to actual or expected climate and its effects, in order to moderate harm or exploit beneficial opportunities. In natural systems, the process of adjustment to actual climate and its effects; human intervention may facilitate adjustment to expected climate.

Adaptation to Climate Change: The adjustment in natural or human systems in response to actual and expected climatic stimuli, such as to moderate harm or exploit beneficial opportunities.

Adaptive capacity: The combination of the strengths, attributes, and resources available to an individual, community, society, or organization that can be used to prepare for and undertake actions to reduce adverse impacts, moderate harm, or exploit beneficial opportunities. Adaptive capacity refers to the ability to anticipate and transform structure, functioning, or organization to better survive hazards.

Capacity: Capacity refers to the combination of all the strengths, attributes, and resources available to an individual, community, society, or organization that can be used to achieve established goals. Capacity is an important element in most conceptual frameworks of vulnerability and risk. It refers to the positive features of people's characteristics that may reduce the risk posed by a certain hazard. Improving capacity is often identified as the target of policies and projects, based on the notion that strengthening capacity will eventually lead to reduced risk. Capacity clearly also matters for reducing the impact of climate change.

Climate change: Climate change refers to a change in the state of the climate that can be identified (e.g. by using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forces such as modulations of the solar cycles, volcanic eruptions, and persistent anthropogenic changes in the composition of the atmosphere or in land use. The Framework Convention on Climate Change (UNFCCC), in its Article 1, defines climate change as: "a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods". The UNFCCC thus makes a distinction between climate change attributable to human activities altering the atmospheric composition, and climate variability attributable to natural causes.

Climate model: A numerical representation of the climate system that is based on the physical, chemical, and biological properties of its components, their interactions, and feedback processes, and that accounts for all or some of its known properties. The climate system can be represented by models of varying complexity, that is, for any one component or combination of components a spectrum or hierarchy of models can be identified, differing in such aspects as the number of spatial dimensions, the extent to which physical, chemical, or biological processes are explicitly represented, or the level at which empirical parameterizations are involved. Coupled Atmosphere-Ocean Global Climate Models (AOGCMs), also referred to as Atmosphere-Ocean General Circulation

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[1] Climate-change related terms are based on UNDP-Vietnam's agreed glossary of terms for CCA (UNDP, 2014). The source of other terms is specified.

Models, provide a representation of the climate system that is near the most comprehensive end of the spectrum currently available. There is an evolution toward more complex models with interactive chemistry and biology. Climate models are applied as a research tool to study and simulate the climate, and for operational purposes, including monthly, seasonal, and inter-annual climate predictions.

Climate scenario: A plausible and often simplified representation of the future climate, based on an internally consistent set of climatological relationships that has been constructed for explicit use in investigating the potential consequences of anthropogenic climate change, often serving as input to impact models. Climate projections often serve as the raw material for constructing climate scenarios, but climate scenarios usually require additional information such as about the observed current climate.

Coping with climate change: Coping: the use of available skills, resources, and opportunities to address, manage, and overcome adverse conditions, with the aim of achieving basic functioning in the short to medium term. Coping is typically used to refer to ex-post actions, while adaptation is normally associated with ex-ante actions. This implies that coping capacity also refers to the ability to react to and reduce the adverse effects of experienced hazards

Environmental sanitation: A range of interventions designed to improve the management of excreta, sullage, drainage and solid waste (WSSCC and WHO 2005).

Exposure: The presence of people, livelihoods, species or ecosystems, environmental functions, services, and resources, infrastructure, or economic, social, or cultural assets in places and settings that could be adversely affected.

Hazard: The potential occurrence of a natural or human-induced physical event or trend or physical impact that may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, ecosystems, and environmental resources. In this document, the term *hazard* usually refers to climate-related physical events or trends or their physical impacts.

Hygienic sanitation: the term “hygienic latrine” is commonly used in Vietnam and is regulated by VIHEMA (Vietnam Health and Environmental Management Agency-MoH) based on the officially approved “hygienic types of latrines”. The Vietnamese standards exclude pit latrines as a “hygienic” latrine; therefore there are disparities in terms of hygienic vs. improved sanitation coverage. While the hygienic sanitation coverage in 2011 was 55%, the improved sanitation coverage was 67% (WB, 2014).

Impacts: Effects on natural and human systems. In this document, the term *impacts* is used primarily to refer to the effects on natural and human systems of extreme weather and climate events and of climate change. Impacts generally refer to effects on lives, livelihoods, health, ecosystems, economies, societies, cultures, services, and infrastructure due to the interaction of climate changes or hazardous climate events occurring within a specific time period and the vulnerability of an exposed society or system. Impacts are also referred to as *consequences* and *outcomes*. The impacts of climate change on geophysical systems, including floods, droughts, and sea-level rise, are a subset of impacts called physical impacts.

Improved drinking-water sources: Piped household water connection located inside the user’s dwelling, plot or yard. Public taps or standpipes, tube wells or boreholes, protected dug wells, protected springs or rainwater collection (UNW-DPAC website)

Improved sanitation: An improved sanitation facility is one that hygienically separates human excreta from human contact and can consist of one of the following facilities: Flush/pour.flush.to piped sewer system, septic tank, pit latrine; Ventilated improved pit latrine; Pit latrine with slab; Composting toilet (UNW-DPAC website). In Vietnam, many stakeholders use the term "hygienic latrine" that excludes pit latrines, as according to the Vietnamese standards those types of infrastructures are not considered as "hygienic" (note of the author).

Latrine: In this document the author will use indistinctly latrine or toilet.

Mitigation: Mitigation refers to the reduction of the rate of climate change via the management of its causal factors (the emission of greenhouse gases from fossil fuel combustion, agriculture, land use changes, cement production, etc.)

Resilience: The ability of a system and its component parts to anticipate, absorb, accommodate, or recover from the effects of a potentially hazardous event in a timely and efficient manner, including through ensuring the preservation, restoration, or improvement of its essential basic structures and functions

Return period: An estimate of the average time interval between occurrences of an event (e.g., flood or extreme rainfall) of (or below/above) a defined size or intensity.

Risk: The potential for consequences where something of value is at stake and where the outcome is uncertain, recognizing the diversity of values. Risk is often represented as probability of occurrence of hazardous events or trends multiplied by the impacts if these events or trends occur (UNDP,2014). Risk results from the interaction of vulnerability, exposure, and hazard (UNDP,2014; ICEM, 2013). In this document, the term *risk* is used primarily to refer to the risks of climate-change impacts and is the result of interaction of hazard per vulnerability.

Runoff: That part of precipitation that does not evaporate and is not transpired, but flows through the ground or over the ground surface and returns to bodies of water.

Sanitation: Sanitation is access to, and use of, excreta and wastewater facilities and services that ensure privacy and dignity, ensuring a clean and healthy living environment for all (UNW-DPAC website). In this document, when referring to sanitation the author might also refer to hygiene that is usually included as part of the term "environmental sanitation".

Sanitation facilities and services: Include the 'collection, transport, treatment and disposal of human excreta, domestic wastewater and solid waste and associated hygiene promotion' to the extent demanded by the particular environment conditions. (UNW-DPAC website)

Uncertainty: An expression of the degree to which a value or relationship is unknown. Uncertainty can result from lack of information or from disagreement about what is known or even knowable. Uncertainty may originate from many sources, such as quantifiable errors in the data, ambiguously defined concepts or terminology, or uncertain projections of human behaviour. Uncertainty can therefore be represented by quantitative measures, for example, a range of values calculated by various models, or by qualitative statements, for example, reflecting the judgment of a team of experts.

Vulnerability: The propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt.

Vulnerability of infrastructures: In this document the term vulnerability of infrastructures is based on ICEM methodology (ICEM, 2009) and adapted to the WASH sector. Vulnerability of infrastructures is a factor of extension (the magnitude/size of the infrastructure), physical vulnerability of the assets, and copying capacity.

viii. List of abbreviations

ADB	Asian Development Bank
CAM	Climate Change Adaptation Methodology (developed by ICEM)
CC	Climate Change
CCA	Climate Change Adaptation
CCFSC	Central/Committee for Flood and Storm Control
CO2	Carbon dioxide
DARD	Department of Agriculture and Rural Development (provincial level)
DoC	Department of Construction (provincial level)
DOET	Department of Education and Training (provincial level)
DoH	Department of Health (provincial level)
DONRE	Department of Natural Resources and Environment (provincial level)
DoT	Department of Transportation
DPC	District People´s Committee
DoT	Department of Transportation
DRR	Disaster Risk Reduction
EU	European Union
EC	European Commission
EMG	Ethnic Minority Groups
GCM	Global Climate Model
GDP	Gross Domestic Product
GIS	Geographic Information Systems
IPCC	Inter-governmental Panel on Climate Change
IWRM	Integrated Water Resources Management
JMP	Joint Monitoring Programme from WHO and UNICEF
MARD	Ministry of Agriculture and Rural Development
MDGs	Millennium Development Goals

MoC	Ministry of Construction
MOET	Ministry of Education and Training
MoH	Ministry of Health
MONRE	Ministry of Natural Resources and Environment
MoT	Ministry of Transportation
M&E	Monitoring and Evaluation
NC	National Communication (on Climate Change)
NGO	Non Governmental Organization
OD/ODF	Open Defecation / Open Defecation Free
OECD	Organization for Economic Cooperation and Development
PPC	Provincial People´s Committee
RCM	Regional Climate Model
SDC	Swiss Development Cooperation
SLR	Sea Level Rise
SNV	SNV-Netherlands Development Organisation (NGO)
SREX	Special Report on Extreme Events (from IPCC)
UNDP	United Nations Development Program
UNDP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
VEI	Vitens Evides International (Dutch water utility)
VWU	Vietnam Women´s Union
WASH	Water Sanitation and Hygiene
WHO	World Health Organisation
WB	World Bank
WEDC	Water Environment and Development Centre, Loughborough University

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1 Introduction

> "Over the next decades, it is predicted that billions of people, particularly those in developing countries, will face shortages of water and food and greater risks to health and life as a result of climate change. Concerted global action is needed to enable developing countries to adapt to the effects of climate change that are happening now and will worsen in the future."
>
> United Nations Framework Convention on Climate Change (UNFCCC), 2008

Vietnam is among the countries most heavily affected by the consequences of climate change. Of the 84 coastal developing countries investigated by the World Bank in terms of sea level rise (SLR), Vietnam ranks first in terms of impact on population, GDP, urban extent, and wetland areas, and ranks second in terms of impact on land area (behind the Bahamas) and agriculture (behind Egypt) (WB, 2007). The authors state that the consequences of SLR for Vietnam are "potentially catastrophic" and demand "intermediate planning for adaptation".

According to another study, 10.8% of Vietnam's population, mostly people living in the two river deltas, would be impacted by a SLR of just 1 m (Dasgupta, 2007). According to the IPCC (IPCC, 2007), a 1 m SLR in Vietnam would lead to flooding of up to 20,000 km2 of the Mekong River delta and 5,000 km2 of the Red River delta. In the Mekong River delta alone, more than 1 million people would be directly affected (need of relocation), and around 20 million indirectly affected (affected by floods).

Vietnam ranks fourth behind China, India, and Bangladesh in terms of the absolute number of people living in vulnerable, low elevation coastal zones (LECZ), defined as the contiguous area along the coast that is less than 10 m above sea level. About 43 million Vietnamese, or about 55% of the country's population (38 % of Vietnam's urban population), are living in those LECZ (McGranahan, 2007). This is the highest percentage of all countries worldwide.

Population living in mountainous areas will also be severely affected by the impact of Climate Change. Although the severity of extreme weather events will be less than in coastal areas, the vulnerability is also high. The majority of poor and marginalised groups (ethnic minorities) are located in mountainous areas with limited infrastructures and coping mechanisms.

The Government of Vietnam (GoV) is very concerned about the negative impact of Climate Change, especially in the coastal areas, and has carried out several initiatives to address this issue. Climate Change is discussed at the highest level, and even a National Target Programme to Respond to Climate Change (NTP-RCC) has been put in place. The recent approval of the Mekong Delta Plan (GoV,2013) puts a lot of emphasis on Climate Change Adaptation. However, the real transfer from policies into practices is still an on-going process with limited results.

The impact of climate change over water resources is becoming a greater object of concern. The international literature has plenty of examples on how climatic factors will negatively affect the provision of water supply services, with a special impact on the most vulnerable groups and in developing countries with less resilient infrastructures.

The sanitation sector will be also negatively affected by climate change, however there are fewer examples of the extension of the impact and, what is more important, how to adapt the sector to the challenges of climate change.

In Vietnam, most of the Climate Change Adaptation efforts have been allocated to water resources management in lowland and coastal areas, but most of those efforts address the water used for irrigation (a key sector in the country´s economy). Water supply in the Mekong Delta has received significant attention and several investments have been included in the recent Mekong Delta Plan. However, water supply in other settings, and especially sanitation has been almost neglected both at the policy level and also in the implementation of Climate Change Adaptation (CCA) programmes.

This research aims to analyse how the water and sanitation sector in Vietnam will be affected by climate change and, based on the international practice and some national case studies, propose recommendations on climate change adaptation options.

The research objectives can be summarised as follows:

1. To identify which are the main risks and vulnerabilities that the water and sanitation sector is facing with respect to climate change (chapter 3).
2. To identify lessons from the international practise in climate change adaptation in WASH and what can be applicable for the Vietnamese context (section 4.1).
3. To identify and analyse possible options for climate change adaptation in the WASH sector in Vietnam (section 4.2).
4. To provide some recommendations to decision makers on the priorities and the potential climate change adaptation options (chapter 5).

1.1 Introduction to climate change

The Framework Convention on Climate Change (UNFCCC), in its Article 1, defines Climate Change as: "a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods." (IPCC, 2014)

The fifth assessment report of the Intergovernmental Panel on Climate Change (IPCC WGII AR5) (IPCC, 2014) is the most comprehensive document on Climate Change that currently exists. The document available on IPCC website[2] offers some conclusions on the "state of the art" of climate change research:

- Compared to previous WGII reports, there is a larger body of evidence, knowledge and scientific research about Climate Change effects.
- Climate Change is already happening: The IPCC WGII AR5 report identifies impacts on human systems that can be clearly attributed to climate change.
- Climate change is affecting water resources in terms of quantity and quality. Climate change over the 21st century is projected to reduce renewable surface water and groundwater resources significantly. However, there is no evidence that surface water and groundwater drought frequency has changed over the last few decades, although impacts of drought have increased mostly due to increased water demand (IPCC, 2014).

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[2] Fifth IPCC assessment reports consulted on December 2014 at: http://www.ipcc.ch/report/ar5/wg2/

- Climate change is one of the issues that affect exposure and increase risks. Differences in vulnerability and exposure arise from non-climatic factors and from multidimensional inequalities often produced by uneven development processes. For instance, people who are socially, economically, culturally, politically, institutionally, or otherwise marginalized are especially vulnerable to climate change.
- Extreme weather events are directly related to Climate Change.
- Climate-related hazards exacerbate other stressors, often with negative outcomes for livelihoods, especially for people living in poverty.
- Dealing with uncertainty: Uncertainties about future vulnerability, exposure, and responses of interlinked human and natural systems are large. Predicting future vulnerability, exposure, and response capacity is very complicated due to the number of interacting factors (social, economic, cultural, etc.).

The scientific community is providing more and more evidence of climatic changes in the mean, variability and symmetry of aspects such as temperature and rainfall. Those factors, especially rainfall, have a direct impact on the water and sanitation sector.

Figure 1: Changes of the mean, variability and symmetry. Source: IPPC (SREX), 2012

The" Viet Nam Special Report on Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation," commonly known as SREX Vietnam, was published in 2015 and is the latest and most comprehensive study on the expected impacts of climate change in Vietnam. The document, produced by IMHEM (Institute for Meteorology, Hydrology and Climate Change), involved a multidisciplinary team of scientists and experts for several years.

In general, extreme weather events are more important than averages for the design of water and sanitation infrastructures. In most of the cases, the increase/decrease of average rainfall as a consequence of climate change is lower than the inter-annual variability of rainfall.

Based on that document, the researchers concluded that climate extremes have changed in Viet Nam over the last few decades. However, extreme events are rare, so there are few data to assess those changes. What can be observed is that:

- Number of cold days and nights decreased nationwide
- Number of hot days increased, especially in the North region and in the Central Highlands
- Number of extreme rainfall events increased, especially in Central and South Central regions
- Number of consecutive dry days increased and total precipitation decreased in Northern regions
- No evident variability in the frequency of tropical cyclones, but those with very high intensity increased

The latest climate change predictions for Vietnam included in the RSEX 2015 report estimate:

- Confidence in changes in extremes depends on many factors
- Number of heat waves will increase, especially in the Central Region
- Frequency of heavy rainfall will increase, especially in the South
- Low statistic confidence in change of river flooding because of extremes
- Drought is likely to increase in most climate zones
- Number of typhoons is uncertain but strong typhoons are likely to increase
- Very likely increase in extreme coastal water levels
- Extreme impacts mainly on sectors linked to climate (e.g. water resources)
- Increased exposure is expected to cause higher economic losses (e.g. typhoons), in absence of additional protection measures
- Extreme weather events (disasters) are expected to influence population mobility (e.g. Mekong delta migration)

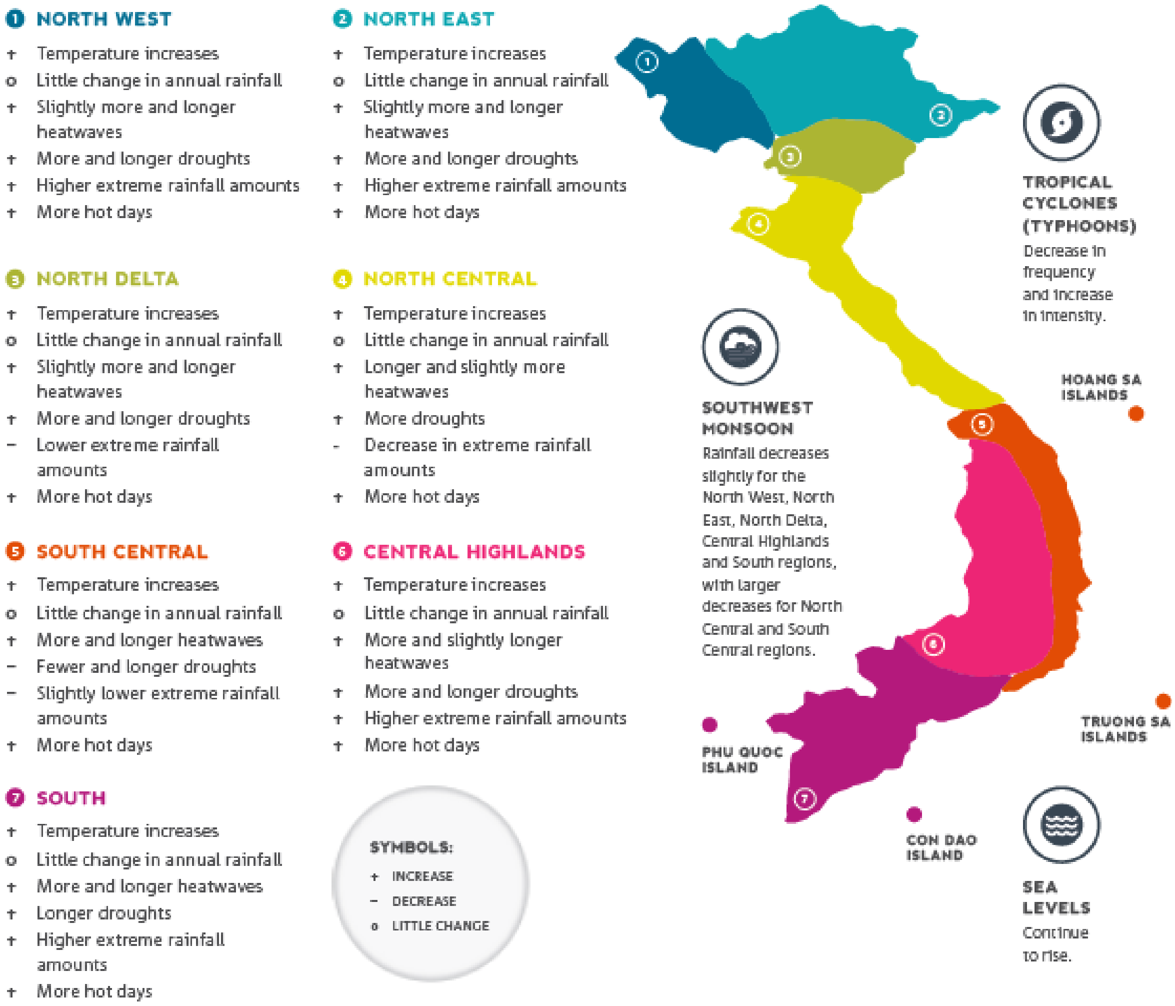

Figure 2: Major projected changes for the seven climatic regions through the 21st century, under the higher greenhouse gas scenario (RCP 8.5). Source: IMHEN, 2014

1.2 Overall analysis of the water and sanitation sector in Vietnam

The country has made remarkable progress in increasing the coverage of water and sanitation, in a context of rapid socio-economic progress, urbanisation, and population growth.

At the moment rural sanitation still lags behind the government plans in comparison with water supply, although in rural water supply there are some problems of functionality of piped water systems. Water and sanitation in small towns still has some deficiencies, especially in comparison with the bigger cities (VIHEMA, 2011).

Climate change threatens that positive trend, especially in lowland areas that are more vulnerable to floods and sea level rise (SLR) and mountainous areas affected by flash floods.

In recent years there has been positive progress in the institutional arrangement and management of WASH services. However, there are still some obstacles that limit the full potential of the structures put in place. Access to finance and limited capacities at sub-national level are among the key barriers identified by the people interviewed.

A culture of subsidy, where the government subsidizes construction of toilets in rural areas or the cost of water supply in most of urban and rural areas, compromises the sustainability of the services. That prevents potential private sector investment; as in many cases local governments set low tariffs for water and sanitation to gain political support and/or to help the poor. However, in the long term, these aspects consume a significant portion of sector investment in a critical moment where investments might be more needed in strategic and long-term plans (author´s opinion).

A better management of water resources is one of the pending tasks in the country. IWRM is very inefficient, and the country lacks functional river basin authorities that contribute to order in the use and priorities of water resources, which are expected to be more and more difficult to manage. This is critical in a context where extreme weather events, both floods and droughts, are expected to be more frequent and intense.

Annex 2 provides an overview of the water and sanitation sector in Vietnam.

1.3 Overall analysis of the policy framework

The analysis of the policy framework shows that, in general terms, Vietnam possesses a strong institutional framework and a solid policy framework.

With respect to climate change adaptation, many strategies and action plans have been developed over the last years. These documents cover from overall strategies, to sector-specific action plans, and involve institutions at the national level (e.g. multi-ministerial committees) all the way down to the city level.

These initiatives have been promoted either by the government, or by development partners (e.g. USAID, UNDP); and in some cases (e.g. Mekong Delta Plan) have involved a large variety of different stakeholders (e.g. ministries, provincial authorities, unions, research centres, communities) for the development.

The government has set up a National Target Programme to Respond to Climate Change (NTP-RCC), and both international donors and state budgets are contributing to fund some key initiatives.

However, finance might be the main limiting factor to further development and practical implementation of those plans. In the case of the “Action Plan on Disaster Risk Management and Climate Change Adaptation in Rural Water Supply and Sanitation in Dien Bien province” the budget proposed is completely unrealistic, even considering additional external funding.

So far, there has been limited implementation of these strategies and action plans. According to some sources consulted during the fieldwork phase, actual implementation and budget allocation of NTP-RCC is low; and in many cases the strategies and action plans are “just a document on a bookshelf” (expression used by one of the informants), but with no real implementation.

Nevertheless, most of these strategies and documents have been recently approved, and there seems to be some agreement among decision/policy makers that some actions are needed to address the challenges of climate change. Therefore, Vietnam seems to have excellent conditions for starting the implementation of climate change adaptation on a large scale.

Annex 3 includes an overview of some policy documents that regulate the water and sanitation sector and climate change adaptation in Vietnam.

2 Methodology

2.1 Introduction

The author lived in Vietnam for almost 5 years. During this time, he mostly worked as a WASH expert in the development sector. Early in 2014, he was involved as international expert in a climate change adaptation project in another sector. Both experiences motivated him to combine his main expertise in the WASH sector with his newly acquired experience in climate change in Vietnam, in the belief that there was very limited considerations of climate change adaptation in the WASH sector, and with the aim of contributing to better understand the links between climate change and the WASH sector.

The research objectives can be summarised as follows:

1. To identify the main risks and vulnerabilities that the water and sanitation sector is facing with respect to climate change.
2. To identify lessons from the international practise in climate change adaptation in WASH and those that can be applicable in the Vietnamese context.
3. To identify and analyse possible options for climate change adaptation in the WASH sector in Vietnam.
4. To provide some recommendations to decision makers on the priorities and the potential climate change adaptation options.

The key research questions that were identified at the beginning of the study are:

- What are the most vulnerable areas and sub-sectors (e.g. water or sanitation) with respect to climate change and what are the expected impacts in the water and sanitation sector.
- What has been done so far with respect to climate change adaptation in the water and sanitation sector, both in Vietnam and internationally
- What are the expected impacts and potential adaptation measures in some case studies that could be representative of the sector, including both rural and urban and both water and sanitation.

2.2 Detailed approach

In order to respond to these research questions, the following approach was developed:

Preliminary stages

As a preliminary stage before developing the research proposal, a rapid literature review was carried out.

At the same time the author carried out some preliminary interviews with resource people. The preliminary meetings allowed the author to better orient the scope of the research and to identify other resource people/organisations, as well as some key documentation.

Literature review

The literature review has been an important part of this research dissertation, and has taken place in the preliminary stages, during the field data collection, and also during the analysis and development of the document.

References on the extended documentation can be found on annex 8, and are related to the following key topics:

1. General information about climate change impact scenarios and its consequences for Vietnam
2. General information about the water and sanitation sector in Vietnam
3. General information about climate change adaptation in Vietnam and the main government policies and strategies
4. International practice in climate change adaptation in the water and sanitation sector
5. Information and experiences about climate change adaptation in the WASH sector in Vietnam
6. Research methodologies and tools on climate change vulnerability analysis, and climate change adaptation, with special emphasis on water and sanitation infrastructures and considering also social and environmental aspects.

There is a lot of information related to climate change adaptation (CCA). A Google search of the term “climate change adaptation” shows more than 78 million entries; and narrowing to “climate change adaptation WASH” it reduces the number to over half a million entries. However, most of the existing information on CCA is very general, and there is far less literature on practical implementation of CCA.

Besides a general search on the Internet (using Google, Google Academic and the Library Catalogue Plus of Loughborough University), some of the most interesting documents and areas of interest have been proposed by the resource people interviewed.

In some cases, those resource people have shared unpublished documents, or even internal documents.

In depth interviews

The key resource people interviewed have represented an invaluable source of information and have contributed to orient the research.

The interviews have included a variety of stakeholders: government officials from three ministries (MARD, MoC, MONRE), UN Agencies (UNICEF, WHO and UNDP), Universities (NUCE-IESE, University of North Carolina, CSIRO and Dragon Institute), NGOs (Plan International, Oxfam, Care), private companies (VEI), cooperation agencies (GIZ, JICA and Finish Cooperation) and development banks (World Bank and Asian Development Bank). A detailed list of the experts interviewed is provided in annex 6.

The type of interview was semi-structured, allowing new ideas and questions to be raised during the interview. The interview questions were prepared in advance, and followed a similar structure in most of the cases, however specific questions were adapted to the interlocutor; and in some cases the limited time allowed a focus on only a few key questions. A copy of the questionnaire used is available on annex 7.

Case studies

Case studies have been included to document some climate change adaptation actions currently taking place in the country, as well as some examples that could help to dimension the challenges of climate change implementation.

The document includes 10 case studies from Vietnam and also from other countries, which can contribute to highlight certain technological solutions or barriers. In some cases, those case studies are based on previous knowledge that the author had of the area of focus, while in other cases the information is based on secondary sources.

In November 2014, the author participated in a 3-day seminar on “Water Utilities and the Challenges of Climate Change” organized by Vitens Evides International – a Dutch firm- in the Mekong Delta. That seminar included two field visits that have been incorporated as cases studies in the document.

Data analysis

In total 25 people were interviewed from 19 different organisations. Most of them occupy senior positions and in some cases shared personal opinions that do not necessarily represent the official position of the organisation they represent. In order to preserve the confidentiality of some of those opinions, and to avoid potential misunderstandings, the references to interviewees do not include names or organisations, but a generic mention to the type of organisation (e.g. according to one government official). For that same reason, the transcription of those interviews is not included in the research dissertation in order to preserve confidentiality of the sources.

Information from the interviews was mostly qualitative, therefore the student carried out a basic qualitative data analysis. Considering the size of the population, the student did not use any specific software for data analysis. In all cases, information from informants was also triangulated with information collected from other informants or other sources (e.g. literature review).

2.3 Risk assessment and ethical issues

One of the biggest challenges and risks identified at the beginning of the research was the access to information. The author had an existing network of contacts, but was not sure if people would be willing to be interviewed and share data with “just a student”.

In general terms, the Vietnamese government agencies are very reluctant to disseminate information, especially with foreigners. Some information, especially at the local level, is only available in Vietnamese language and/or in hard copies, making it difficult to access. The ability to get access to official data was identified as a main determinant.

At the same time, the initial research proposal raised ethical questions such as: the confidentiality and safety of informants, especially low rank officials and villagers, in a still relatively totalitarian system, the security clearance to carry out field visits in rural areas by a foreigner, and the payment of some people to be interviewed at local level (as is the custom in the country).

Those issues were overcome as follows:

- The student was able to interview a relevant group of key resource people at the national level, both from the government and also from international organisations, that provided very useful information to orient the research, and facilitated acquisition of unpublished documents and additional data. The interview of people at national level, including government officials, did not represent any risk or ethical issue.

- The main source of "field data" were the interviews carried out at national level, the participation in a workshop on climate change adaptation in the water sector in the Mekong, and the accumulated knowledge of almost 5 years of work in the country.
- Given the information collected from the national level, and the scope of the research, the information that would have been collected at local level, would have had limited added value and representativeness.

2.4 Timeframe and process

The preliminary contacts with potential research people and the initial literature review were conducted from September to October 2014.

A significant part of the literature review was conducted during November, as well as the participation in the 3-days seminar on "Water Utilities and the Challenges of Climate Change".

The in-depth interviews were mostly conducted from November until February 2015; and data analysis and writing was done from April until August 2015.

The document follows a structure similar to the development of the work. The author started with an overall analysis of the water and sanitation sector, as well as with an analysis of the policy and legal framework.

That initial analysis showed a significant progress being made by Vietnamese government at the policy level. For that reason, the author continued it's study analysing the vulnerability of water and sanitation infrastructures in Vietnam, in order to identify potential areas of improvement and further recommendations to the decision makers (4th objective of the research).

The vulnerability analysis of water and sanitation infrastructures, followed CAM methodology developed by ICEM, an Australian firm specialized in climate change adaptation in infrastructures. The process of analysis is detailed in annex 5, and provided some interesting findings that oriented the focus of the research on potential options to adapt to climate change.

One of the initial assumptions of the author was that coastal areas had received too much attention and funding in comparison with other areas that might be at least as vulnerable as the coast. However, the vulnerability analysis demonstrated that floods and sea level rise are key hazards, therefore the author focused the review of literature, case studies, and proposed options, to those aspects that can better contribute to reduce vulnerability towards those hazards.

For that part, the author started with a review of international literature on how other countries cope with climate change, and how those countries adapt their water and sanitation services to the challenges of CC. Section 4.1. provided general recommendations and also new insights to orient the last step.

Section 4.2. included a compendium of potential options to adapt to climate change in Vietnam. The structure of that section highlights not only structural solutions, but also non-structural solutions and some recommendations at policy level.

The solid policy framework identified during the early stages of the research, both by the literature review and by the interviews, lead the author to spend less time on that part and to focus on structural and non-structural options.

The identification of those options has three sources; interviews, literature review and authors own reflections. However in most of those cases, the identification and inclusion of those options is the result of a combination of those three sources. For example, an informant raises one issue that the author deepens in the literature review and adds some recommendations based on his own knowledge or experience.

3 Vulnerability assessment of the water and sanitation services

Vulnerability, in the context of climate change and according to the IPCC definition, is an integrated measure of the expected magnitude of adverse effects to a system caused by a given level of certain external stressors. This definition includes an external dimension, which is represented by the 'exposure' of a system to climate variations, as well as an internal dimension, which comprises its "'sensitivity' and its 'adaptive capacity' to these stressors (IPCC, 2001).

There are different methodologies and options to evaluate vulnerability. However, when considering the impact of climate change on infrastructures and services such as water and sanitation, the menu of alternatives for carrying out a risk/vulnerability analysis is drastically reduced.

The methodology chosen to analyse the vulnerability of water and sanitation services is the Climate Change Adaptation Methodology *(CAM). That methodology has been developed by the International Centre on Environmental Management (ICEM),* an Australian firm specialized in climate change adaptation in the field of infrastructures in developing countries.

The CAM impact and vulnerability assessment process includes six steps as shown in the figure below.

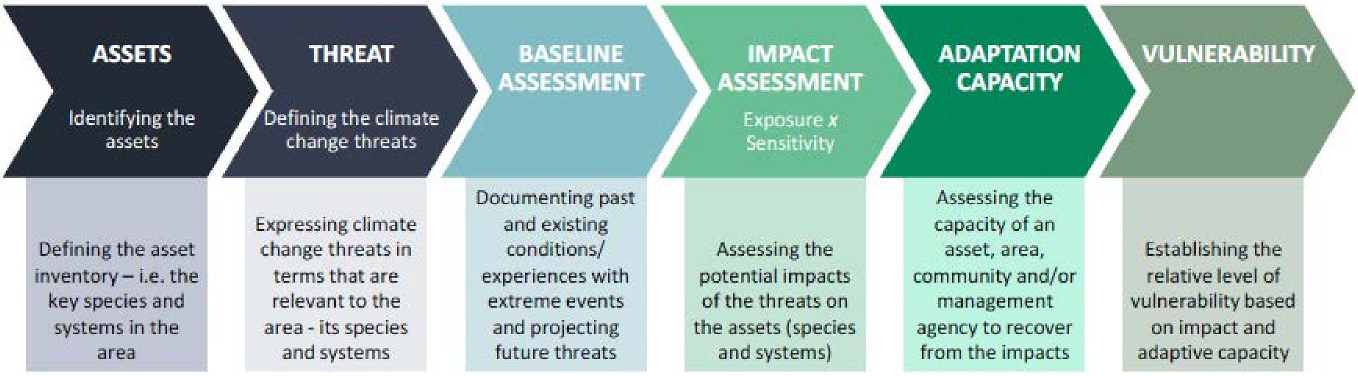

Figure 3: The CAM impact and vulnerability assessment process. Source: ICEM, 2013

Based on the CAM methodology, the author has carried out an analysis of the different water and sanitation assets for Vietnam. The table below summarizes the exposure, sensitivity, impact, adaptive capacity and overall vulnerability, of a variety of assets. Those assets, or components of water and sanitation infrastructures, are susceptible to impact by different climate change-related threats, such as floods, droughts, typhoons, heat waves or sea level rise.

Threat	Asset	Exposure	Sensiti-vity	Impact level	Adaptive capacity	Vulnera-bility
Floods	Surface water from springs or small rivers except in coastal areas)	H	H	H	VL	VH
	Surface water from dams or big rivers (except in coastal areas)	H	VH	VH	VL	VH
	Surface water from rivers in coastal areas	VH	VH	VH	VL	VH
	Groundwater in coastal areas affected by seawater intrusion and subsidence (e.g. Mekong Delta)	VH	VH	VH	VL	VH
	Groundwater in other areas (not in the coast or lowland areas)	M	H	M	L	M
	Treatment plants (except in coastal areas)	H	H	H	L	H
	Treatment plants in coastal areas	H	H	H	L	H
	Household and community water supply systems (e.g. wells, handpumps, community water supply schemes)	H	H	H	L	H
	Household and community water supply systems (e.g. wells, handpumps, community water supply schemes) in coastal areas	H	H	H	L	H
	Large scale distribution systems (urban)	VL	M	L	L	M
	Large scale distribution systems (urban) in coastal areas	L	M	M	L	M
	On-plot sanitation (rural or urban)	VH	M	VH	L	VH
	On-plot sanitation (rural or urban)in flooded areas	VH	M	VH	L	VH
	City sewerage (either combined or separate)	VH	M	VH	L	VH
	City sewerage (either combined or separate) in coastal areas	VH	M	VH	L	VH
	Wastewater treatment plants (except in coastal areas)	VH	M	VH	L	VH
	Wastewater treatment plants in coastal (or low-land) areas	VH	M	VH	L	VH
Drought s	Surface water from springs or small rivers except in coastal areas)	M	H	M	VL	H
	Surface water from dams or big rivers (except in coastal areas)	L	M	M	VL	H
	Surface water from rivers in coastal areas	M	H	M	VL	H
	Groundwater in coastal areas affected by seawater intrusion and subsidence (e.g. Mekong Delta)	M	H	M	VL	H
	Groundwater in other areas (not in the coast or lowland areas)	L	M	M	VL	H
	Treatment plants (except in coastal areas)	L	VL	L	L	M
	Treatment plants in coastal areas	L	VL	L	L	M
	Household and community water supply systems (e.g. wells, handpumps, community water supply schemes)	VL	L	VL	L	M
	Household and community water supply systems (e.g. wells, handpumps, community water supply schemes) in coastal areas	VL	L	VL	L	L
	Large scale distribution systems (urban)	VL	M	L	H	L
	Large scale distribution systems (urban) in coastal areas	VL	M	L	H	L
	On-plot sanitation (rural or urban)	M	L	M	L	M
	On-plot sanitation (rural or urban) in flooded areas	M	L	M	L	M
	City sewerage (either combined or separate)	M	L	M	L	M
	City sewerage (either combined or separate) in coastal areas	M	L	M	L	M
	Wastewater treatment plants (except in coastal areas)	M	L	M	L	M
	Wastewater treatment plants in coastal (or low-land) areas	M	L	M	L	M
Thypho ons	Surface water from springs or small rivers except in coastal areas)	VL	VL	VL	L	L
	Surface water from dams or big rivers (except in coastal areas)	VL	VL	VL	L	L
	Surface water from rivers in coastal areas	L	VL	L	L	M
	Groundwater in coastal areas affected by seawater intrusion and subsidence (e.g. Mekong Delta)	L	VL	L	L	M
	Groundwater in other areas (not in the coast or lowland areas)	VL	VL	VL	L	L
	Treatment plants (except in coastal areas)	L	L	L	L	M
	Treatment plants in coastal areas	M	L	M	L	M
	Household and community water supply systems (e.g. wells, handpumps, community water supply schemes)	L	L	L	L	M

	Household and community water supply systems (e.g. wells, handpumps, community water supply schemes) in coastal areas	M	L	M	L	M
	Large scale distribution systems (urban)	L	L	L	H	L
	Large scale distribution systems (urban) in coastal areas	L	L	L	H	L
	On-plot sanitation (rural or urban)	L	L	L	L	M
	On-plot sanitation (rural or urban) in flooded areas	L	M	M	H	M
	City sewerage (either combined or separate)	L	VL	L	H	L
	City sewerage (either combined or separate) in coastal areas	L	L	L	M	M
	Wastewater treatment plants (except in coastal areas)	L	VL	L	M	M
	Wastewater treatment plants in coastal (or low-land) areas	L	L	L	M	M
Heat waves	Surface water from springs or small rivers except in coastal areas)	VL	VL	VL	L	L
	Surface water from dams or big rivers (except in coastal areas)	L	VL	L	L	M
	Surface water from rivers in coastal areas	VL	M	L	L	M
	Groundwater in coastal areas affected by seawater intrusion and subsidence (e.g. Mekong Delta)	VL	M	L	L	M
	Groundwater in other areas (not in the coast or lowland areas)	L	VL	L	L	M
	Treatment plants (except in coastal areas)	VL	M	L	H	L
	Treatment plants in coastal areas	VL	M	L	H	L
	Household and community water supply systems (e.g. wells, handpumps, community water supply schemes)	VL	M	L	H	L
	Household and community water supply systems (e.g. wells, handpumps, community water supply schemes) in coastal areas	VL	M	L	H	L
	Large scale distribution systems (urban)	VL	L	L	H	L
	Large scale distribution systems (urban) in coastal areas	VL	L	L	H	L
	On-plot sanitation (rural or urban)	VL	M	L	H	L
	On-plot sanitation (rural or urban) in flooded areas	VL	M	L	H	L
	City sewerage (either combined or separate)	VL	M	L	H	L
	City sewerage (either combined or separate) in coastal areas	VL	M	L	H	L
	Wastewater treatment plants (except in coastal areas)	VL	VL	VL	H	L
	Wastewater treatment plants in coastal (or low-land) areas	VL	VL	VL	H	L
Sea Level Rise	Surface water from springs or small rivers except in coastal areas)	VL	VL	VL	L	L
	Surface water from dams or big rivers (except in coastal areas)	VL	VL	VL	L	L
	Surface water from rivers in coastal areas	VH	VH	VH	L	VH
	Groundwater in coastal areas affected by seawater intrusion and subsidence (e.g. Mekong Delta)	VH	VH	VH	L	VH
	Groundwater in other areas (not in the coast or lowland areas)	VL	VL	VL	L	L
	Treatment plants (except in coastal areas)	VL	VL	VL	H	L
	Treatment plants in coastal areas	VH	VH	VH	L	VH
	Household and community water supply systems (e.g. wells, handpumps, community water supply schemes)	VL	VL	VL	H	L
	Household and community water supply systems (e.g. wells, handpumps, community water supply schemes) in coastal areas	VL	VL	VL	H	L
	Large scale distribution systems (urban)	VL	VL	VL	H	L
	Large scale distribution systems (urban) in coastal areas	H	M	H	H	M
	On-plot sanitation (rural or urban)	VL	VL	VL	H	L
	On-plot sanitation (rural or urban) in flooded areas	H	M	H	M	H
	City sewerage (either combined or separate)	VL	VL	VL	H	L
	City sewerage (either combined or separate) in coastal areas	H	H	H	L	H
	Wastewater treatment plants (except in coastal areas)	VL	VL	VL	H	L
	Wastewater treatment plants in coastal (or low-land) areas	H	H	H	L	H

Table 1: Summary of the vulnerability assessment by hazard. Source: author

Legend: VL (very low), L (Low), M (Medium), H (High), VH (Very High). For more details consult annex 5.

Annex 5 includes a description of the CAM methodology and the results obtained for each asset. The objective of this exercise is to identify the key elements that make water and sanitation infrastructures vulnerable to climate change, and to identify which components of those infrastructures (assets) or threats are more particularly relevant.

The vulnerability analysis is a generalisation of types of infrastructures that can be found in Vietnam, therefore the results have to be considered in general, as each infrastructure should be evaluated individually to determine the level of vulnerability towards climate change.

However, some interesting conclusions can be extracted. In general terms, floods and sea level rise (SLR) are the main hazards to water and sanitation infrastructures. Floods affect significantly (High or Very High) to almost all types of infrastructures, in terms of exposure and sensitivity, that leads to a high to very high impact levels and contributes to high to very-high overall vulnerabilities.

Similar results are obtained in some water infrastructures located in coastal areas, such as surface water intakes from rivers, groundwater and treatment plants. However, in those areas the adaptive capacity is, in general terms, higher than in other geographical regions, due to the higher concern of climate change and sea level rise that leaded to higher investments.

The levels of exposure, sensitivity and impact are quite high in general for most of the assets analysed, with “low” and “very low” adaptive capacities in general. The combination of relatively high impact with low coping mechanisms contribute to increase vulnerability of most of the types of infrastructure analysed.

The results of this vulnerability analysis present an interesting finding, as they highlight the Mekong Delta and low land areas affected by SLR and floods as the most vulnerable areas to climate change. This is also the perception of most of people interviewed, however it differs from other (general) vulnerability assessments carried out in the past (e.g. Wilderspin & Le Dang, 2013) which tend to highlight the Northern Mountainous provinces and the Central Highlands, where poverty levels are higher, as the most vulnerable areas. The author agrees that poverty is a significant factor that reduces adaptive capacities and coping mechanisms, however, in the specific case of water and sanitation infrastructures, those factors are less determinant than the threats or the levels of exposure.

4 Proposed options to adapt to climate change

4.1 Literature review on what we can learn from the international experience

4.1.1 General climate change adaptation recommendations

From the review of literature, some commonalities can be found from the analysis of climate change adaptation into national and WASH sector strategies:

1. **Dealing with uncertainty**

Planning long-term adaptation measures without solid data is not feasible, and both policy makers and design engineers need to be well informed about the implications of climate change. However, section 1.1 and annex 4 of this document already evidence the difficulties of making proper estimations of future climate change scenarios. In Vietnam, where engineers are used to following clear guidelines and instructions, dealing with additional levels of uncertainty might represent an additional difficulty.

2. **Long-term implications in a long-term adaptation process**

Climate Change Adaptation (CCA) measures have to be considered as part of an evolving environmental and socio-economic process. Most water and sanitation infrastructures are expected to have a long lifespan, and are built gradually, therefore the design process has to consider a long-term perspective and anticipate future scenarios.

On the other side, lacking anticipation of long-term changes can cause additional expenditures (e.g. upgrading infrastructures that have not considered the impact of more frequent and extreme weather events). Infrastructures can become obsolete before their expected lifespan if they have not been designed taking into consideration future CC scenarios.

3. **Cross-cutting prospective with proper coordination between actors**

CCA requires a cross-cutting approach that affects a variety of policy areas and stakeholders. From national strategies to sector-specific strategies and plans the process of CCA requires a holistic and multidisciplinary approach. For instance, in the Netherlands, Integrated Water Resources Management (IWRM) involves a variety of sectors, from land planning and urban development, to irrigation, communications, water supply and sanitation, or environmental protection. Understanding the specificities and needs of each sector and the balance between different groups of interest requires a proper coordination mechanism.

Great Britain follows a coordinated approach that covers almost all policy areas and involves all key actors (Meister, 2009). CCA in Great Britain focuses on integrating adaptation policy into the general political process (e.g. adaptation is considered in the government investment process and in the evaluation of municipalities). The British government set up an information and coordination centre that brings together academia and policy-makers. That centre provides municipalities with analysis and assessment tools that help them estimate the risk of climate change and plan the appropriate adaptation measures.

Successful CCA strategies involve a large group of actors. Among those group of actors the IPCC (IPCC, 2014) put emphasis on:

- National governments who can coordinate adaptation efforts of local and subnational governments, for example, by safeguarding vulnerable groups, by providing information, policy and legal frameworks, and by financially supporting infrastructure investments.
- Local governments, who are increasingly recognized as critical to progress in adaptation, given their roles in scaling up adaptation of communities, households, and civil society and in managing risk information and financing.
- Organizations bridging science and decision-making, including climate services, play an important role in the communication, transfer, and development of climate-related knowledge, including translation, engagement, and knowledge exchange.
- Engagement with local communities and the private sector is crucial to developing adaptation actions that will work best on the ground.

4. Local implementation to fight against a global problem

While global warming is caused by the accumulated impact of local actions, climate change adaptation can also start at local level.

Adaptation to climate change is not only a national issue. In countries like the USA, Spain or Australia, regional governments are developing their own local CCA plans. Even big metropolises like London, Chicago or New York have their own climate change adaptation strategies in which they combine raising awareness, adaptation and mitigation measures.

5. Local implementation has to be context specific

According to the fifth IPCC report (IPCC, 2014), adaptation is place and context specific, with no single approach for reducing risks appropriate across all settings.

Effective risk reduction and adaptation strategies consider the dynamics of vulnerability and exposure and their linkages with socioeconomic processes, sustainable development and climate change.

During the search process, the student has confirmed that statement. Many adaptation measures carried out in third countries have limited applicability to the context of Vietnam.

Developed countries with good infrastructures tend to put less emphasis on the upgrade of infrastructures (hardware) and focus more on “software” options (e.g. raising awareness among population on efficient use of water, especially during droughts).

6. Starting with no-regret, low-regret and win-win measures

Some adaptation measures can be costly and/or can be criticized by actors negatively affected by those measures (e.g. land use policy changes). Focusing on no-regret, low-regret and win-win measures provide decision makers with a more interesting approach to carry out decisive actions.

- No-regrets are actions that will pay off immediately under the current climate conditions, such as changing the water supply source of a city or upgrading an old infrastructure.
- Low-regrets are actions that have potentially large benefits. An example would be if the upgrade of the infrastructure contributes to prevent floods.
- Win-win actions are those that help to tackle several risks/benefits at once. For instance, using surface water instead of groundwater in the Mekong Delta, which contributes to reduce subsidence and at the same time provides an alternative source that is less vulnerable to saltwater intrusion.

In general terms, developed countries have more resilient infrastructures than developing countries. Infrastructures that were designed with high margins of security might cope better with the effects of climate change and/or other unexpected/unknown hazards.

Taking into consideration the high level of uncertainty, some countries have decided to minimize risks to levels that might not be justified from the existing scientific knowledge on climate change. Korea changed their dam safety code followed by a typhoon episode that seriously damaged and compromise the stability of a dam. In that case, the decision on increasing the level of safety was a political decision criticized by some scientist that considered it to be excessive because of the economic implications of the measure (Kim, 2010).

Other countries, such as Switzerland are also changing their focus from disaster management to preventative measures. In the UK the government is not only analysing the impact of single infrastructures, but cascade of failures that can lead to major damages (e.g. a dam destroying a road downstream).

In other cases, such as in Copenhagen, their risk and cost-benefit analysis suggest that is better to oversize the drains today than to replace the entire city drainage network[3].

7. **Looking on the bright side as well**

Climate change represents a threat for most countries, however a wider perspective might also identify opportunities. For instance, Finland is expected to experience both risks and opportunities as a consequence of climate change. Compared to other countries, and because of the high level of resilience of its infrastructures, the need for action in Finland is limited to a small number of areas (Meister, 2009).

As a middle-income country, Vietnam is facing a gradual phase up of Official Development Assistance (ODA). Climate funding could be a good opportunity for accessing new modalities of ODA that can contribute to maintain, or even increase ODA.

8. **Climate changes, but societies and the environment will also do so**

The development of adaptation measures must take into account future environmental and socio-economic scenarios as well as future climate change scenarios. Practitioners need to understand the relevance of a future climate to a future society, rather than to the reality today. Considering realistic socio-economic scenarios are required to provide a framework for adaptation decision-making for practitioners.

9. **Governments, even in developed countries, are slow on real integration of CCA into their policies.**

Several countries have identified adaptation options, however the operationalization of CCA into strategies, plans and programs is still very limited (OEDC, 2006; Alvarez-Sala 2014)

Vietnam can be considered among the countries that have more seriously considered the threat of climate change, and are discussing CCA at the highest level. However, as is the case with the majority of countries in the world, still lacks substantial and practical implementation of CCA actions, especially in the WASH sector.

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[3] Copenhagen new city construction codes use run-off figures that are 70% larger than their current level (Arosio, 2012)

10. Adaptation is not only “fighting against” but “coping with”

One of the most remarkable examples of this approach can be found in the Netherlands. Almost half of the country is below sea level, and on reclaimed land. For centuries Integrated Water Resources Management put the emphasis on flood control, rising dikes each time a “historic” flood proved existing infrastructures insufficient. That approach to flood prevention evolved in the 90s from fighting against the rising tide to living with and adapting to it.

Rising sea levels will result in an increased likelihood of flooding, therefore CCA is a matter of national security. The issue has been on the political agenda for many years, especially in the context of water management, costal protection, and land use planning. In 2007, the Netherlands approved its national program for adaptation and the “Delta Commission” was also established in order to develop a flood prevention strategy that identifies those areas that will be affected by controlled floods (Meister, 2009).

11. Reliable data contributes to better adaptation solutions

Cambodia, due to its recent history of conflicts, lacks a proper hydro-meteorological network and enough historic data records to carry out proper climate change predictions. Therefore, even if Cambodia (as Vietnam) is one of the most vulnerable countries to climate change; the country can only rely on General Circulation Models (GCM) and rough estimations of CC impact (source author).

A deficient hydro-meteorological network and unreliable and discontinuous data records impede, for instance, the development of proper early warning system for floods.

12. There are no silver bullets or shortcuts. Even easy solutions might be difficult to implement

While there may be many simple adaptation measures that could theoretically be introduced to address a particular risk or opportunity, these may only be practically possible under certain circumstances.

For example, increasing the size of drains and sewers seems an evident CCA measure. Even if CC was considered in construction codes, replacing the entire network of a city would be impossible in the short term.

13. Use existing and emerging economic instruments

Some countries are using existing and emerging economic instruments that can provide incentives for anticipating and reducing impacts. Those instruments include public-private finance partnerships, loans, payments for environmental services, improved resource pricing, charges and subsidies, norms and regulations, and risk sharing and transfer mechanisms.

Risk financing mechanisms in the public and private sector, such as insurance and risk pools, can contribute to increasing resilience, but without attention to major design challenges, they can also provide disincentives, cause market failure, and decrease equity. Governments often play key roles as regulators, providers, or insurers of last resort (IPCC, 2014).

14. Necessity to start now

The Stern Review (Stern, 2006) pointed out the need to take action now in order to make future risk avoidance more affordable and to minimize the damage of climate impacts to society. For example, if decisions being made now, on water and sanitation infrastructure, fail to take into account the adverse impacts of climate change, the results could be very costly in the long term. The previous example of city drains and sewers demonstrates the importance of considering climate change impact as soon as possible, as WASH infrastructures, especially in urban areas, tend to have a (real) lifespan of more than 50 years.

15. Understand existing vulnerabilities to climate and identify critical thresholds

The need for adaptation is greatest in areas that are already vulnerable to climate risks. Understanding what the vulnerability of a given area is and identifying critical thresholds, such as the maximum rainfall capacity of a storm sewer system, can help determine when and what adaptation actions to undertake. In that sense, the vulnerability analysis carried out in chapter 3 and annex 5, is an attempt to identify those critical elements at the country level, although a proper analysis has to be done case by case.

16. Set up adaptable, flexible and resilient policies and measures

Shaw (2007) recommends setting up adaptable, flexible and resilient policies and measures so places can adapt to a continually changing climate.

By adopting a sequential and risk-based approach to development decision (e.g. when allocating land in development plans or deciding applications for development), decision-makers should demonstrate that there are no reasonable options available in a lower-risk category, consistent with other sustainable development objectives.

It is also important to avoid actions that will make it more difficult to cope with climate risks in the future These are called “adaptation constraining decisions”. One example is inappropriate urban development in a flood risk area.

There is also a need to regularly review the adaptation strategy. Adaptation strategies must be kept under regular review, keeping abreast of new knowledge about climate change and learning from experience. This is particularly important now, as current climate change research still shows has high levels of uncertainty, and it is expected that we will be able to provide more accurate estimations in the future.

17. All countries have similar constraints on implementation

Both developing and developed countries have common constraints on implementation. Some of those constraints include; limited financial and human resources, limited integration or coordination of governance, uncertainties about projected impacts, different perceptions of risks, competing values, absence of key adaptation leaders and advocates, and limited tools to monitor adaptation effectiveness. Another constraint includes insufficient research, monitoring, and observation and the finances to maintain them. Underestimating the complexity of adaptation as a social process can create unrealistic expectations about achieving intended adaptation outcomes (IPCC, 2014)

18. Maladaptation can increase the vulnerability

Maladaptation can increase the vulnerability or exposure in the future, or the vulnerability of other people, places, or sectors. Some near-term responses to increasing risks related to climate change may also limit future choices. For example, enhanced protection of exposed assets can lock in dependence on further protection measures (IPCC, 2014). Another example is CCA interventions that take place upstream and might negatively impact downstream increasing the severity of floods.

4.1.2 Examples of climate change adaptation in the design of water and sanitation infrastructures

As shown above, many countries have developed a policy framework and have carried out research studies to analyse the impact of climate change in the water and sanitation sector. However, there are far less examples of practical implementation of climate change adaptation in the design of water and sanitation infrastructures.

Very few developed countries have upgraded their construction codes taking into consideration climate change. In most cases, those upgrades have considered the precautionary principle included at the Rio Declaration on Environment and Development (DESA, 1992) and have increased the margins of security above what shall be considered as pure climate change adaptation strategy.

Adapting construction codes and standards to climate change has been carried out in only a few developed countries, and it has been limited to only a few codes. Moreover, the criteria used to increase resiliency of infrastructures has very limited scientific proof and is usually justified from a risk aversion prospective.

The additional costs of upgrades of the construction codes for the infrastructure sector might not be assumable in some middle-income countries like Vietnam. Building in redundancy has clear and positive impact in the quality and lifespan of infrastructures, nevertheless that has to be done with a more solid cost-benefit analysis.

There are very limited cases of climate change strategy mainstreaming into construction codes that can be used as an orientation/example for Vietnamese decision makers. The case study below shows how decision makers reacted after an extreme weather event that put water infrastructures at a serious risk. As a consequence, Korea upgraded its code, but for some Korean scientists (Kim, 2003) the new standard was excessive and costly.

Case study 1: CCA of dam safety standards in Korea

In 2002, typhoon Rusa caused 870.5mm/24h (and 100.5mm/hour) rains in Korea. Heavy rain caused partial collapse of embankments and spillways in the Sung-ju irrigation dam (28 HM3). The government changed the previous 200 years of frequency design criterion to the Probable Maximum Flood (PMF) criteria for irrigation dams. That decision almost doubled the size of the spillway and cost USD 12 million for only one single dam.

The decision to upgrade design criteria and reinforce emergency spillways was not intentionally made to adapt to climate change, but eventually it was. The upgrade of design criteria significantly increased the safety level, but also the cost.

Source: Kim, 2003

Another example of building in redundancy can be found in the UK, where climate change considerations are less important than other aspects, such as water safety.

Case study 2: West-East Link pipeline (UK)

In the design of West-East Link pipeline, several aspects such as climate change were considered.

Options were evaluated through a whole life costing and Net Present Value (NPV) approach (which included looking at both a 'standard' discount rate and a discount rate that incorporated environmental and social costs).

The three main CC scenarios were translated into forecasts of river and reservoir flows. Climate change impacts were incorporated into the assessment using a standard methodology. The forecast impact of climate change on water resources suggested a need for a pipeline with a capacity of 60 million litres. However, in response to the security of supply driver, the pipeline was built with a capacity of 100 million litres and is expected to remain fit for purpose for the duration of its 100-year asset life.

The long-term impacts of climate change were not considered in isolation. In this case, adaptation was only one of many drivers for the investment. Security of supply ended up dominating the consideration of the pipeline capacity, with headroom capacity over and beyond that would have been built in if climate change impacts were considered in isolation.

Source: PWC (2010)

Some other countries, such as Denmark, have introduced a **climate change factor** into the design of infrastructures.

Case study 3: Improved drainage standards in Denmark

Drainage design standards in Denmark were revised in 2009. For the design of pipes, culverts, and basins on the most important roads, the minimum return period for critical water levels (e.g. water levels exceeding road pavement level) is set at 25 years. In addition, flood situations demanding full utilization of the cross-sectional area of culverts should not occur more than once a year.

Dimensioning precipitation is based on data series up to 2005. To compensate for increased precipitation in the future, a climate uncertainty factor is introduced. Recommended values for the climate factor originate from guidelines published by the Danish Society of Engineers, Water Pollution Committee (SVK guidelines no. 29). The values are: 1.3 when run-off calculations are based on a 10-year return period and 1.4 for a 100-year period.

Independently of the climate factor, another factor is added, considering uncertainties rising from statistics and methods. This model factor should normally be in the range 1.1–1.5 based on the quality of available data.

Source: CEDR, 2011

4.2 Proposed options for CCA in water supply and sanitation

The proposed options to adapt to climate change in the WASH sector can be organized in three groups: policy, infrastructure level, and other non-structural measures. The following table summarizes the measures proposed for each sub-sector and area, and are described in this section:

	Urban Water	Urban Sanit.	Rural Water	Rural Sanit.	Coastal/ lowland areas	Other areas (not coastal)
Proposed options at policy level						
1. Ensuring proper mechanisms for Integrated Water Resources Management (IWRM) at national, provincial and community level	x	x	x	x	x	x
2. Development of river basin authorities for better water management	x	x	x	x	x	x
3. Better coordination and management for flood and storm control	x	x	x	x	x	x
4. Centralisation versus decentralisation management models	x	x	x	x	x	x
5. Set up water efficiency measures	x		x		x	x
6. Set up water conservation measures	x		x		x	x
7. Control of other water uses, especially agriculture	x		x		x	x
8. Replace water sources in delta and coastal areas	x		x		x	
9. Improve water quality control	x	x	x		x	x
10. Improve urban planning and land planning	x	x	x	x	x	x
11. Climate financing	x	x	x	x	x	x
12. Combine adaptation and mitigation	x	x	x	x	x	x
13. Improve knowledge management on climate change	x	x	x	x	x	x
14. Develop capacities on climate change adaptation	x	x	x	x	x	x
Proposed options at infrastructure level						
1. Climate change adaptation integrated in the design phase	x	x	x	x	x	x
2. Upgrade of construction codes and standards	x	x	x	x	x	x
3. Better consideration of return periods and lifespan of infrastructures	x	x	x	x	x	x
4. Climate proofing infrastructure: building more resilient infrastructures	x	x	x	x	x	x
5. Using innovative technologies and solutions for climate proofing infrastructure	x	x	x	x	x	x
6. Climate proofing infrastructures at household/community level			x	x	x	x
7. Increase storage capacity (in reservoirs, ponds, rainharvesting and underground)	x		x		x	x
8. Coastal protection ditches and other "grey infrastructures"	x	x	x	x	x	
9. Modifying the hydraulics of rivers	x	x	x	x	x	x
10. Managing rainwater through separated drains instead of combined sewer systems		x			x	x

11. Adapting latrine designs for flood prone areas				x	x	
Non-structural options for CCA in the WASH sector						
1. Combining poverty reduction with climate change adaptation	x	x	x	x	x	x
2. Hygiene promotion and vector control		x		x	x	x
3. Early warning systems	x	x	x	x	x	x
4. Improve Operation and Maintenance (O&M) of infrastructures	x	x	x	x	x	x
5. Community Based Disaster Risk Management (CBDRM)			x	x	x	x
6. Water Safety Plans (WSP)	x		x		x	x
7. Raising awareness among population	x	x	x	x	x	x
8. Introduce more flexible approaches	x	x	x	x	x	x
9. Relocation	x	x	x	x	x	

Table 2: List of proposed options at policy level, structural and non-structural, and its use in each sub-sector (e.g. rural water supply) and area (e.g. coastal areas). Source: Author

4.2.1 Proposed options at policy level

Even if, in comparison with other countries, Vietnam possess a solid legal framework, there are some aspects that are required to better adapt to climate change, especially those aspects related to water management.

1. **Ensuring proper mechanisms for Integrated Water Resources Management (IWRM) at national, provincial and community level**

Several people interviewed for this study stated that Vietnam lacks proper mechanisms for Integrated Water Resources Management (IWRM) policy development and (especially) implementation. According to one representative of a development organisation, the “Vietnamese Water Law is there, but there are no teeth, no real capacities to control and manage the water resources”.

The Water Law (Order No. 15/2012/L-CTN of July 2, 2012), is well structured and clear on the roles and responsibilities of government agencies on the planning, control and management of water resources. Most of those responsibilities belong to the Ministry of Natural Resources and Environment (MONRE), however MONRE has limited budget and institutional capacities to fulfil that mandate.

At the provincial level, the Departments of Natural Resources and Environment (DONRE) are understaffed and lack any practical means to carry out their mandate. Even if DONRE officials identify violations of environmental laws, they lack any real jurisdiction to impose fines to the perpetrators (according to one DONRE staff officer). Many industries and industrial parks drop untreated wastewater into rivers and streams; however, those industries tend to have the favour of provincial authorities and senior government officials. Therefore, DONRE officials inhibit fulfilment of their responsibilities, being afraid of the consequences of pursuing companies that have the political back up of their superiors or the Provincial People´s Committees (PPC).

Lack of staff at provincial level undermines the capacity to even carry out an inventory of water resources or infrastructures. In the Northern province of Son La, the author was unable to collect data of the number of dams existing in the province. Neither DONRE nor the provincial Department of Agriculture and Rural Development (DARD), have an inventory of dams or a list of irrigation districts.

The Water Law does not include a priority of different uses in case of shortage, which in practice allows anybody with a license to exploit water without much consideration of water needs downstream. Article 47 of the law states that "exploitation and use of water sources for hydropower generation must ensure integrated and multiple-purpose use, except for water exploitation and use on a small scale". However, even that relatively ambiguous article is not properly followed in practice.

Son La provincial capital reported a shortage of water for its urban water supply system, even if the province has 10 to 12 large hydropower dams, including Son La dam, 9,260 HM^3 and 2,400 MW capacity. This is the largest hydroelectric power station in South East Asia according to VNCOLD website.

According to local DONRE, that province has around 2000 irrigation systems - 9 of them are large scale - however none of those districts have official permission to use water. The number of dams and weirs used for irrigation purposes is unknown, as well as the status of those infrastructures. Several dams and weirs collapse every year in Son La during the rainy season, seriously disrupting agricultural production and damaging communities and assets downstream. In the province there are around 56 hydropower dams, 23 of them fully operational. However, the total number of water licenses in the province, including urban water supply, is only 10.

The situation is not better in other provinces in the Mekong and Red river deltas. Decentralisation of water resources management at provincial level might even increase the floods in nearby provinces as explained below in this section.

In theory, Vietnam has sufficient water resources per capita, estimated as 11,102 m^3/capita/year, according to FAOSAT website. In fact, the abundant rainfall causes floods in most parts of the country. However, that amount per capita represents a third of Cambodia´s and a sixth of Lao´s; and according to the World Bank, Vietnam shall be considered as a water stress country.

Climate change is expected to increase the intensity and frequency of droughts during the dry season, and hence the punctual shortages of water during the dry season are expected to increase in the future. That could be solved, however, with better management of priorities and setting up of criteria for sector distribution. The Spanish Water Law, with much drier conditions and droughts, but with a large number of dams and hydropower dams, could be used as an example. In that case the priorities in case of water scarcity are in that order:

1. Drinking water supply, including water supply to industries of limited water consumption connected to the municipal water network
2. Irrigation and other agricultural uses
3. Industry and hydropower
4. Other industrial use not included in the previous sections
5. Aquiculture
6. Recreational uses
7. Navigation and aquatic transportation
8. Other uses

In the case of Vietnam, due to the critical importance of hydropower for the provision of electricity to the industrial sector, that order might be altered and hydropower might be prioritised with respect to irrigation. However, those decisions have to be discussed and agreed as the consequences of lack of water for irrigation purposes could be devastating to poor and nearly-poor farmers.

Increasing both capacities and investment in water management shall be a priority. However, due to limited political will, and budget restrictions, this seems to be of limited applicability in the short term.

2. Development of river basin authorities for better water management

At the moment, article 54 of the Vietnamese Water Law simply requests to regulate water resources according to “master plans”, and gives the authority and mandate to Provincial People´s Committees (PPC) to regulate the use of water resources in their provinces.

As previously said, the lack of knowledge and registry of existing water users, makes it almost impossible to define a realistic master plan, as the needs of different users are just not known. Besides, the role of PPCs in water resources regulation and distribution is contradictory with the logic of river basins. As most river basins in Vietnam go through several provinces, supra-provincial entities are needed to ensure proper management and distribution of water resources.

One clear and evident example can be found in the Mekong River. The river basin is shared by China, Myanmar, Thailand, Laos, Cambodia and Vietnam. The Mekong River Commission (MRC) was created in 1995 to “develop work programmes and strategies that best serve its mission to provide effective support for sustainable management and development of water and related resources”. MRC is a trans-boundary body that includes all countries except China and Myanmar that are included as “dialogue partners” according to the organisational structure included in its website. Although it has budget restrictions and political limitations, it serves as an example of river basin authority.

At the national level, the Vietnamese Mekong River Committee is supposed to liaise with the MRC secretariat.

The creation of river basin authorities is still incipient in Vietnam, with very few examples in the country. The author has been able to identify only three operational river basin authorities; one in the Mekong Delta; another one in the *Đồng Nai* river that supplies water to HCMC and is supported by ODA, and a third one in the Hong Thai Binh river basin in the Red river.

Creation of river basin authorities at the country level should be a priority for the country. In those river basin authorities, the needs, interests, and resources shall be discussed with a variety of stakeholders including; central, provincial and municipal governments, hydropower companies (public and private), farmer unions, environmentalist, research centres and CSOs.

The Network of Committees for Floods and Storm Control at all levels, including infrastructures, equipment and O&M has to be strengthen. That might include recentralising some decisions currently taking place at provincial level, to new structures created at river basin level.

3. Better coordination and management for flood and storm control

According to the Ordinance on Prevention and Control of Floods and Storms and Implementation Provisions (Number: 09-L/CTN, 1993) the authority and responsibilities are stipulated as follows:

- The General Department for Meteorology and Hydrology (at MONRE) is in charge of forecasting rain, floods, storms, tropical depressions and rise in the level of seawater in the entire country.
- The Provincial Committees for Prevention and Control of Floods and Storms are in charge of issuing warnings for floods and storms in their areas. For mountainous and remote areas, in necessary cases, the flood and storm control committees of districts can issue warnings as well.
- The Central Committee for Prevention and Control of Floods and Storms (at MARD) is in charge of issuing warnings for floods and storms in the entire country.
- The Prime Minister shall issue decisions on urgent measures that need to be taken for control of floods and storms.

However, according to the stakeholders interviewed, the daily opening and closing of gates is managed by the provincial Departments of Agriculture and Rural Development (DARD). The Provincial Committees for Storm and Flood Control (PCSFC) are active during extreme weather events, however, the final decision relies on the Provincial People´s Committees (PPC). PPCs make political decisions on which areas shall be protected and which others shall be flooded.

At the national level, the Central Committee for Storm and Flood Control (CCSFC) is responsible for overall supervision, however CCSFC lacks proper information and on-site knowledge to make any decisions, as the CCSFC office is located in Hanoi, at over 1,200 km from the Mekong.

Even if, in theory, flood and storm control systems are in place, in practice, decisions are made at provincial level, thus lacking any larger-scale vision. In case of large-scale disasters, the Vietnamese armed forces take control of the infrastructures.

Ordinance on Prevention and Control of Floods and Storms and Implementation Provisions (Number: 09-L/CTN, 1993) provides a good set of recommendations that are valid for climate change adaptation. Based on that ordinance, the author made some recommendations for further improvement on the real implementation of the ordinance:

- IMHEM provides proper information on climate change scenarios, however that information is seldom used for planning purposes. It is recommended that steps be taken to ensure that IMHEM predictions are properly disseminated and used by decision makers.

- Several flood prevention and control plans have been approved, however real implementation is scarce due to budget restrictions. In addition, there is still limited knowledge and experience on climate-proof infrastructures, especially with respect to bio-engineering and non-structural options. The recommendation is to revise investment plans and to put more emphasis on low-cost and non-structural alternatives rather than expensive grey infrastructure.

- Several master plans have been recently developed, however, those plans hardly consider future changes due to climate change and other factors such as deforestation and land use changes. Future flood plans should take those aspects into consideration and not only assess the current situation but estimate future scenarios.

- There has been a remarkable investment in flood and storm control infrastructures. However, those infrastructures are not always properly managed. The recommendation is to put more emphasis on O&M and on management of existing infrastructures. To evaluate the negative impact of maladaptation, as for instance in the Mekong Delta, some proposed infrastructures in some provincial plans would be against the Mekong Delta Plan.

- Current Operation and Maintenance (O&M) is insufficient to keep all flood and storm control infrastructures fully operational. The most critical ones, dams, are clearly not prepared for weather extremes, with hundreds of then being damaged every year. A revision of dam safety standards is currently taking place, however that has to be accompanied by a multimillion investment in dam safety and dam management.

4. Centralisation versus decentralisation management models

Decentralisation is one of the key aspects of Doi Moi (renovation), with 55% of the State´s general expenditures and 75% of capital expenditures done at the sub-national level, Vietnam could be seen as a highly decentralised country by international standards (World Bank, 2014 on Charlier, 2015). The State Budget Law (No. 01/*2002*/QH11 of December 16, *2002*) gave a lot of freedom to PPCs to organise the affairs (expenditures and revenue assignments) of districts and communes. The Decree 29/1998/ND-CP on Regulation of the Exercise of Democracy in Communes (commonly known as Grassroots Democracy) also contributed to a significant level of decentralisation.

However, according to several authors (Charlier, 2015) lack of accountability of local governments for budgetary allocations leads to inferior outcomes, even if there are adequate resources from the higher-level governments.

Both the Water Law and the Ordinance on Prevention and Control of Floods and Storms and Implementation Provisions, give significant roles to the provinces, especially to the Provincial People´s Committees (PPC) and Provincial Committees for Storm and Flood Control (PCSFC). That is also part of a decentralisation process, but in that case IWRM cannot be done exclusively at provincial level.

According to some sources consulted in the Mekong region, neither the Central Committee for Storm and Flood Control (CCSFC) nor the Vietnamese Mekong River Committee have much control over the decision on opening and closing gates during floods. The final decision is taken at provincial level by the PPC. In some cases, the decision of opening a gate to release water, might prevent some areas in the province from being affected by floods, but can have catastrophic consequences to nearby provinces.

At the moment, the best practice on IWRM in the Mekong Delta consists of informing in advance the nearby provinces, that a specific PPC is planning to open/close some gates (source: author´s interview to senior official in the Mekong).

There is a clear need to set up proper decentralised decision making systems, but those decentralised decisions should be taken at river basin level, not following other geographic references such as provinces.

The development of river basin authorities is still incipient as stated before. Therefore, setting up river basin authorities countrywide shall be one top priority for the government.

5. **Set up water efficiency measures**

Water consumption is growing as quickly as degradation of water resources. In fast growing cities like Danang, in central Vietnam, with a 3% annual growth according to city authorities, the existing water sources will be insufficient to provide water supply to its population. Besides, NRW accounts for 30% as an average, with 38-40% in big cities such as HCMC and Hanoi (VIHEMA, 2012).

Danang, is currently planning to find alternative water sources and to build a reservoir that should ensure enough water for the future generations. Other cities like Hanoi, or HCMC are also planning ambitious projects to increase its water sources and storage capacity.

But none of those cities, even if they all have climate change adaptation plans, are properly considering the impact of climate change in their design. With support from the Dutch company Vitens Evides International, Danang water company (DAWACO) was able to reduce Non Revenue Water (NRW) from 40% to around 15% today, through identification of water losses. That represented a significant impact to the utility, which was able to make a profit while keeping its water tariff low.

The example of Danang shows how water efficiency measures, such as eliminating NRW and controlling leaks, can contribute to make a water utility profitable. But at the same time, those measures can contribute to fight against climate change. A 25% of gross water demand reduction might be the difference between keeping the existing water source and having to invest in an expensive new dam. In that case, the reduction of NRW allowed Danang municipality to “buy time” and delay the investment in alternative water sources.

Besides, there are other options to improve water availability, such as recycling. In Hue city, in central Vietnam, HueWACO, the water operator, is developing a water treatment technology to recycle water used in aquaculture farms that has a high concentration of algae and organic wastes (Nguyen Thi, 2014).

In other cities, the use of treated wastewater for irrigation is still considered as a taboo. However, the improvement of wastewater treatment, and the improvement of the O&M of existing WWTP can lead to additional quantities of water for other uses.

6. **Set up water conservation measures**

Similar to water efficiency, water conservation measures can also contribute to adapt to climate change. Those water conservation measures are positive actions, carried out in the catchment area, to increase the availability of raw water.

One of the most innovative water conservation measures is the Payment for Environmental Services (PES) mechanisms. PES mechanisms create incentives for individuals and communities to protect environmental services, such as watershed conservation, by compensating them for the costs incurred in managing and providing those services. Starting from 2004, Vietnam is the first country in Asia that has established those mechanisms countrywide (Pham Thu et al, 2013), and despite its

limitations, offers an interesting opportunity to explore.
According to CIFOR (Pham Thu et al, 2013), PES implementation in the period 2009–2012 generated total revenue of VND 1,782 billion (about USD 85 million). Of this sum, payments from hydropower plants account for nearly 98%, water utilities for about 2% and tourism for 0.1%. This shows the potential for growth of that mechanism for water utilities.

One of the examples of PES in water utilities can be found in HCMC with SAWACO (Saigon Water Company). A pilot project supported in 2008 and 2009 by DANIDA, WWF, Dong Nay Departments of Agriculture and Rural Development (DARD) and Natural Resources and Environment (DONRE), for the water shed protection of Dong Nai River.

In that case, funds were used to encourage local communities to improve their land-use practices, to fund Vinh Cuu Nature reserve, Vinh Cuu Nature Reserve and the Tan Phu protection forest management board, to maintain and support forest protection and restoration activities around Tri An reservoir.

In 2012, VND 17,8 billion (USD 0.85 million) were collected from water utilities to fund PES mechanisms in Vietnam (Pham Thu et al, 2013).

Decree 99 (*Decree 99*/2010/ND-CP) regulates PES schemes and establishes the amount of payment included in the water tariff as 40 VND/m3 (0.002 USD/m3) of clean water produced for water supply companies. Although this amount is still very low, the possibilities of setting up the system and increasing the amount in the future offer a good opportunity.

For a megacity like HCMC with a supply of 1.34 million m^3/day and 734,000 connections (ADB, 2011), the PES would represent total revenues of VND 19,5 billion/year (0,93 million/year), which is a promising mechanism but clearly insufficient to fund the environmental services needed to ensure the protection of Dong Nai basin.

7. Control of other water uses, especially agriculture

As agriculture represents almost 80% of water consumption, the control of water used for irrigation seems to be a priority, especially in areas currently affected by water shortage during the dry season.

According to the water sector review project (ADB, 2008) during the dry season, the Dong Nai, the Red, the Ma and the Kone basins, the south east rivers, the dry provinces of Khanh Hoa, Ninh Thuan and Binh Thuan, are at, or are approaching, high levels of risk of irregular or local water shortages by international standards.

One of the most important indicators for water scarcity or water stress is the Water Exploitation Index (WEI) or Water Stress Indicator (w.t.a.), which is defined as the total water withdrawals-to-water availability ratio within a river basin. Water scarcity can be the result of intensive water use, low water availability (climate driven) or a combination of these pressures. WEI between 0.0 and 0.2 is considered a low water stress, WEI between 0.2 and 0.4 medium water stress, and a value greater than 0.4 severe water stress. (ClimWatAdapt website, 2015).

According to the water sector review project (ADB,2008) 4 of the major 16 basins are currently classified as being ‘highly stressed’ (the Ma, the south east rivers, Huong and Dong Nai) and a further 6 are classified as ‘moderately stressed’ by WEI index. The Red River basin is at the high end of this scale; and for the Ma River, up to 80% of the dry season flows are currently extracted.

Groundwater resources are no better. With uncontrolled extractions of groundwater for irrigation in several rice production areas of the country. The situation is more critical in the Red River and Mekong delta areas, as overexploitation of aquifers contribute to subsidence and seawater intrusion. The figure below shows the most affected areas by subsidence in the Mekong Delta. Those areas correspond to areas of overexploitation of groundwater resources, such as HCMC or around large cities such as Vinh Long and Ca Mau.

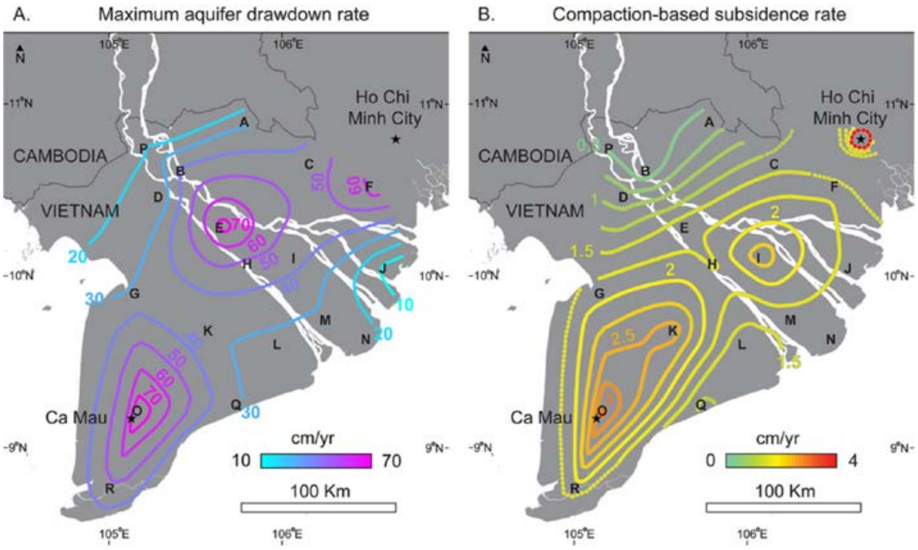

Figure 4: Impact of groundwater extraction on subsidence and drawdown rates in the Mekong delta. Source: Erban et al, 2014.

The control of agriculture extractions seems a logic solution. However, several sources interviewed, especially in the Mekong delta, recognize that it is impossible, with the existing means, to control thousands of illegal wells.

8. Replace water sources in delta and coastal areas

Considering that the previous proposed solution, control of groundwater extractions, seems not possible with the existing means at provincial level, the climate change adaptation options proposed in several areas of the Mekong Delta include the replacement of groundwater resources for surface water resources.

The figure below shows the rapid deterioration of the shallow aquifers in the Mekong Delta. Wells used for irrigation purposes are usually shallow wells of less than 100 m deep. The overexploitation of the upper aquifers contribute to seawater intrusion and the rapid salinization of the groundwater resources. On the other side, the deeper aquifer, located at 400 m depth has not been affected significantly by seawater intrusion.

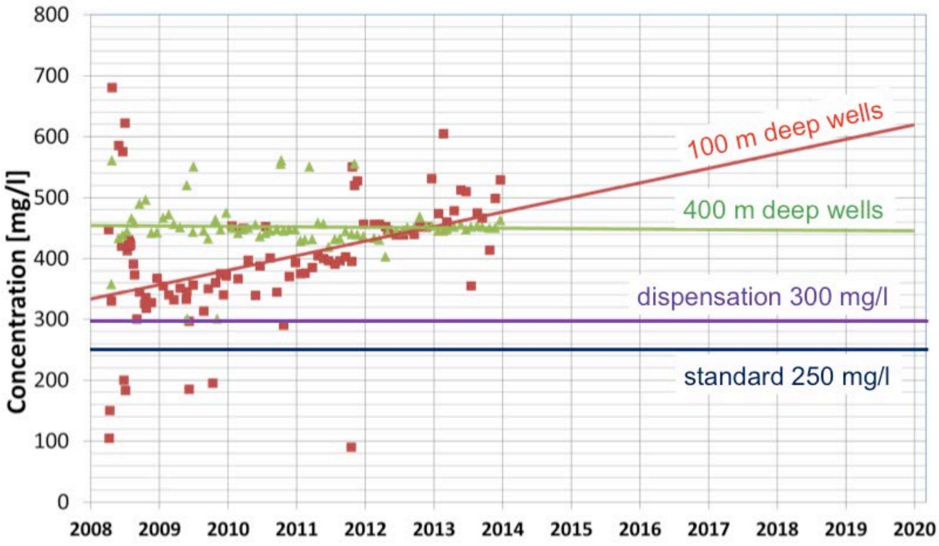

Figure 5: Chloride concentration of wells located in Soc Trang province (Mekong delta). Source: Vitens Evides International as quoted by de Jong, 2014

However, the use of deeper aquifers is only a short-term option, as other users (especially industries) are expected to do it as well. The figure below shows how aquifer "qp23" , one of the most important ones in the Mekong Delta, is currently being overexploited in several parts of the region. Besides, exploitation of groundwater resources contribute to subsidence, and this increases the negative impact of Sea Level Rise (SLR) due to climate change.

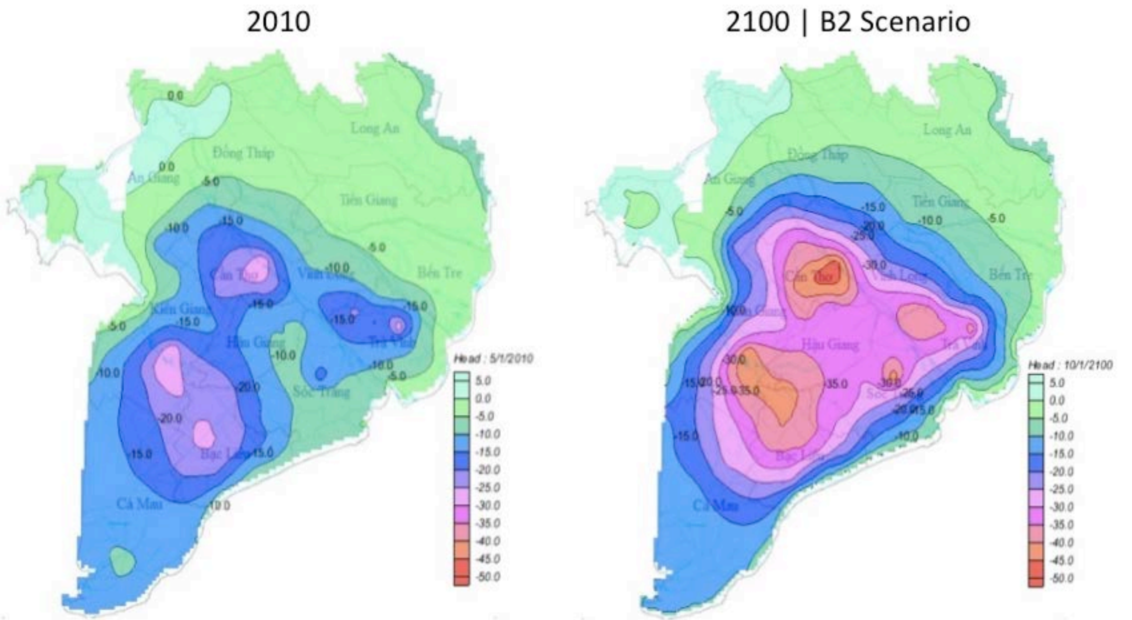

Figure 6: Groundwater level dropdown of "qp23" aquifer in the Mekong delta: Situation in 2010 vs. expected scenario in 2100. Source: Vitens Evides International as quoted by Dierk, 2014

Vitens Evides International, a Dutch firm, is currently supporting several utilities in the Mekong delta as well as in HCMC to adapt to climate change. After a comprehensive study of alternatives, the proposed solution includes replacing groundwater sources for surface water, sometimes collected upstream to avoid salinity in the estuaries during high tides.

For instance in Soc Trang city, VEI´s estimation is that by 2020 4 out of the 6 existing water supply wells will have a salinity concentration above the standard. Therefore the impact of overexploitation and climate change is not decades ahead, but in the very near future.

In theory, groundwater resources are expected to be more resilient to the impacts of climate change. So far, IPCC has not found strong evidence of climate change impact on groundwater resources globally (IPCC, 2014). However, in delta regions of Vietnam, replacing groundwater resources for surface water seems to be the most appropriate solution. The example of Soc Trang shows how climate change adaptation solutions have to be tailored and contextualized to each specific case.

9. Improve water quality control

According to the IPCC´s Technical Paper VI on Climate Change and Water: "Higher water temperatures and changes in extremes, including floods and droughts, are projected to affect water quality and exacerbate many forms of water pollution; from sediments, nutrients, dissolved organic carbon, pathogens, pesticides and salt, as well as thermal pollution, with possible negative impacts on ecosystems, human health, and water system reliability and operating costs (high confidence). In addition, sea-level rise is projected to extend areas of salinization of groundwater and estuaries, resulting in a decrease of freshwater availability for humans and ecosystems in coastal areas" (IPCC, 2008)

With rapid economic growth and industrial development, the clean water resources are starting to reduce quickly in Vietnam. The negative effects of climate change will enhance that trend.

One development bank officer suggested that the Vietnamese government should preserve some critical rivers (or sections of rivers) as reservoirs for clean water, preventing heavy industries from establishing its operations in those basins. Unfortunately, the still insufficient land planning and economic interests make this recommendation difficult to implement.

Cleaning up a polluted river, or even treating wastewater produced by industries is more expensive than preventing pollution though relocation of the activities to less vulnerable areas, or by establishing greener production practices. Tanneries and fabric dyeing industries, that are relatively common in Vietnam, should be better scrutinized according to a government official.

In coastal areas, the impact of sea level rise is expected to increase the salinity of estuaries. The sea-intrusion in lowland areas of the Red and Mekong deltas include dozens of kilometres, and are expected to increase as a combination of SLR and more frequent and intense drought periods. Therefore there are two adaptation options proposed:

- The first one, as a short-term solution, consists on pumping water only during low tides. That option requires a good monitoring and management system, and may not be appropriate when it is in combination with low water levels (e.g. caused by a drought or a closed gate/dam upstream).

- The second option, which is currently being explored in several areas of the Mekong and Red river deltas, includes moving the pumping stations upstream, to areas that are less vulnerable to SLR. Sometimes, that even forces the look for sources outside the provincial boundaries, what is in many cases a limitation. The decentralisation process already in place undermines looking for alternative water sources outside the province, and significantly reduces the potential benefit of that adaptation alternative (based on interviews with mid-rank officials in the Mekong region).

10. Improve urban planning and land planning

Another climate change adaptation measure consists of improving urban planning and land planning.

In urban centres, climate change might have an impact on the water supply and sanitation services. An increased water demand, linked to less reliable water sources might imply considering alternative water sources for the future. Identifying those potential water sources, and protecting them today, even if they are not used at the moment, might be very useful for future adaptation measures.

In coastal areas, the impact of sea level rise and high tides, might affect drainage and sewerage systems, as well as wastewater treatment plants. The cost of pumping sludge might represent a significant proportion of the treatment tariff, therefore designing infrastructures today that can cope with future scenarios, might represent a significant cost-saving in the lifetime of those infrastructures.

In rural areas, the need for land planning might be less evident, at least as a climate change adaptation measure. However, it is also important to analyse trends in the long term. The CCA example of replacing groundwater for surface water in Soc Trang city, in the Mekong Delta also applies to small-scale water supply systems. Rural water supply in the Mekong Delta will also be affected by salinization and dropdown of the upper aquifer. Therefore, rural development plans should consider planning today for alternative water sources. A short-term solution could be the promotion of rain harvesting systems, while in the mid/long-term, interconnected rural water supply systems could be the most suitable alternative.

In any case, those options start with proper land use planning and a long-term vision of the present and future needs and scenarios.

11. Climate financing

According to UNFCCC, the funding needs for climate change adaptation of developing countries by 2030 are USD 9 billion for the water sector, and USD 22-41 billion for the infrastructure sector. The World Bank (2010) estimates similar net finance needs for the water sector.

	East Asia and Pacific region	World
Gross costs for Flood protection	USD 0.9-1.6 billion	USD 5.3-7.0 billion
Net costs for Flood protection	USD 0.8-1.6 billion	USD 3.6-5.8 billion
Gross cost for Water Supply	USD 2.1-3.1 billion	USD 18.6-19.2 billion
Net cost for Water Supply	USD 0.3-0.6 billion	USD 10.0-11.1 billion

Table 3: Gross and net annual adaptation costs for water supply and riverine flood protection, 2010-2050. Source: World Bank, 2010.

Note: Gross costs set negative values to zero for sector protection in any country with negative costs. Net costs are pooled costs without restrictions on pooling across country borders (positive and negative costs are treated symmetrically).

Although cumulative funding for climate change has grown significantly since 1992, reaching a total of almost USD 10 billion, the amounts effectively disbursed are far behind the expectations and the needs.

A recent research carried out by ODI (2014) confirms that commitments to deliver climate finance to developing countries are longstanding. Developed countries pledged to deliver finance approaching $30 billion between 2010 and 2012, in the context of a commitment to mobilise $100 billion per year from public and private sources by 2020 in the Copenhagen Accord of 2009.

Only a small part of climate finance is currently being allocated to adaptation, while most of the money is invested in climate change mitigation. As can be seen in the figure below, out of the USD 10 billion disbursed so far, only 20% (in red) has been spent on climate change adaptation (ODI, 2015).

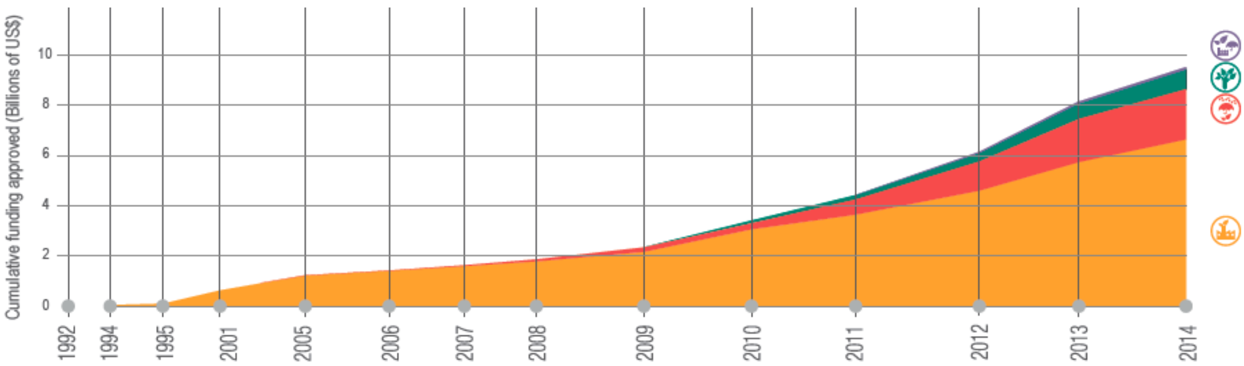

Figure 7: Cumulative climate funding approved in billions of USD since 1992. Source: ODI, 2014

According to "Climate Funds Update," an independent website that monitors climate financing flows, Vietnam ranks as one of the top 20 recipients of climate funding globally, with USD 109.2 million approved in 2014. However, only 8.3 million were allocated to climate change adaptation. Out of the total, only USD 21.7 million are grants and the rest are concessional funds (Climate Funds Update, 2015).

In terms of multilateral funding recipients, Vietnam ranks 11th globally, with USD 240.8 million approved. Out of those funds, USD 20.1 million are for adaptation. With respect to bilateral funds, Vietnam ranks 12th globally, with USD 26.8 million invested, with USD 6.36 million earmarked for adaptation (Climate Funds Update, 2015).

The figures above show a big potential for future climate funding in Vietnam. The country has been able to position itself among the top recipients, and has accumulated significant experience managing and accessing those funds. Climate funding is expected to grow even faster, offering a unique opportunity to fund climate change adaptation activities.

A USAID mission carried out in 2011 highlighted the fact that there are dozens of development assistance partners and NGOs involved in climate change projects. In order to create an enabling environment for climate funding, USAID recommends improved coordination and operational capacity. According to that agency, there are unmet needs, gaps and challenges that remain to be fully addressed, including further training and capacity building, and better application of available knowledge (USAID, 2011)

12. Combine adaptation and mitigation

In some cases, climate change adaptation can be combined with mitigation measures. That is interesting, not only because of the double benefit of the measures, but also because of the opportunity to have access to mitigation funds, which at the moment are more profuse than those for adaptation. One of those combined actions include reforestation of catchment areas to protect the water sources. Reforestation contributes to capture CO^2 (mitigation), and at the same time contributes to increase water availability (adaptation).

Case study 4: Vietnam Biogas Programme

The Vietnam Biogas Programme was initiated in 2003 by SNV, Netherlands Development Organisation. In this period of time, the programme has trained 800 technicians and 1,400 biogas mason teams, who have built over 150,000 biodigestors which provide safe management of both animal and human waste.

The programme, currently managed by MARD, contributes to reduced greenhouse emissions, to an estimated 5.9 tons of CO_2/plant reduced a year, which represents 885,000 tons of CO_2 per year countrywide. With support from SNV, the programme has been able to access the financial benefits of **carbon credits** generated through the **Voluntary Gold Standard** (VGS) and the **Clean Development Mechanism** (CDM). Those carbon credits are used to continue expanding the programme, and contribute to ensure the financial sustainability of this programme (SNV,2015).

In this case, biodigestors contribute to climate change mitigation, through the reduction of CO_2 and methane emissions, and also contribute to provide a sustainable sanitation solution.

13. Improve knowledge management on climate change

There is a gap between climate change scientists and water and sanitation practitioners. The scientific community in Vietnam has made a remarkable effort to identify the main threats and estimate the consequences of climate change. Vietnam is much more advanced than its neighbours with respect to climate research.

However, when speaking with water and sanitation experts, both in the government and in the private or in the development sector, they recognise that their knowledge about climate change is very limited. In many cases there is confusion between climate and weather, and a tendency to consider individual weather extremes as evidences of climate change.

It would be very difficult for the sector to adapt to something that is not properly understood, especially when there are several misconceptions about the real impacts of climate change in the sector.

For that reason it is essential to ensure that knowledge about climate change is broadly disseminated within the sector, and good practices are also known. Managing and disseminating knowledge, especially among decision makers, but also among design engineers, is critical to adapt to climate change.

Access to information has to improve significantly in Vietnam. If a design engineer wants to know the average rainfall in a certain area, he/she has to buy that information at MONRE´s office in Hanoi. Paradoxically, MONRE staff responsible for climatologic data collection and reporting at provincial level, do not have access to the processed data. During a field visit to the Northern province of Son La, DONRE staff was unable to provide simple information from any of the 4 provincial meteorological stations on average rainfall or temperature to the author of this document, let alone climate change predictions or scenarios.

If information is not easily accessible it would be very difficult for decision makers and design engineers to make informed decisions and to design infrastructures taking into consideration climate change.

14. Develop capacities on climate change adaptation

Capacity development is at the core of any climate change adaptation policy. Based on FAO´s capacity development framework, there are technical and functional capacities that have to be developed at individual, organisation and as part of an enabling environment.

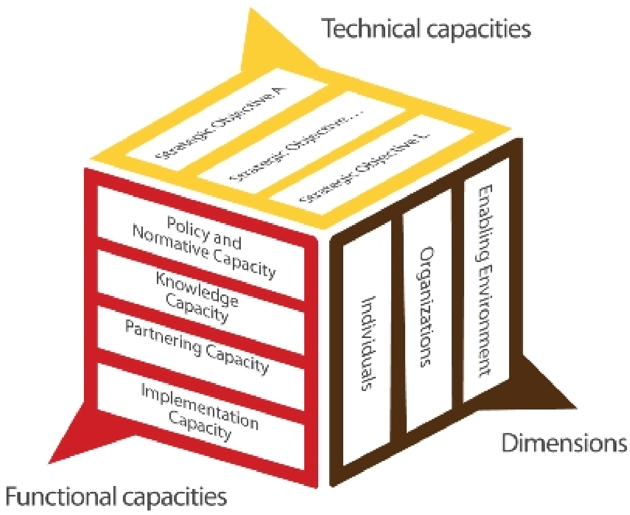

Figure 8: Capacity development framework. Source: FAO website, 2015

When analysing the functional capacities, the policy and normative capacity seems to be quite well developed in Vietnam (see annex 3). In terms of knowledge capacity, as stated in the previous point, there is a gap between the scientific knowledge on climate change and the knowledge of WASH practitioners.

That knowledge gap could be reduced with the organisation of WASH-sector training and dissemination sessions targeting government, development organisations, and the private sector. Climate scientists have to make a bigger effort to make information about climate change more oriented to its practical use on CC adaptation (and mitigation).

In the long term, including climate change in the curricula of engineering studies might help to overcome this gap. Some post-graduate studies on climate change adaptation in the WASH sector, could contribute to spread the knowledge base and disseminate good practices.

The development sector already has some coordination mechanisms for organisations working in CC, but the debate on climate change adaptation in the WASH coordination structures is just commencing (based on author's own experience).

The government of Vietnam has strong implementation capacities and has leaded a remarkable infrastructure development over the past decades. However, climate change adaptation requires, in general, less grey infrastructure and more soft skills to better plan and to put in place better management systems (e.g. river basin authorities). In that particular aspect Vietnam still has some room for improvement.

4.2.2 Proposed options at infrastructure level

There are many technological options to adapt infrastructures to climate change. In many cases these technologies are already in place and/or widely known, such as rain harvesting. In this section, the author has included some examples on how these options are contributing to climate change adaptation. Due to the scope of this research, the list of examples does not pretend to be exhaustive but is representative of some proposed options for the Vietnamese context.

1. **Climate change adaptation integrated in the design phase**

There are two main approaches to integrate climate change adaptation into the design phase:

- The **precautionary principle** approach is usually suggested to mitigate risk. This principle comes from Principle 15 of the Rio Declaration on Environment and Development (DESA,1992): "*Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing measures*".
- The alternative is a **proportional approach** to risk regulation and is the approach that might be more suitable for developing countries like Vietnam. This approach is a complex, careful, and thoughtful examination of the dangers and costs of each option.

VIHEMA in a WASH assessment report (2012) stated "for planning of water supply and sanitation, many localities have not fully and timely updated, paying not enough attention to the impacts of climate change. Quality and management of planning are still limited and not close to reality, not meeting fully requirements from water supply and sanitation planning".

In order to overcome those limitations, climate change adaptation has to be considered from the early stages of the design phase. In that sense, the design process might imply using a more flexible approach, where uncertainties are acknowledged and considered, and where longer-term impacts are considered in the cost-benefit analysis.

There are several methodologies for considering climate change adaptation in the design phase. One of the most interesting ones is the Robust Decision Making Analysis (RDM). The RDM approach was designed by RAND Corporation, and is an iterative decision analytic framework that helps identify potential robust strategies, characterize the vulnerabilities of such strategies, and evaluate the trade-offs among them. This approach is pertinent when uncertainty is high, such as under existing climate change predictions (Lempert et al, 2012).

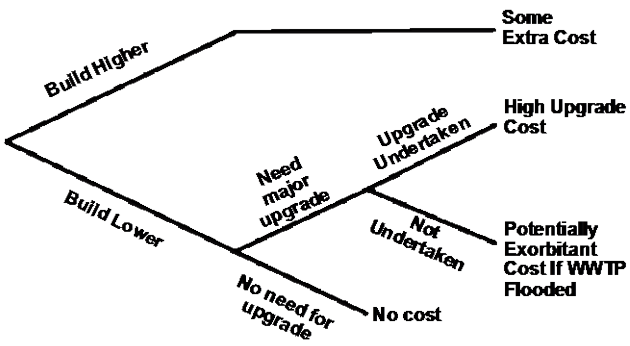

Figure 9: Simplified representation of a municipality decision regarding whether or not to build higher a wastewater treatment plan (WWTP), and what would be the future options if the decision is to build it at a lower level. Source: adapted from Lempert et al, 2012

RDM address this design dilemma by answering two questions: (1) under what future conditions would the municipality find it advantageous to build (for instance) a WWTP at a higher level, and (2) does the current science and other available information suggest that these conditions are sufficiently likely to justify the decision?

The RDM methodology has four steps:

1. Considering some parameters (e.g. climate change scenarios) as deeply uncertain and evaluating over many cases, each described by some combination of values of these parameters;
2. Concisely summarizing the common factors among those cases in which elevating the WWTP at the next upgrade passes the cost-benefit test;
3. Estimating the probability threshold that is the likelihood for these cases that would justify hardening at the next upgrade, and
4. Evaluating scientific lines of evidence to help judge whether or not these cases are sufficiently likely to justify the decision at the next upgrade.

The RDM approach is quite comprehensive and complex for smaller systems, such as rural water supply schemes, but in the case of large scale of infrastructures it might be the most appropriate method. Even in mid-size utilities highly vulnerable to climate change, such as a WWTP that could be eventually affected by sea level rise, or a water intake that might be affected in the future by shortage of water; the RDM approach might be a useful tool to be used.

2. **Upgrade of construction codes and standards**

In comparison with other countries, the Vietnamese legal framework is quite large and complex. Besides the national bodies, such as the Government, the National Assembly and the different Ministries, at provincial level, PPCs also produce a significant amount of regulations that exponentially increase the number of legal documents.

At the technical level, the construction standards can be at national level (TCVN, TCXD, TCDXVN) or developed by an specific ministry and applicable for an specific sector (22 TCN, 14 TCN). There are more than 7,500 National Standards (TCVN) and more than 1,300 Construction Standards (TCXDVN).

The upgrade of those construction standards shall be one of the main priorities for the Vietnamese government. The existing process of upgrading standards does not promote an in depth analysis and critical consideration of the future impacts of climate change.

The author has been able to identify only one construction code in the WASH sector that is currently being upgraded with consideration of climate change. With support from JICA, the Ministry of Construction is currently upgrading the building code QCVN 07:2010/BXD on Urban Engineering Infrastructures. At the moment, drains are designed for the largest storm in 10 years, which seems quite low to cope with climate change predictions. The code was still under development at the time of collecting field data, and the preliminary draft included a significant increase for drain sections. For instance, at the current code, the recommended 300mm drains have been changed to 500 mm (a 2.78 times larger section).

However, that example is quite exceptional in comparison with other construction codes that clearly require a significant and urgent upgrade.

Case study 5: QP.TL C-6-77 "Guidelines calculating characteristics of hydrologic design"

QP.TL C-6-77 establishes the guidelines for calculating characteristics of hydrologic design in 1977. The code is the foundation for the design of rural infrastructures, however it is out of date, first of all because it only covers design criteria for North Vietnam, but mostly because the formulas and codes included are inspired by very old formulas.

For instance, the Sokolovsky formula was developed in 1945 for rivers in West Russia and is no longer in use in that country. More accurate formulas have replaced the Sokolovsky formula in Russia. Vietnam seems to be the only country currently using that formula, which represents an anachronism.

QP.TL C-6-77 proposes some empiric formulas that facilitate the design process. However, those formulas are based on coefficients that were calculated a long time ago, with limited resources and limited historic data. Keeping the same formulas, and recalculating the coefficients based on a larger historic database will demonstrate the need to upgrade that code. Besides, climate change is not considered, and in some cases (e.g. Sokolovsky formula) the formulas themselves are completely out-dated and inaccurate for the specific conditions of Vietnam.

Nowadays, the use of CAD and GIS software allows designers to use data in a completely different way. However, those powerful tools require the use of the right data. At the moment, those models are calibrated with the results and coefficients calculated in 1977 and lead to large variations and errors. Hence, the potential of those powerful tools (e.g. MIKE) is limited by the fact that it is calibrated with data that is completely out of date (e.g. historic data of floods included in QP.TL C-6-77).

QP.TL C-6-77 requires an urgent upgrade, however, there seems to be a common understanding in Vietnam that upgrading this code requires a significant multidisciplinary effort, and that it cannot be done as with other upgraded construction codes.

Improving the accuracy of formulas can generate significant savings that can be used to reinvest on improving resiliency in other more vulnerable assets.

Source: author in a consultancy assignment with UNDP (Alvarez-Sala, 2015)

The recommendations on upgrading construction codes and standards include:

- The most important aspect to consider when upgrading construction codes is the need to incorporate a more flexible approach when estimating climatic factors. Historic meteorological data records alone, are insufficient to predict future climatic patterns.
- Climate change adaptation has to be considered as a key element for building more resilient infrastructures. However, there are many other aspects such as the socio-economic changes that occur in the area/country, that also have a significant impact. For instance, land use changes have a substantial impact on water runoff in the catchment area, and land use trends shall be included in future scenario analysis.
- Reservoirs are key assets that require special attention. Those key infrastructures not only represent a risk for communities and assets downstream; a disruption of service (e.g. damages) or a reduced functionality of the reservoirs (e.g. as a consequence of reduced water supply), but might also have major impact on the users (hydropower companies, farmers, water utilities, etc.)
- In general terms, the construction codes in Vietnam are vague in comparison with similar codes in other countries. Different users can interpret some articles differently, and therefore law enforcement tends to be more difficult. Introduction of specific design criteria (e.g. coefficients, formulas, or margins of safety) can contribute to develop a more solid legal framework.
- River flows (especially floods and flow peaks) shall be calculated taking into consideration future climate change scenarios. There is, however, need to specify which CC scenarios should be used and which timeframe to consider for each type of infrastructure. These are not straightforward or easy decisions and while in some cases a precautionary approach shall be considered (the worst case scenario) in others, the most probable scenarios and shorter timeframes might be more appropriate. It might require using different criteria to calculate the flow peaks for designing a rural water supply scheme as opposed to designing the drains of a city.
- Over the last decades, the socio-economic progress has also impacted the use of natural resources, including water and land use. Hence, the historical recordings from hydrological stations might also reflect those changes, especially in small basins, or in river basins that have changed intensively (e.g. by the construction of new reservoirs). On top of that, climate change is expected to have an influence.

The upgrade of the code should also reflect the impact of climate change and the trends at river basin level.

3. Better consideration of return periods and lifespan of infrastructures

In Vietnam, there seems to be some confusion between expected lifespan of the infrastructure, return periods and timeframe of CC scenario. The dates do not necessarily need to be the same. For instance, a large reservoir might be build for a lifespan of 50 years, but the return period should be much larger than that (in some countries such as the Netherlands or Spain up to 10,000 years), but climate change scenarios are predicted only until 2100 (85 years). A critical infrastructure with catastrophic results in case of breakdown, should use higher margins of safety than the lifespan.

Even if some infrastructures are build for a relatively short lifespan (e.g. 50 years), in most of cases the nature of these infrastructures does not allow the dismantling of the whole asset, but “upgrading” it. Some infrastructures, especially pipes and sewers in urban areas, are expected to have a longer lifespan than the design periods. In the case of reservoirs, even if they would be filled with sediments after several decades of service, those infrastructures are unlikely to be dismantled, therefore critical parts of the infrastructure, such as spillways, should be designed taking into consideration much larger return periods and lifespans.

On the other side, other assets, such as rural water supply schemes, might have a shorter lifespan than the expected impact of climate change. Understanding the different lifespan of each asset might contribute to the building of resilient infrastructures at acceptable costs. The figure below shows how the use of increased return periods would lead to bigger and (sometimes) more expensive infrastructures.

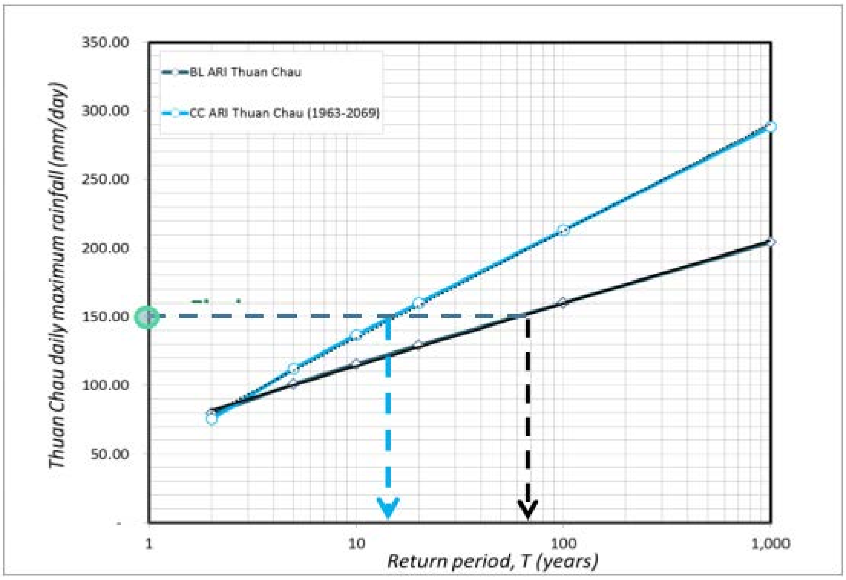

Figure 10: Frequency distribution of rainfall events for historical and climate change data in Thuan Chau district (Son La province). Source: ICEM, 2014, based on IMHEM predictions.

For shorter return periods (e.g. 10 years) the difference between the historic meteorological data and the CC predictions is small, 115 mm/day versus 140 mm/day. However, if the return period were increased (e.g. 100 years), the maximum rainfall would increase to 160 mm/day (without climate change considerations) and 210 mm/day with climate change considerations.

That example illustrates how for water and sanitation infrastructures that (in theory) will last longer, and require longer return periods[4], climate change considerations are much more important.

4. Climate proofing infrastructure: building more resilient infrastructures

Construction codes are important, but the final decision relies on the design engineering criteria. In that sense, putting emphasis on building climate-proof infrastructure is paramount to cope with future extremes.

Climate proofing usually refers to the process of crosschecking that all elements of a programme and its implementation, including specific measures and projects, address climate change issues (Hjerp et al 2012). That represents an approach to reduce the potential impacts of CC through anticipation and allocation of investments on specific measures. In that case, while the upfront costs of such an approach are usually higher than doing nothing or doing passive adaptation options, the estimation of overall socio-economic benefits and the potential losses and damages in case of disaster, tend to favour those options.

One example of climate proofing infrastructure is the extension of the capacities of storm retention reservoirs in urban areas. Those reservoirs can prevent flooding and avoid discharge of sewerage during storms. However, in the case of Vietnam, due to the generalized use of septic tanks as a pre-treatment before discharge in the sewerage network, the risk of pollution of receiving waters is minimized as sludge can is diluted during storms.

Other climate proofing solutions could be the protection of water treatment plants and WWTP from floods, through the construction of those plants in flood-free areas. In the case of WWTP, especially in lowland areas it might be technically complicated, and hence, other alternatives such as building a flood barrier around the plant could be an option. Those options are not new for Vietnam, but the long-term considerations of future climate scenarios are not always considered.

5. Using innovative technologies and solutions for climate proofing infrastructure

Many developed countries are starting to use Sustainable Urban Drainage Systems (SUDS) as an innovative approach to address the problem of water runoff caused by storms. SUDS offers several options to reduce the need of enlarging drains by increasing infiltration rate of rainwater. Permeable pavements, rainwater harvesting systems at the household level (in-house), rainwater butts (gardens), green roofs and green spaces, swales, infiltration ditches or filter drains are among the technological options that can contribute to increase the infiltration rate.

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[4] Lifespan is usually linked to longer return periods for design purposes. However, the return period is not equal to lifespan. For instance, critical infrastructures, such as dams, might be built for return periods of 1,000 or even 10,000 years, even if the lifespan is expected to be much lower.

However, a study carried out by the Institute European Environmental Policy (IEEP) on the cost-benefit of some climate change adaptation technologies, alerts that the annual investment needed to introduce those technologies in Europe would be as high as EUR 4,131 million (USD 4,544 million), but the benefit would be far less (between 325 to 3,041 million/year) (Hjerp et al 2012). Nevertheless, some of these alternatives have additional benefits such as the reduction of demand for drinking water as decentralized storage can increase self-consumption, and can also reduce the heat-island effect in cities and reduce CO_2.

6. Climate proofing infrastructures at household/community level

At the household and community level there are also alternatives to adapt to climate change. Oxfam is currently implementing the “water resources management and climate change” project in the delta province of Ben Tre. This project aims to improve resiliency of rural communities. The activities focus on:

- Improving rainwater collection systems at household and communal level
- Empowering women’s unions to manufacture ferro-cement storage tanks
- Engaging with water vendors to improve water quality and regulation for improved service provision
- Encourage the uptake of household latrines
- Engage in water resource management and facilitate the establishment of broader water safety plans.

Although the organisation recognises that some measures, such as rain harvesting, can contribute to reduce risks only in the short term, that project seems to be the best example of climate change adaptation in the WASH sector in rural areas of Vietnam.

In the long term, Oxfam’s proposal is to encourage long-term management strategies built on clear relationships between strengthened support institutions and private sector participants, and communities, acknowledging that the private sector has a key role to play in the distribution of safe drinking water in a region affected by rapid salinization of groundwater resources. At the moment, local water vendors provide treated water, sometimes with expensive RO equipment, at very high costs, that prevent the poorest households from having access to safe drinking water.

One of the CCA technologies that Oxfam is exploring for the long-term includes the use of mobile water treatment plants installed in boats that have the flexibility to move if salinity (or other) conditions affect the water intake (Oxfam, 2010).

7. Increase storage capacity (in reservoirs, ponds, rainharvesting and underground)

According to Dao Trong (2000), existing **reservoirs** can store only 6 % of total annually generated water resources. And for water coming from cross-national basins, mostly Mekong and Red rivers, the storage capacity is only 2.8 %. Storage capacity is essential in a country where 70-80% of rainfall occurs during the 4-5 months of rainy season, and with expected longer and dryer dry seasons due to climate change.

Even if the storage capacity at river basin level is limited, and even if one of the most evident CCA measures would be to increase the number of reservoirs, the country can still improve the management of the existing infrastructures. As explained in section 4.2.1, IWRM and river basing planning is still limited in Vietnam. Reservoirs can be multipurpose, in fact it should be multipurpose, and the different uses (hydropower, irrigation, water supply, flood control, etc.) can be compatible with better management and coordination between the different users.

At the moment Vietnam is investing in new dams that are expected to generate renewable energy, thus contributing to reduce greenhouse emissions. Those dams can also contribute to adapt to CC, by increasing the storage capacity, and by laminating water runoff.

In a lower scale, **community ponds** are also good alternatives to ensure access to water in case of droughts. In the Cambodian lower Mekong, community ponds are the main source of water in the dry season when most of shallow wells dry up as a consequence of overexploitation of the aquifer. Although that phenomenon seems to be less frequent in Vietnam, the climatic trends and the increased demand for water (especially for irrigation), suggest that this might be a mid-term adaptation measure in some plain and coastal areas.

Groundwater counts for a significant proportion of water supply, especially in rural areas, but also in large cities like Hanoi. However, as explained before, groundwater might be less reliable in the future, especially in coastal areas affected by seawater intrusion. Some **alternatives** include the creation of a super sea dike in Rach Gia bay in the delta province of Kien Giang. That sea dike of 30-47 km would close the bay and store fresh water for the region (Trinh Thi, 2014). In the central province of Thua Tien Hue, the provincial authorities are planning the construction of Thảo Long, and Cửa Lác dams to fight salinity intrusion (HUEWACO, 2014).

Rainwater harvesting is currently being promoted in several coastal areas affected by seawater intrusion. In Ben Tre province, local authorities provide a subsidy of VND 4 million (USD 200) to support households building these systems. However, these systems are relatively basic with limited roof guttering and no pre-storage filtration systems. Storage facilities often do not sufficiently reduce the potential for mosquito breeding. Furthermore once household water containers are filled, no secondary options exist for maximizing rainwater retention or recharging brackish or saline groundwater wells.

According to OXFAM (2010), who is promoting those systems, the design can be strengthened with the introduction of “first flush” runoff systems, filtration systems and appropriate water storage to minimize the potential for mosquito breeding. Rainwater collection systems and their design could be improved to maximize rainwater collection at household and communal level, and to maximize groundwater recharge to reduce salinity levels.

Artificial aquifer recharge, the process of artificially recharging aquifers by infiltrating water through permeable media or by direct injection through boreholes, is an adaptation method used throughout the world. The aim is to store water in a suitable aquifer during times when water is available, and recover water from the same aquifer when it is needed. Large volumes can be stored underground, reducing or eliminating the need to construct surface reservoirs and minimizing evaporation losses (Bantram & Howard, 2010). In Tra Binh city, the water utility is planning to build a retention reservoir in an abandoned branch of Lang The River. That reservoir would have an estimated capacity 0.7 Hm^3, and, apart from water supply, the reservoir could be eventually used to recharge the aquifer (TRAWACO, 2014).

8. Coastal protection ditches and other "grey infrastructures"

The Mekong Delta Plan (GoV, 2013) suggests to revise the land use and productive orientation of the region, and to replace grey infrastructures and ditches for natural mangroves and aquaculture in brackish areas (e.g. shrimp production). Those recommendations are contradictory with other master plans that promote construction of hundreds of kilometres of ditches along the coast and protecting urban and industrial areas. Unfortunately, the provincial initiatives lack a river basin vision, where protective actions in one province can exacerbate the negative impacts in nearby provinces.

That said, it is clear that "grey infrastructures", such as river embankments, ditches, tide gates and elevation of some areas are an alternative to consider; especially taking into account the high importance that both Vietnamese design engineers and decision makers give to those types of options.

Nevertheless, Vietnam should also learn from other countries experience like the Netherlands where "grey infrastructures" and "flood prevention" are moving into a more adaptive "flood control"

Case study 6: The Netherlands moving from "flood prevention" to "flood control"

For centuries Integrated Water Resources Management in the Netherlands put the emphasis on flood control, rising dikes each time a historic flood proved existing infrastructures insufficient. That approach to flood prevention evolved in the 90s from fighting against the rising tide to living with and adapting to it.

Adaptation to climate change is regarded as a matter of national security. Rising sea levels will result in an increased likelihood of flooding. The issue has been on the political agenda for many years, especially in the context of water management, costal protection, and land use planning. In 2007, the Netherlands enacted its national program for adaptation.

Furthermore, the Netherlands is adopting approaches aimed at carefully "accommodating, rather than resisting", flood waters where possible. The essence of this principle is: flexible integration of land in sea and of water in land, making use of materials and forces present in nature. The Netherlands plan to return 90,000 hectares of land to floodplain buffers for use as marshland or natural forestland. They have placed a moratorium on new flood- prevention infrastructure in some towns and are lowering, repositioning, or removing some dikes. This marks a significant change in the way they think of water management (Waterman, 1991).

9. Modifying the hydraulics of rivers

In Vietnam, some provincial master plans and flood control plans include measures such as dredging and "cleaning" of vegetation riverbeds in order to facilitate the flow of water and reduce the risk of floods. Dredging can increase the hydraulic radius, and cutting vegetation on the floodplains can reduce the roughness; both contributing to increase the capacity of evacuation of water.

In Vietnam, river embankments made of concrete blocks are more frequent than other more environmentally friendly alternatives such as controlled development of river vegetation, vegetated rip raps, live stake planting or dry fascines.

However, although those measure modify the hydraulics of rivers and increase the capacity of rivers to quickly evacuate water during floods; a deeper analysis of the impact of those measures, at least in some cases, should be considered. The following case study in Spain shows the complexity, and the side effects, of interventions along the riverbeds.

Case study 7: Ebro river (Spain) and the importance of keeping riverbeds "clean"

In February this year the floods at Ebro River in Spain reached the highest level in a decade. Although the amount of water was 9% lower than 2003 floods, the water level was 10% higher. (CHE, 2015).

Farmers along the river blamed the "mismanagement" of the riverbeds. For years, the Environmental Department prevented cutting vegetation on the riversides, what increased roughness and served as a barrier. Besides, river embankments carried out to protect urban areas (e.g. is Saragossa city) contributed to change the hydraulic dynamics of the river, in some cases acting as natural barriers.

Interventions in the riverbeds have to be carefully planned with a river basin prospective, not provincial level as sometimes happens. Increasing the velocity of the flow, or reducing it, have an impact both downstream and upstream. Dredging can have a positive impact during the rainy season, but the consequences of dredging have to be considered also for the dry season, especially in the delta areas, where dredging could increase salinity intrusion.

10. Managing rainwater through separated drains instead of combined sewer systems

The vast majority of sewerage systems in Vietnam are combined (WB, 2013). However 40% of urban dwellers are still not connected to any kind of sewerage system, and the vast majority of them are in small cities and towns where there is complete absence of sewerage systems.

That absence offers the opportunity to plan from scratch the entire sewerage network and to introduce separate sewerage systems. There is an intense debate in Vietnam, and most probably in other parts of the world around the vantages and disadvantages of combined vs. separated systems. From a climate change adaptation prospective, a separated system would avoid that large amounts of rainwater are mixed up with sludge, forcing WWTP to be oversized to cope with those peaks.

Detractors of separated systems, argue that both installation and O&M costs are much higher. An alternative solution could be to build storage systems that can intercept and store the combined sewer overflows until they can be conveyed to the WWTP. Inflow controls can also be a good alternative, such as introducing special gratings and restricted outflow pipes, or capturing runoff and retaining the flow before it reaches the sewer system (Bantram & Howard, 2010).

11. Adapting latrine designs for flood prone areas

In areas that are prone to floods or where water tables are high, latrine designs might be challenging. That might be the explanation why the Mekong region, even if is very dynamic and more developed than other regions in Vietnam, still has one of the highest concentrations of Open Defecation in the country (Jensen et al, 2012). Climate change will exacerbate those problems and can contribute to damages in the infrastructures and pollution of the environment.

However, several adaptations can be made to the latrines to reduce their vulnerability to floods and rising groundwater, and to reduce their impact on the local environment; the latrines can be raised on mounds so that the depth of the pit does not extend deep into the ground; short-life pits can be introduced; the pits can be emptied regularly to reduce the volume of waste in the pits and to avoid the need to construct new pits each time one fills up; and covers can be fitted to the pits to prevent the release of solids during floods (Bantram & Howard, 2010)

4.2.3 Non-structural options for CCA in the WASH sector

1. **Combining poverty reduction with climate change adaptation**

A technical USAID mission to Vietnam concluded that “Poverty is at the root of heightened vulnerability to the risks and hazards associated with climate change. While dikes and other infrastructure investments can help Vietnam to respond to the anticipated impacts of sea level rise and other long term consequences of climate change, continued progress with poverty reduction, especially among the rural poor and most vulnerable groups is critically important and should be fully integrated into responses to climate change and associated development programs” (USAID, 2011).

A recent vulnerability assessment carried out by UNDP, highlighted that the most vulnerable areas to climate change were the Northern mountain provinces and the central highlands where the vast majority of ethnic groups and poverty is concentrated (Wilderspin, 2013).

In the estimation of the Integrated Risk Index (IRI) the reduced copying capacities of poor communities increased the climatic risks, even if other provinces such as the coastal areas are more exposed to climatic hazards such as the sea level rise or typhoons.

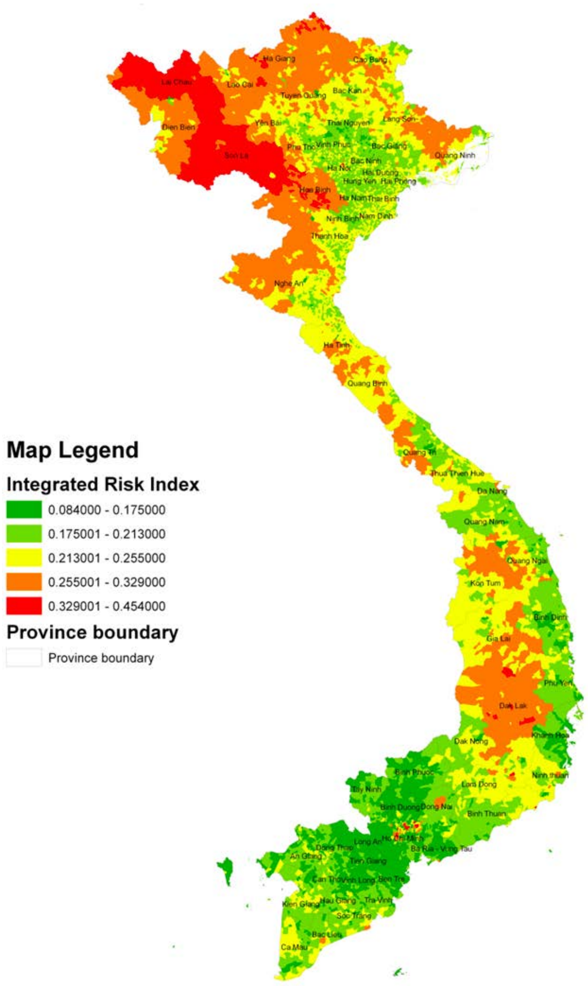


Figure 11: Vulnerability Index. Source: Wilderspin, 2013

2. Hygiene promotion and vector control

Climate change is expected to affect mortality and morbidity by creating favourable environments for, and altering the distribution of, climate-sensitive infectious diseases, particularly water-borne diseases.

For example, warmer climate often increases the risk of mosquito-transmitted diseases such as dengue fever and malaria. It does so by shortening disease incubation time and breeding cycle, and by increasing feeding frequency. In the case of dengue fever, disease transmission from mosquitoes to humans becomes more efficient in high temperature. In addition, reduced availability of safe drinking water caused by droughts, floods, or intrusion of warmed salt water into fresh water due to sea level rise increases the risk of diarrheal diseases (Kazuyuki, 2012).

Surprisingly, the climate change scenarios also consider the positive impact of socio-economic development, and when including those aspects in the equation, the negative impact of climate change is lower than expected. A recent WHO research (WHO, 2014) on the impact of climate change shows the following predicted impacts:

- About 5% of the global malaria cases, or 21 million cases, would be attributable to climate change in 2030
- The impact of climate change on the distribution of dengue is still uncertain, and related to influencers of several co-acting factors such as urbanization and population movements
- 3% of global diarrheal cases, or 132 million, were projected to be attributable to climate change in 2010

The options to fight against those diseases are yet conventional; promoting more hygienic practices; and establishing some vector control measures (such as spraying the most affected areas, etc.)

3. Early warning systems

Early-warning systems can be defined as a set of capacities needed to generate and disseminate timely and meaningful warning information to enable individuals, communities, and organizations threatened by a hazard to prepare and to act appropriately and in sufficient time to reduce the possibility of harm or loss (UNISDR, 2015).

Vietnam already has a centralized early-warning system. In the main rivers there are early warning systems in place. A country assessment report of hydro-meteorological services carried out in 2013 identified the following systems:

River/Basin	Software model used for flood forecasts
Tuyen Quang reservoir inflow on Lo river	TANK model; the Muskingum-Curge and reservoir water balance method
Hong river basin	SH2 model; using SSARR model and forecasting error update
Red River system for Hanoi forecast station	MIKE 11
Ca river system	NAM; Muskingum-Curge models
Vu Gia- Thu Bom river system	NAM and Hydraulic model; Wetspa and HECRAS model

Tra Khuc river	SSARR model; HMS-HecGeoRAS
Mekong river	Nam and hydraulic models

Table 4: Rainfall-runoff models used for flood forecasting in Vietnam. Source: National Hydrological and Meteorological Services (NHMS), United Nations International Strategy for Disaster Reduction (UNISDR), World Meteorological Organization (WMO). 2013

Surprisingly there is no standardized system to model river basins and to establish early warning systems.

It would be interesting to analyse the accuracy of those models and to propose a benchmark. At the same time, one of the modelling experts interviewed advised that those software models are calibrated based on the empirical results of using the code QP-TL C-6-77, guidelines calculating characteristics of hydrologic design. Those guidelines were developed almost 40 years ago, for only a few provinces in the North, and based on empirical and out-of-date formulas used in a completely different context (rivers in the North-West of Russia). The "calibration" process with the results of using C-6-77 guidelines could lead to significant errors in the development of the models and the early warning systems, and the update of those guidelines should be a priority.

A joint assessment carried out by the National Hydrological and Meteorological Services (NHMS), the United Nations International Strategy for Disaster Reduction (UNISDR), and World Meteorological Organization (WMO) in 2013, identified the following needs:

- Increase the number of Automated Weather Stations (AWS)
- More adequate and site-specific weather forecasts and flood forecasts and better dissemination
- More real-time weather and hydrology data, and radar images; and better dissemination
- Better forecasts and analysis and explanation of outlooks on droughts
- Better information on climate variability
- Better database of natural disasters, losses and damages; with focus on climatic disasters
- Assessment of vulnerability towards natural disasters, and inundation and flood hazard maps
- Regional cooperation and data sharing

Furthermore, a combination of national/river basin systems with local early-warning systems might be the most appropriate solution. Some community-based early warning systems, already piloted by some NGOs like CARE, could contribute to increase resiliency of communities. Knowing that dissemination of weather forecasts and alerts is not always properly done and site-specific, the use of locally managed Early Warning Systems, such as flood marks, could reinforce the existing mechanisms at national level.

4. Improve Operation and Maintenance (O&M) of infrastructures

Operation and maintenance (O&M) is critical to keep most of the water and sanitation infrastructures functional. However, according to one senior staff of an international organisation, Vietnam invests far less in O&M than required.

The author has seen rural water supply systems build under the National Target Programme on Rural Water Supply and Sanitation (NTP-RWSS) that are completely dysfunctional just 6 months after construction.

In urban water supply, public utilities use their limited resources to expand the network rather than to reduce NRW, which could eventually increase the revenues at a relatively low cost. In Danang, the reduction of NRW from 40% to around 15%, made DAWACO (Danang Water Company) be profitable for the first time, thus reducing dependency from government funds and allowing the company to invest in the expansion of the network with their own resources (Vitens Evides International, 2014).

Septic tanks in both rural and urban areas are emptied only when there is a problem, like the toilet does not flush or the tank overflows and affects the neighbours (according to a URENCO staff). If drains are not regularly cleaned at least one time before the beginning of the rainy season, the effective hydraulic radius is reduced and sewers can be easily blocked.

The problems of inappropriate O&M are not new, but in the context of climate change, those problems could be exacerbated. Reduced water availability during the dry season is expected to emphasize the importance of NRW. Increased frequency and intensity of storms are expected to cause more problems of overflows and blocked sewers, if O&M investment does not increase.

5. Community Based Disaster Risk Management (CBDRM)

Community Based Disaster Risk Management (CBDRM) is one of the most promising options to adapt to climate change in rural areas. CBDRM was introduced 10 years ago by some NGOs, such as CARE, Oxfam and Plan International.

In 2009, the Vietnamese government adopted the concept of CBDRM and developed a national strategy on CBDRM targeting 6,000 communes (60% of the country). According to one of the stakeholders that has been active in developing CBDRM in the country, the policy focus on preparedness, but very little on risk reduction.

The government-led CBDRM focuses mostly on reforestation and sensitization campaigns, and the budget investment relies on ODA (45%), with 50% of government funds, and 5% of community participation (CARE, 2014). Some organisations estimate that not more than 500 communes have been reached so far, less than 10% of the target.

Some activities included under CBDRM are hazard mappings, historical timelines, community meetings, activities in schools, and the creation of village/commune committees for disaster management (UNISDR/ Plan international, 2013). When communities carry out their own risk assessment, WASH is usually highlighted as one of the most critical and vulnerable sectors.

According to CARE (2010), some of the recommendations to fully benefit from CBDRM would include:

- To identify good practices and DRR champions in the country, systematizing all the experiences on CBDRM over the last 10 years
- To strengthen capacities at sub-national level, especially at provincial level, so they can provide support and orientation to the communities
- To prioritise investment in non-structural options, rather than infrastructures
- To identify more sustainable funding mechanisms, either through a 100% government-paid scheme, or through other modalities of climate funding (e.g. Support Programme to Respond to Climate Change in Vietnam (*SPRCC*))

- To promote healthy competition between provinces for budget allocation on CBDRM initiatives, what can incentivize provincial authorities to do more and better
- To improve coordination between CBDRM and other government programmes, such as the New Rural Development programme.

6. Water Safety Plans (WSP)

The water safety plan is a flexible approach that systematically assesses and manages risks in order to ensure the safety and acceptability of a drinking-water supply (WHO, 2009).

The impacts of climate change on water quality can be also assessed through a risk assessment and risk management process, both at community and at utility level, which includes all steps in water supply from the catchment to the final consumer. The implementation of WSP consists of three main components that are further described below:

I. System assessment: which determines if the drinking water supply chain as a whole is capable of supplying water of sufficiently high a standard to meet regulatory targets
II. Operational monitoring: in order to identify control measures in the drinking water system
III. Management plans: which document the system assessment, describe actions taken during various operational conditions and define monitoring and communication plans.

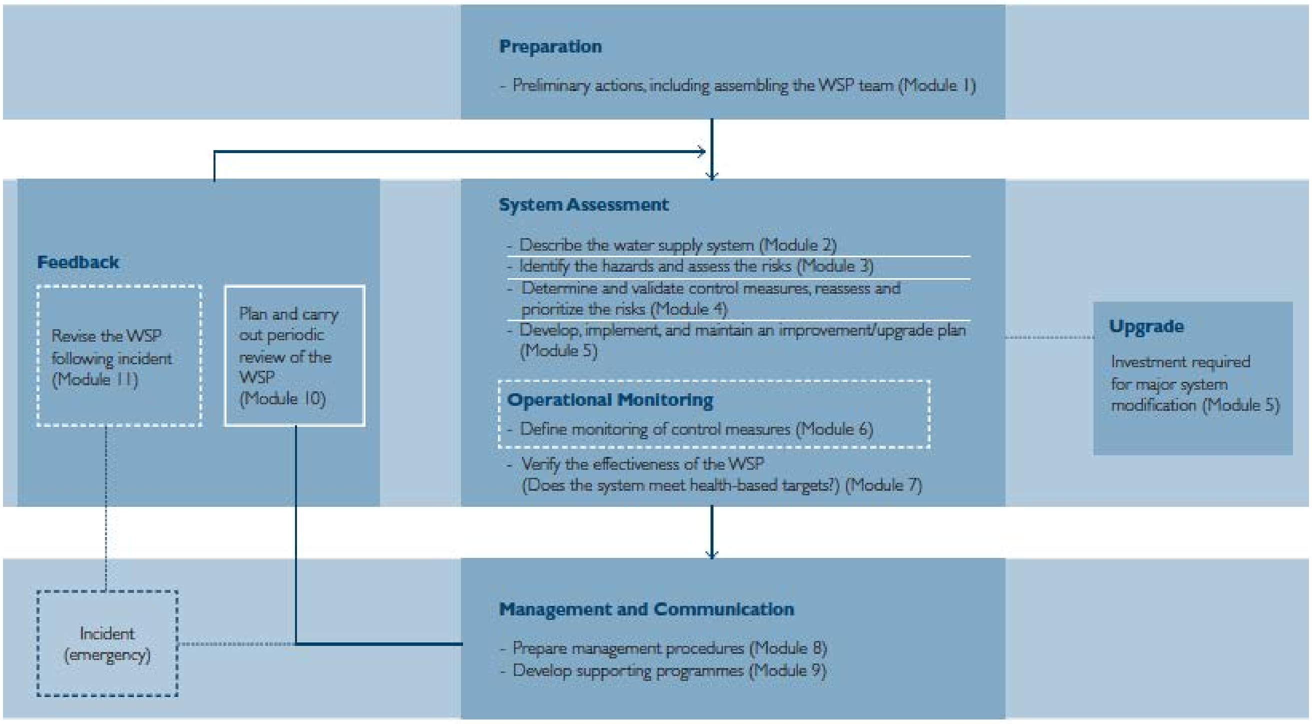


Figure 12: Step-by-step modules to prepare a WSP. Source: WHO, 2009

Case study 8: WSP in Hue urban water supply

HueWACO (Hue Water Company) is one of the best water operators in the country, and one of the pioneers developing WSP with consideration to climate change adaptation. HueWACO operates the water supply of Hue city, in central Vietnam, as well as 30 small utilities in the province.

The national policy framework was supported by a number of provincial policies such as: the Action Plan No. 64/KH-UBND on "Protecting the environment to fight climate change in the province of Thua Thien Hue, 2011-2020"; the "Disaster Risk Management" Plan of the province until 2020 under Decision No. 1113 / QĐ-UBND dated 06.14.2010; or Resolution No. 8i / 2010 / NQCD-dated 02/06/2010 on thorough "protection planning and development of Thua Thien Hue forestation period 2009-2020" (Nguyen Thi, 2014)

The provincial action plans include the construction of a new reservoir (*Tả Trạch)*, and Thảo Long and Cửa Lác dams to fight salinity intrusion.

Besides structural options, HueWACO is in close coordination with disaster management committees during floods to; quickly dismantle mobile treatment plants, ensure proper functionality of generators to provide power during blackouts, revising potential leaks and damages of the network, and provide public awareness.

HueWACO WSP include post-disaster interventions, such as distribution of water through water-trucking if the network fails, financial support for affected households, and distribution of chlorine tablets for households not connected to the network (Nguyen Thi, 2014).

As part of its CC adaptation plans, the utility is developing DAF technology for water reuse from aquaculture farms, and treatment of water with high concentration of algae and organic wastes, or changing the water intakes on Hương river to abstract water from the surface of the river, where salinity is lower.

At the time of writing this report, this public company was drafting the "Action plan to fight Climate Change for water resources of HueWACO"

But WSP can also be used in small-scale water supply systems, as some community-managed water schemes that Oxfam is supporting in Ben Tre province.

Case study 9: Using WSP in Community Based Water Resource Management (CBWRM) interventions in Ben Tre

Oxfam's Community Based Water Resource Management (CBWRM) approach is based on WHO´s WSP (Oxfam, 2010). The CBWRM includes the following steps:

- -- Identify key stakeholders (including managing institutions and end water users) to be involved within Binh Dai and Tanh Phu districts
- -- Describe the process and system to stakeholders
- -- Undertake hazard assessment and risk identification alongside stakeholders
- -- Identify means by which risks may be controlled
- -- Define monitoring requirements, which essentially means establish benchmarks by which risk controls can be measured

-- Establish procedures to verify that control measures and monitoring is effective

-- Develop support tools, such as IEC materials for household water storage and treatment and hygiene messages

-- Prepare management procedures that should be undertaken during normal and incident or emergency settings. This compliments the disaster risk reduction planning training already provided by Oxfam;

-- Establish documentation and communication tools so that improvements are made through action research or learning by doing, which is essentially good project cycle management.

7. Raising awareness among population

In 2009, the World Bank carried out a study on public attitudes toward climate change in several countries including Vietnam. Out of the 15 countries analysed, Vietnam ranked 4th in terms of level of concern; with 69% of the citizens considering the threat as "very serious", and 21% as "somewhat serious".

86% of Vietnamese respondents considered that climate change was harming people substantially "right now"; and 77% considered that the government was not doing enough. However the percentage of respondents that estimated that people would have to move their house to another location was just 42% (WB, 2009). That could be consistent with the wrong perception in Vietnam that the government will build thousands of kilometres of ditches to prevent sea level rise, and that mitigating or adapting to climate change is a task that has to be done by the government.

In that sense, the Vietnamese population seem to be quite aware of the problem of climate change, even more than the average of the countries analysed, but in terms of individual actions to cope with climate change, the level of awareness might be less. This is especially expected in a communist-led country, where the solutions to the big problems are expected to be solved by the State.

A USAID report on CCA in Vietnam suggested expanding geographic coverage and frequency of Information Education and Communication (IEC) for issues such as climate change awareness, sea level rise, disaster preparedness, adaptation strategies, forest practices and water quality, safe drinking water, and waste water treatment and water quality. Another recommendation was on the use of IEC to strengthen social institutions and local governance capacity in ways that contribute to managing and reducing risks associated with climate change, and to help to increase the resiliency of the poor and enable them to adapt to the challenges and opportunities associated with climate change (USAID, 2011).

8. Introduce more flexible approaches

In the Netherlands, the Flooding Defence Act (1996) mentions the safety standards for all water defences varying from one in 10,000 to one in 1,250 years. Every 5 years the Minister has to determine the decisive water levels matching these frequencies. Since these decisive levels will determine the height of the embankments, the most recent knowledge on climate change is incorporated every 5 years into the design of the flood defence (PWC, 2010).

The following case study shows how Vietnam urgently needs to revise the calculation of thousands of infrastructures built in the 60s and 70s based on short climatic series (10 years as an average) and to consider other aspects such as land use changes over time and climate change.

Case study 10: Predicting flood discharges in Núi Cốc dam

In 1972 Núi Cốc dam was built in Thai Nguyen province, in Northern Vietnam, using the time series of rainfall at Dai Tu station from 1961 to 1972. With that short data records the designed one-day maximum rainfall was 125 mm (frequency of 1%), and the designed maximum discharge was 1645m^3/s.

The 4th November 1978, one-day rainfall reached 475.1 mm and the flood caused breaks of the transitional parts of the dam and landslide of the dam slope and shoulder.

Today, with longer meteorological data records (1961 to date), the 1% frequency one-day maximum rainfall would be 437 mm (frequency 1%) and the maximum discharge is 3035 m^3/s (Nguyen Hung, 2014).

Using the same design criteria but with a large historic record (now over 50 years) the size of the spillway would be more than two times the initial design criteria (from *1460 m^3/s to* 3035 m^3/s), and this significant increase of the spillway doesn´t even consider other aspects that should be also taken into consideration, such as the need to increase the safety level, land use changes (especially deforestation) and climate change.

The cost of recalculating the existing infrastructures and adapting them to the actual circumstances, only for critical infrastructures such as dams, would costs hundreds of millions of dollars countrywide (author´s estimation).

Under these circumstances, considering as well the future climate change scenarios and forecasted land use changes, might multiply the costs. For Núi Cốc dam, the spillway might easily have to be increased to triple the existing size.

For that reason there is need to introduce a flexible approach that allows design engineers not just to base their calculations on meteorological historic data, but also to forecast the future scenarios and to include some additional margins of safety.

Modifying the spillway capacity of Núi Cốc dam would be extremely costly, and in some cases technically complex. The additional benefits of building a more resilient infrastructure today might not be seen immediately but will appear in the decades to come.

9. Relocation

Relocation might be perceived as the last resource, and is included here because this is a realistic option in some lowland areas that will be affected by sea level rise. Vietnam tends to look at countries like the Netherlands, where one third of its population lives under the sea level, but the Dutch experts that contributed to the development of the Mekong Delta Plan appear to say: “Do not follow us” (GoV, 2010).

The recommendations included in the Mekong Delta Plan contradict some of the previous regional and sectorial master plans for the Mekong Delta. The “safe, prosperous and sustainable” vision includes the recommendation to adopt a dual coastal zone management strategy. With the outer zone explicitly focused on the creation of a healthy brackish/saline zone with and integration and restoration of mangroves in combination with poly-aquaculture.

5 Conclusions and recommendations

Compared to other middle-income countries, Vietnam is better prepared to cope with climate change. However, Vietnam is among the countries most heavily affected by the consequences of climate change, and the consequences of SLR for Vietnam are “potentially catastrophic” and demand “intermediate planning for adaptation” (WB, 2007).

According to Dasgupta (2007), 10.8% of Vietnam’s population, mostly people living in the two river deltas, would be impacted by a Sea Level Rise (SLR) of just 1 meter as a consequence of climate change. Vietnam has done more preparation than similar developing countries, but that is because Vietnam has to do more to cope with a larger risk.

The analysis of the policy framework illustrates the significant effort made by the Vietnamese government to create the foundation for climate change adaptation. The country has a large number of master plans, strategies and programmes that contribute to a solid policy framework both at the national and sub-national levels.

However, as with many other countries, Vietnam still has to improve its practical implementation of climate change adaptation measures. The National Target Programme to Respond to Climate Change (NTP-RCC) is a promising initiative, but the resources allocated so far are very limited.

Vietnam is positioned as one of the main recipients of climate funding globally, and has access to a variety of instruments. However, it still lacks proper mechanisms to efficiently and effectively manage those funds. Several initiatives have been successfully piloted, but then the scaling up has been very limited. Two of its very few success histories are the National Biogas Programme and the Community Based Disaster Risk Management (CBDRM) programme.

A lot of research and knowledge has been generated for the Mekong Delta, with the Mekong Delta Plan as the best example of solid scientific research combined with applied technologies. A lot of resources have been invested in research and in master plans, however both scientists and local officials feel frustrated by the lack of political commitment and funding to carry out the ambitious measures that this region requires to adapt to climate change.

This research aimed to contribute to the knowledge already generated by addressing the following objectives: (i) To identify the main risks and vulnerabilities that the water and sanitation sector is facing with respect to climate change; (ii) to identify lessons from the international practise in climate change adaptation in WASH which can be applicable for the Vietnamese context; (iii) to identify and analyse possible options for climate change adaptation in the WASH sector in Vietnam; and (iv) to provide some recommendations to decision makers on the priorities and potential climate change adaptation options.

In order to address the first research objective, the author carried a vulnerability assessment. Chapter 3 uses CAM (Climate Change Adaptation Methodology) to identify the most vulnerable assets and/or the most vulnerable areas that would require additional effort. The findings of this exercise shall be used just as a reference, as it is very difficult to generalise and analyse all the water and sanitation infrastructures as a whole. However, the exercise highlights that floods and sea level rise (SLR) are the main hazards to water and sanitation infrastructures. The levels of exposure, sensitivity and impact are quite high in general for most of the assets analysed, with “low” and “very low” adaptive capacities in general. The combination of relatively high impact with low coping mechanisms contribute to increased vulnerability of most of the types of infrastructure analysed.

This finding is interesting, as the results tend to highlight as the most vulnerable areas the Mekong Delta and low land areas affected by SLR and floods. However, other general vulnerability assessments carried out in the past (e.g. Wilderspin & Le Dang, 2013) tend to highlight the Northern Mountainous provinces and the Central Highlands, where poverty levels are higher, as the most vulnerable areas.

The correlation between poverty and vulnerability to climate change is clear; and poverty reduction is an important tool to adapt to climate change; but in the specific case of the water supply and sanitation sector, the environmental and physical conditions appear to be more important than the socio-economic aspects related to coping capacities.

The second objective of the research was the analysis of the international practice. That analysis shows that among the developing countries, Vietnam is quite in the vanguard; and that most countries, both developing and developed, are struggling with similar problems.

All countries in the world are dealing with high levels of uncertainty about the climate change scenarios, which obliges decision makers to develop more flexible approaches. Everybody agrees on the need to start now, although the adaptation process, especially in the WASH sector, is a long-term process.

Unfortunately there are not silver bullets, and in most of the cases solutions have to be tailored to the local context, even within the same country, although there seem to be some common trends related to the prioritization of no-regret and low-regret options.

In terms of practical adaptation to climate change, the country already has had some successful cases that are worthy of dissemination and replication countrywide. Nevertheless, it is important to mention that practical implementation of climate change adaptation in the WASH sector is still incipient globally; therefore Vietnam can learn as much from the outside as it can learn from its own case studies.

The Mekong Delta, again, has attracted a lot of research and practical solutions, such as switching water supply from groundwater resources to surface water. However those solutions - and this is clear for this example - are specific for that context.

The Vietnamese society is concerned about climate change, but this does not immediately convert into real actions. As seen throughout the document, the policy and systems are already in place, but the real activities still lack concretion and realization.

The usual barriers that WASH practitioners experience in their day to day work, such as lack of capacities, limited investment or weak O&M, become stressors that contribute to make the process of CC adaptation more difficult.

The good news is that the technological options are already available, and in some cases are as simple as greater awareness of the potential future changes, either climatic or other type, and acting accordingly in the project cycle.

The fourth chapter of the document is intended to respond to the third objective of the research, on possible options to adapt to climate change.

The entire section 4.2 includes a set of options that have been organized in three groups: policy options, structural and non-structural. From the revision of those options, the conclusions of the fourth research objective can be extracted.

There is need to put more emphasis on the design phase, and especially on the adaptation of construction codes and standards. Vietnam has an extensive and not always consistent system of construction codes. The process of updating those codes is not always done with the level of detail that is advisable. As a consequence, several critical infrastructures, such as dams, but also drains, have very low resiliency to existing environmental conditions.

Improving Integrated Water Resources Management (IWRM) is one of the main recommendations made by most of the informants, and is one of the most urgent measures to properly adapt to climate change. In that sense the need to develop river basin authorities is also one of the most important barriers to improved adaptation to climate change.

The structural solutions represent a relatively smaller part, in comparison to the recommendations at policy level, or the non-structural solutions. The need to orient the efforts to those non-structural aspects is also one of the recommendations to the Vietnamese decision makers. Usually those options are cheaper and easy to implement than large–scale grey infrastructures.

Another area of improvement for Vietnam is on the Early Warning Systems (EWS) both at national and sub-national levels. In addition, there is need for the improvement of Water Safety Plans (WSP) and Operation and Maintenance (O&M) of infrastructures. Lifespan of rural infrastructures is relatively limited due to substandard O&M investments. Low tariffs in urban water and sanitation limit the potential to expand or provide better services.

Grey infrastructure investments, especially in urban areas, shall be properly estimated in terms of cost-efficiency and cost-benefit; and have to combined with a variety of non-structural solutions. In that sense, mid and small-size Vietnamese towns still lack any drainage or sewerage network; and that offers a golden opportunity to design efficient systems from the scratch.

Vietnam is on the right path, and has shown political will and some good progress at the policy level. However, the practical implementation of projects and initiatives shows that the process of proper climate change adaptation in the WASH has just started, and has a long way ahead.

Annexes:

Annex 1: Snapshot of Vietnam

Source: World Bank Databank, 2015

Geography and Land Use

Location: Southeast Asia, bordering the Gulf of Thailand, Gulf of Tonking and East Sea, alongside China, Laos PDR and Cambodia.

Total area: 3331,210 Km^2; land area 310,070 Km^2; water area 21,140 Km^2;

Total land boundaries: 4,639 km

Coastline: 3,444 km (excludes islands)

Terrain: low, flat delta in South and North; central highlands; mountainous in North and Northwest.

Elevation extremes: 0 sea level, 3,144 Fansipan peak.

Land use: 20.14% arable land, 6.93% arable crops; 72.93% other.

Irrigated land: 30,000 km^2

Total renewable water resources: 891.2 km^3/year

Freshwater withdrawal: 71.3 km^3/year; per capita 847 m^3/year; 8% domestic, 24% industrial, 68% irrigation.

Natural hazards: occasional typhoons (May to January) with extensive flooding, especially in the Mekong Delta.

Main environment issues: logging and slash-and burn agricultural practices contribute to deforestation and soil degradation; water pollution and overfishing threaten marine life populations; groundwater contamination limits potable water supply; growing urban industrialization and population migration are rapidly degrading environment in Hanoi and Ho Chi Minh City (HCMC).

Climate

Tropical/monsoonal in the South; monsoonal in the North, with hot, rainy season (May to October) and warm, dry season (November to April).

Frequent tropical cyclones affecting the northern and central regions. They also occur in southern areas but less frequently.

The seasonal distribution of rainfall is closely related to the monsoons. Rainfall intensity can be high, producing a rapid rate of runoff and serious flooding.

Annual rainfall: 1,800-2,500 mm. Approximately 70% of the rainfall occurs during the main rainy season.

Because of its low coastal topography, the country is exposed to the high winds and storm surges brought by tropical cyclones.

People

Population: 90.73 million (2014)

Life expectancy: 71.7 years

Ethnic groups: Kinh (86.2%), Tay (1.9%), Thay (1.7%), Muong (1.5%), Khome (1.4%), Hoa (1.1%), Nun (1.1%), Hmong (1%), others (4.1%) (1999 census)

Literacy rate: 90.3%

Government

Government type: Communist state

Administrative divisions: 58 provinces (tinh) and 5 municipalities (thanh pho)

Economy

Income level: Lower middle income

GDP: USD 186.2 billion (current) (2014),

GDP growth: 6.0% (2010-2014)

GDP per capita: USD 2,052 (2014)

GDP distribution: 20.7% agriculture, 40.3% industry, and 39.1% services

Labour force: 43.87 million, 51.8% agriculture, 15.4% industry, 32.7% services, unemployment rate 7.5%.

State budget: revenues (US$21.89 billion), expenditures (US$30.42 billion) (2009)

Population below poverty line: 12.3% (2009)

Water and Sanitation (JMP, 2015)

Water supply: 99%, urban 99%, and rural 97%

Sanitation: 83%, urban 99%, rural 74%

Annex 2: Overview of the water and sanitation sector in Vietnam

Over the last three decades, Vietnam has experienced remarkable socio-economic development. Starting from 1986, the Đổi Mới (renovation) introduced a “socialist-oriented market economy” that liberalised the economy and modernised the country.

The latest report of the Joint Monitoring Programme (JMP) for Water Supply and Sanitation (WHO/UNICEF JMP, 2015) shows how the socio-economic development experienced countrywide has also impacted the water and sanitation sector.

Since 1990, the coverage of improved water supply has increased from 90% to 99%, and in rural areas has increased from 56% to 97% (WHO/UNICEF JMP, 2015). However, this statistics might not reflect properly the use of improved water sources in rural areas, as many piped water supply systems are dysfunctional (based on author´s experience).

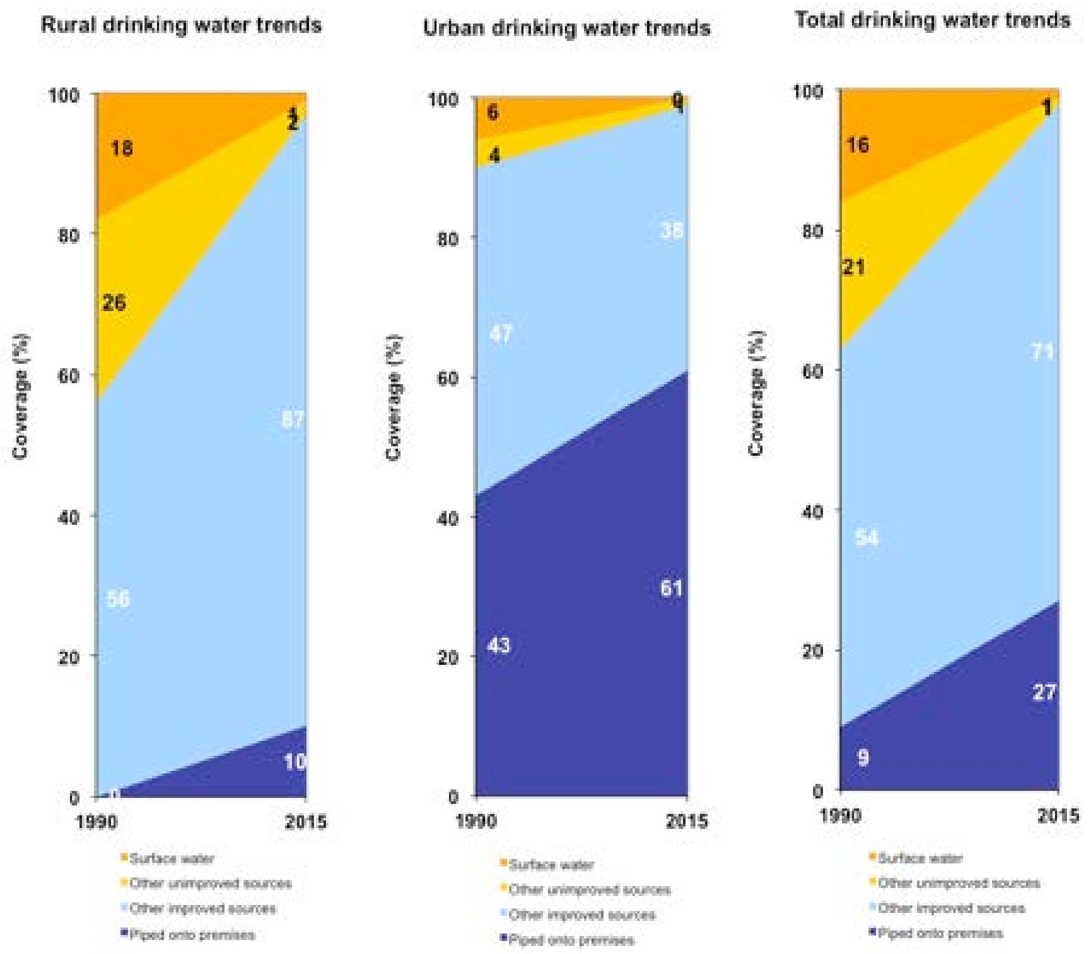


Figure 13 : Progress of drinking water trends -both rural and urban- in Vietnam 1990-2015. Source: WHO/UNICEF JMP, 2015

Sanitation coverage has also increased from 69% to 99% in urban areas, and from 31% to 74% in rural areas (WHO/UNICEF JMP, 2015). Open defecation has dropped from 43% in 1990 to 1% and is mostly practiced by ethnic minorities. According to JMP figures that represents over 600,000 people; however some authors (UNICEF, 2014) estimate that the total population practicing open defecation is 3.7 million.

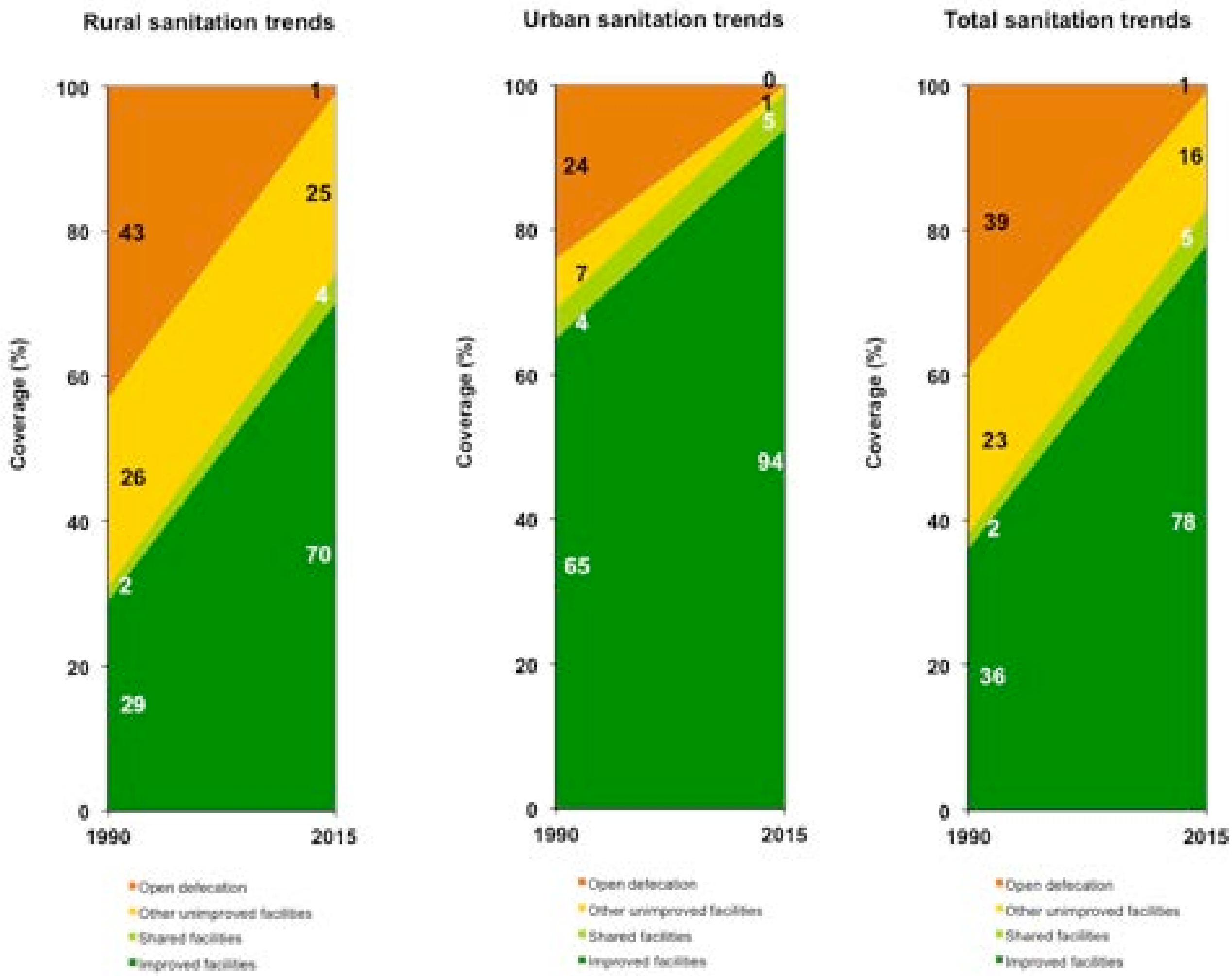


Figure 14 : Progress of sanitation trends -both rural and urban- in Vietnam 1990-2015. Source: WHO/UNICEF JMP, 2015

2.1. Urban water supply

The urban population has rapidly increased in Vietnam since 1990. According to the General Statistics Office (GSO) urban population represented 20% of the total population (14 million) in 1990, and has expanded to more than 31 million today (34% of total population). Currently urban population is growing at 2% per year (VIHEMA, 2012). This figure might not consider migrants from rural areas that move to cities pursuing better opportunities.

That rapid increase of population has represented a significant challenge for Vietnamese authorities. While in 1990, 6 million urban citizens had piped water into their premises, that figure has multiplied three times to reach 18.9 million.

Increased coverage of urban water supply 1990-2015					
Year	Total improved	Piped onto premises	Other improved	Other unimproved	Surface water
1990	90%	43%	47%	4%	6%
1995	92%	47%	45%	3%	5%
2000	94%	51%	43%	3%	3%
2005	95%	55%	40%	4%	1%
2010	97%	59%	38%	3%	0%
2015	99%	61%	38%	1%	0%

Table 5: Urban water coverage estimates 1990-2015. Source: WHO/UNICEF JMP, 2015

The Ministry of Construction is responsible for urban water supply and sanitation. One of the keys to success in the rapid increase of coverage, especially in larger cities, is the remarkable investment in the construction and extension of infrastructures. In some cases, connection fees are subsidized for the poor, and even water tariffs are regulated. Those pro-poor support mechanisms have contributed to increased access to utilities for poor and nearly poor families living in the outskirts of cities, however the low tariffs represent a risk of sustainability for most utilities.

According to VIHEMA (2012) In Vietnam, there are 68 water utilities, providing water to urban areas. Surface water sources account for 70% of the total source water and the remaining 30% is ground water.

In most of the cases, water utilities operate as public companies receiving an annual subsidy from the local People´s Committee. Without that government subsidy, utilities would not be able to continue expanding their networks; and in some cases, tariff revenues alone would not be enough to cover O&M costs.

The private sector is increasing its presence and investment in urban water supply, with some private operators being part of joint investment companies.

Besides tariffs and sustainability of water utilities, some other problems still persist. 38% of urban population still lack a piped water supply, and in many cases rely on alternative water sources (such as wells) that are difficult to control and might be polluted.

Small towns usually lack the investments that other bigger cities receive. A World Bank research study carried out in 2003 showed that only 30 % of small towns had piped water systems, and that the connection rate ranges from 20 to 80 % in those small towns. That situation has not change significantly, and according to the World Bank currently only one third of district towns have piped water. Even if in some cases population living in small towns have access to piped water, service levels are usually substandard, with water being available only a few hours, or with problems of turbidity or quality.

Decision No 1929/QD-TTg sets a goal to meet 100% of the demand for water use with a norm of water usage of 120 L/capita/day and reduction of non-revenue water down to 15% and 24 hours/day water supply service in all urban areas in Vietnam by the year 2025.

2.2. Rural water supply

Rural water supply coverage has rapidly increased over the last decades. Based on the information published on the General Statistics Office (GSO) website, rural population increased from 55 million in 1990 to 65 million in 2015, and improved water supply increased from 56% in 1990 to 97% in 2015, which means that over 32 million additional people achieved improved water supply over the last 25 years.

Increased coverage of rural water supply 1990-2015					
Year	Total improved	Piped onto premises	Other improved	Other unimproved	Surface water
1990	56%	0%	56%	26%	18%
1995	64%	1%	63%	19%	17%
2000	72%	4%	68%	15%	13%
2005	80%	6%	74%	12%	8%
2010	89%	9%	80%	7%	4%
2015	97%	10%	87%	2%	1%

Table 6: Rural water coverage estimates 1990-2015. Source: WHO/UNICEF JMP, 2015

The progress made over the last 25 years is extraordinary, however there are some aspects that put those achievements in question. According to research carried out by SNV (2010), up to 50% of rural water supply systems are dysfunctional or sub-standard. Some piped water schemes stop working after few months of operation due to lack of involvement of users in the O&M of the systems, and due to the lack of capacity of PCERWASS (Provincial Centres for Rural Water Supply and Environmental Sanitation) to manage and monitor those systems.

The Ministry of Agriculture and Rural Development (MARD), through the National Centre for Rural Water Supply and Environmental Sanitation (NCERWASS), is the main body responsible for the coordination and implementation of rural water supply activities.

Most of rural water supply investments have been channelled through the National Target Programmes in Rural water Supply and Sanitation (NTP-RWSS). The first NTP ran from 2000 until 2005, the second ran until 2010, and the current NTP-3 will finish at the end of 2015. From 2015 onwards, the New Rural Development programme is expected to merge many National Target Programmes into a single strategy.

According to JMP figures, 87% of rural households rely on other improved water sources such as wells, springs or rainwater harvesting. In some cases, the availability of those alternative (and safe) water sources reduce willingness to pay and use and maintain piped water systems. Provincial authorities are sometimes afraid of the political consequences of rising water tariffs, and thus set a cap of tariffs that in many cases cannot cover even the most basic operational costs (i.e. in Lao Cai province in 2013 the maximum tariff for rural water supply schemes was a mere 1,500 VND/m3 (0.07 USD/m3) in comparison with an average of 0.26 USD/m3 in urban schemes).

Very limited involvement of communities in the decision making process for designing, building, and managing rural water schemes, leads to large investments being wasted, and unsustainable systems that are at risk of being dysfunctional very soon.

2.3. Urban sanitation

Urban sanitation has also experienced a significant improvement over the last 25 years. According to the General Statistics Office (GSO) urban population represented 20% of the total population (14 million) in 1990, and has expanded to more than 31 million today (34% of total population). While in 1990, 9.6 million urban citizens had access to sanitation, that figure has multiplied three times to reach 30.7 million.

Increased coverage of urban sanitation 1990-2015				
Year	Improved	Shared	Other unimproved	Open defecation
1990	65%	4%	7%	24%
1995	71%	4%	8%	17%
2000	77%	4%	8%	11%
2005	83%	5%	8%	4%
2010	88%	5%	7%	0%
2015	94%	5%	1%	0%

Table 7: Urban sanitation coverage estimates 1990-2015. Source: WHO/UNICEF JMP, 2015

One peculiarity of the Vietnamese urban sanitation sector is that almost all households have a septic tank, even those connected to a sewer.

The Vietnam Wastewater Review, produced by the World Bank provides a better analysis of the current situation and its challenges.

The investment in urban sanitation has been USD 2.5 billion since 1995, around 0.45 of Vietnam´s GDP annually (USD 150 million/year) (based on WB, 2013).

Besides construction of drains and sewers, there are more than 20 wastewater treatment plants constructed and around 30 are in design or construction phase (different sources, including WB report).

However, there are several critical issues related to wastewater treatment and disposal. 60 % of households dispose of wastewater to a public sewerage system, primarily comprised of combined systems.

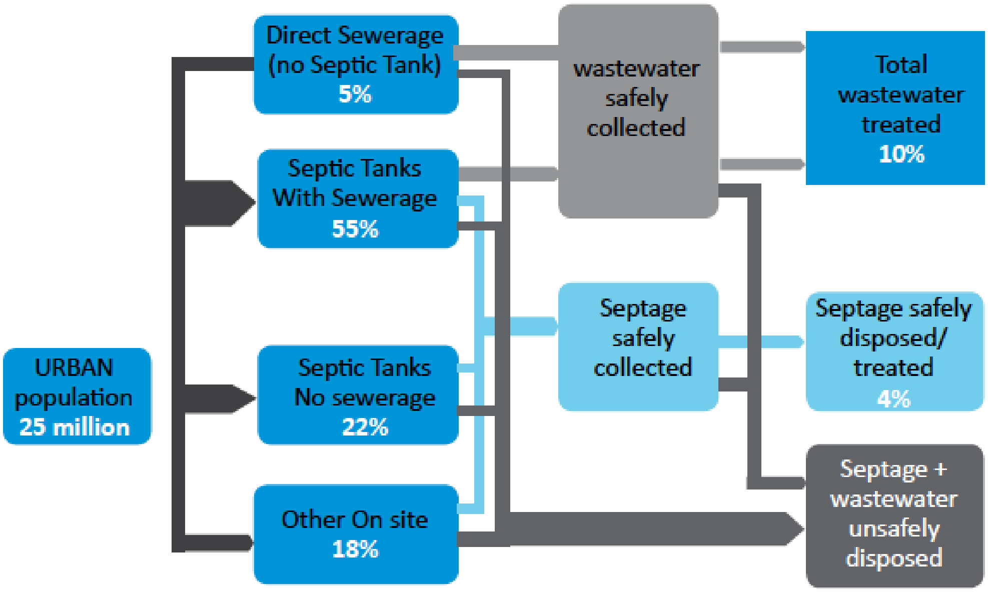


Figure 15: Status of urban wastewater use in Vietnam. Source: World Bank, 2013

While the majority of households dispose of wastewater to septic tanks, only 4 % of sludge is treated. Faecal sludge management is poor in most cities (WB, 2013).

Several wastewater treatment plants have been built, in some cases using state-of-the-art technologies, however there is no full cost recovery due to the high costs and low tariffs (being in most of the cases, 10% of the water tariff revenues).

Due to the fact that there is primary treatment in septic tanks and in most cases, cities have combined systems (with rainwater), influent is sometimes so diluted that it meets the effluent standards, thus making the WWTP unnecessary.

The World Bank estimates that an additional USD 8.3 billion will be required before 2025 in order to provide sewerage to a growing urban population.

2.4. Rural sanitation

Rural sanitation has also experienced a remarkable and sustained progress over the last 25 years. Open defecation, which was practiced by more than 23 million people living in rural areas, now is practiced by 1% of the population. However, that mere 1% still represents between 0.6 to 3.7 million people, depending on different sources.

Rural sanitation promotion has also evolved over the years, from subsidy-based and government promoted interventions, towards a wider variety of interventions involving CSOs as well as the private sector, and involving innovative methodologies such as CLTS, Sanitation Marketing or output-based support mechanisms.

Increased coverage of rural sanitation 1990-2015				
Year	Improved	Shared	Other unimproved	Open defecation
1990	29%	2%	26%	43%
1995	37%	2%	27%	34%
2000	45%	3%	27%	25%
2005	53%	3%	28%	16%
2010	62%	4%	27%	7%
2015	70%	4%	25%	1%

Table 8: Rural sanitation coverage estimates 1990-2015. Source: WHO/UNICEF JMP, 2015

Leading agencies have also evolved over the last years. While during the implementation of the National Target Programmes phase 1 (2000-2005) and phase 2 (2006-2010), the Ministry of Agriculture and Rural Development was responsible for promotion of rural sanitation. For the on-going NTP-3, the Ministry of Health, and more specifically the Vietnamese Health Environment Management Agency (VIHEMA), is the entity responsible for the coordination and promotion of rural sanitation and hygiene.

Annex 3: Institutional framework and policy development on climate change in Vietnam

3.1. Institutional framework of WASH and climate change in Vietnam

The following government institutions have different roles and responsibilities related to climate change:

Government institutions	Roles and responsibilities
Prime Minister	Although climate change initiatives and responsibilities are the responsibility of different ministries, he provides ultimate approval on all climate change policy instruments, including the National Target Programme to Respond to Climate Change (NTP-RCC). The Prime Minister is also the head of the National Steering Committee on Climate Change, while the Ministry of Natural Resources and Environment (MONRE) has secretariat and coordination functions.
National Council of Sustainable Development	Is responsible for the implementation of the Strategic Orientation for Sustainable Development in Vietnam (Agenda 21). The Deputy Prime Minister is the chair, and includes around fifty members from ministries, the private sector and government-related unions. The objective is to organize and facilitate cross-sector and cross-regional activities in terms of planning and implementation of the Vietnam Agenda 21.
Ministry of Natural Resources and Environment (MONRE)	Is the main ministry with respect to climate change issues. Its primary responsibility is oversight and facilitation of environmental quality standards, land administration, and sustainable natural resources use and conservation. It's roles also include Integrated Water Resources Management (IWRM) at river basin level, although river basin authorities and structures are still incipient. MONRE plays a key role in both climate change adaptation and mitigation, being the focal point responsible for implementing the UNFCCC, the Kyoto protocol and Clean Development Mechanisms (CDM). MONRE is also the coordinator and main implementing agency of the National Target Programme on Response to Climate Change (NTP-RCC).
Vietnam Institute of Meteorology, Hydrology and Environment (IMHEM)	Is a governmental, research and implementation institution under the Ministry of Natural Resources and Environment (MONRE). IMHEM conducts application research in meteorology, hydrology, oceanography and the environment, and is the main knowledge hub on climate change in the country. In partnership with the main climate change research institutions, IMHEM is responsible of the development of climate change scenarios and predictions.
Vietnam National Mekong	This committee is under MONRE and is responsible for oversight of the Mekong River Commission (MRC). The Mekong River Commission was created in 1995 by the governments of Cambodia, Lao PDR, Thailand,

Committee	and Vietnam, for the Sustainable Development of the Mekong River Basin. The national committee participates in the implementation of the MRC Climate Change Adaptation Initiative, which includes the establishment of a Mekong panel on climate change and a network of demonstration projects throughout the Lower Mekong Basin.
Ministry of Agriculture and Rural Development (MARD)	Is responsible for rural development, governance, and the promotion of agriculture, fisheries, forestry, and irrigation in Viet Nam. There are several departments and institutes under the Ministry. In relation to the topic, MARD is the standing chair of the Central Steering Committee for Flood and Storm Control (SCFSC), responsible for organizing responses to natural disasters. MARD is also a member of the Climate Change Steering Committee (CCSC) in supervising, guiding, and facilitating agencies to implement climate-change-responsive agriculture and rural development projects. In that role, MARD is responsible for areas such as irrigation, water management, forest and marine biodiversity. Within the WASH sector, MARD is responsible for the rural water supply sub-sector, and coordinates the implementation of the NTP-RWSS (National Target Programme on Rural Water Supply and Sanitation).
National Centre for Rural Water Supply and Sanitation (*NCERWASS*)	Is a centre that depends directly on MARD. NCERWASS is the MARD body responsible for assisting the implementation of programs and projects in the country and abroad in the field of water supply and rural sanitation in Vietnam (according to Decree No 86/2003 / ND-CP dated 18/7/2003), although at the moment, it mostly focuses on rural water supply. The Provincial Centres for Rural Water Supply and Sanitation (*PCERWASS*) play the same role at provincial level, and in some cases are responsible for the O&M of rural schemes.
Ministry of Planning and Investment (MPI)	Is responsible for state management of planning and investment, including national socioeconomic development plans, and official development assistance throughout the country. According to the national strategy on climate change (2011), MPI is the main implementer in "designing and realizing the framework standards for inserting climate change topic into socio-economic development strategies, programs, schemes and plans". MPI also provides advice to municipalities in its water and sanitation investments.
Ministry of Construction (MOC)	Is responsible for urban and regional infrastructure planning and development control, including investments in urban water supply and sanitation. It administers the national building codes (including water and wastewater standards) and, through its urban planning institutes, prepares plans for most cities, towns, and other settlements in the country, in addition to supporting MONRE in preparing their land use plans. The Ministry of Construction has extensive responsibilities for promoting and implementing climate change adaptation and mitigation measures in the built and urban environment.
Ministry of Health (MoH)	Is responsible for the governance and guidance of the health, health care and health industry of Vietnam. In this role, MoH is also responsible for drinking water quality monitoring. Since 2010, the Vietnam Health Environment Management Agency (VIHEMA), dependent of MoH, is the

	entity responsible for the coordination and promotion of rural sanitation and hygiene.

Table 9: Key roles and responsibilities of government institutions in relation to WASH and climate change. Source: different government websites and ADB,2013

According to the National Strategy on Climate Change, other ministries, ministerial agencies and government agencies are also responsible for the implementation of the strategy within their ambit and functions. Provincial and Municipal People's Committees are also responsible to implement local action plans, to mobilize forces and to periodically report on implementation. CSOs and the private sector are also invited to support and promote community participation in responding to climate change.

3.2. Policy framework on climate change

The policy framework on climate change is well developed and includes strategies, plans, and one National Target Programme to Respond to Climate Change (NTP-RCC). At the national level, 5 out of the 13 main strategies for the period 2011-2020, are related, with climate change, green-growth or environmental protection. That shows a very strong commitment from the political leadership to change the productive system into a green-growth economy, addressing the challenges of climate change, both on mitigation and adaptation.

This section includes an overview of some policy documents that regulate the water and sanitation sector and climate change adaptation in Vietnam. Those key policy documents are:

Key strategies related to sustainability and climate change

- National Strategy on Climate Change
- National strategy on environment protection to 2020, with visions to 2030
- Vietnam Sustainable Development Strategy for 2011-2020.
- Socio-Economic Development Plan (SEDP) for 2011-2015
- Strategic Orientation for Sustainable Development in Vietnam (Agenda 21).
- Second National Strategy and Action Plan for Disaster Mitigation and Management 2001-2020.

Other key laws and strategies related to the WASH sector and climate change

- Law on Water Resources.
- National Target Program to Respond to Climate Change (NTP-RCC)
- Ministry of Agriculture and Rural Development (MARD) Action Plan on Climate Change.
- Ministry of Agriculture and Rural Development (MARD) National Target Program for Rural Water Supply and Sanitation for period 2012-2015.
- Mekong Delta Plan (MDP).
- Climate Change Adaptation Provincial Action Plans.
- Climate Action Plan for Hue city.
- Action Plan on Disaster Risk Management and Climate Change Adaptation in Rural Water Supply and Sanitation in Dien Bien province horizon 2020.

National Strategy on Climate Change. Was approved by the Prime Minister in 2011 (Decision 2139/QĐ-TTg) and is the main strategy on addressing climate change in the country. The two main targets are: (i) To bring into play the whole country's capacity in simultaneously taking measures of adapting to impacts of climate change and cutting down greenhouse gas emission; (ii) To strengthen people and natural systems' adaptability to climate change while developing a low-carbon economy in order to protect and improve quality of life, guarantee national security and sustainable development in the context of global climate change, and proactively work with the international community in protecting the earth's climate system.

Some of the specific targets include water security, poverty reduction, public health, natural resources protection, low-carbon economy, or improving awareness, responsibility and the capacity of coping with climate change.

The strategy defines "strategic missions" as follows:

1. Proactively coping with natural disasters and monitoring climate
2. Guaranteeing food security and water resource
3. Actively responding to sea level rising in line with conditions of vulnerable regions, including the development of infrastructures that can resist level-9 storms and tide with frequency of 5% and prevent inundation of urban areas, industrial plants and big residential zones, as well as developing large scale and multi-purposed works, reservoirs, buffer zones and green belts.
4. Protecting and developing forests sustainably, increasing the absorption of greenhouse gases and preserving biodiversity
5. Reducing greenhouse gas emissions to protect the Earth's climate. In the water sector, this includes; (i) planning schemes for waste management in order to minimize recycle and reuse wastes for lower emission of greenhouse gases; (ii) promotion of research and introduction of advanced waste treating technologies; and strengthening of the management, treatment and reuse of industrial and domestic sewage. By 2020, 90% of the total volume of urban domestic solid wastes should be gathered and treated, in which 85% is recycled and reused.
6. Strengthening the key role of the State in responding to climate change
7. Building communities which can effectively cope with climate change
8. Developing advanced science and technology to cope with climate change, with emphasis on climate change monitoring and forecasting, as well as on adaptation to CC, including technological transfer.
9. Promoting international cooperation and integration while raising the nation's status in dealing with climate change issues
10. Diversify financial resources and boost effective investment

The National Strategy on Climate Change defines a strategy for 2050, with horizon on 2010. But in the short term, it defines programmes and projects to be checked, designed and implemented by 2015:

- National Goal Program on Climate Change, with a plan for expansion in 2016-2025;
- National Scientific and Technological Program on Climate Change;
- Plan on modernizing forecast technology and hydro-meteorological observatory network up to 2020;
- Program on water management and adaptation to climate change in the Mekong and Red River Deltas;
- Plan to appraise and monitor greenhouse gas emission and manage activities of reducing greenhouse gas emission;
- Program on responding to climate change in Viet Nam's large urban areas;

- Program on upgrading and improving the system of breakwater and river dikes in conformity with climate change and sea level rising;
- Plan on upgrading the community health care system in line with climate change and sea level rising;
- Program on socio-economic development in residential islands in response to climate change and sea level rising;
- Plan on piloting and popularizing models of community effectively coping with climate change.

National strategy on environment protection to 2020, with visions to 2030. Was approved by the Prime Minister (Decision 1216/QĐ-TTg) and its main objective is to promote environmental protection, pollution prevention, area-specific environmental management, and biodiversity conservation. The strategy includes the solutions to improve sanitation in urban and rural areas:

- To plan, build and operate concentrated sewage collection and treatment systems in urban areas of grade IV and higher;
- To inspect and monitor treated sewage from industrial parks, complexes, export processing zones, and hospitals;
- To take both State budgets and ODA capital to realize programs and projects on improving and recovering lakes, ponds, canals, channels and river sections in urban and residential areas; especially projects under the National Goal Program on Pollution Mitigation and Environment Improvement;
- To combine plans on urban embellishment, upgrading and completing sewage and rainwater drainage systems, building concentrated sewage treatment systems and plans, programs and projects on improving and recovering lakes, ponds, canals, channels, and river sections in urban and residential areas.
- To amend and raise environment protection fees imposed on domestic and industrial sewage progressively in line with environment pollution levels to gradually compensate for costs of treating domestic sewage and boost social investments in sewage treatment.
- To accelerate the realization of the Orientations for Water Supply Development in Urban and Industrial Parks in Viet Nam to 2025 and Visions to 2050;
- To survey and evaluate the total demand for clean water as well as the supply, including infrastructure, volume and quality, and plan the supply so that everyone can get clean water for their daily activities;
- To continue the implementation of the National Goal Program on Clean Water and Rural Environment Hygiene, focusing on regions with low percentage of residents with access to clean water or regions lacking water resources which can replace clean water; to invest and take ODA capital for upgrading, renewing and building clean water supply works in rural areas, especially remote regions;
- To speed up research and adoption of clean water supply technologies in order to secure sufficient supplies for people, especially in cases of floods, storms, and other urgent situations;
- To gradually narrow the water quality gaps between urban and rural areas, to apply uniform technical standards of domestic water quality both in urban and rural areas.
- To enhance general management of water resource in river basins, to combine planning schemes for the development of industries and sectors, especially those intensely consuming water, and plans on seeking and exploiting water resource. To tighten control over water pollution and pay attention to monitoring pollution in river basins and trans-border water sources;

- To strictly manage the exploitation of surface and underground water, especially in dry season; to apply quotas for underground water exploitation in specific regions; to review and readjust planning schemes for socio-economic development and industrial crop development in conformity with specific regions' surface and underground water potential;
- To renovate the regime of water irrigation for agricultural activities in order to improve efficiency of water exploitation and use in these activities; to popularize the payment for forest environment and ecosystem services in order to protect water sources.

The strategy also includes an ambitious set of indicators and targets for 2015 and 2020. Some of the actions included in that strategy are; the revision of the Land Law (2003), the amendment of the Law on Environment Protection (2005) and the development of the Law on Water Resources (new law, finally approved in June 2012).

Vietnam Sustainable Development Strategy for 2011-2020. Was approved by the Prime Minister (Decision No. 432/QD-TTg). The general objective is: "Sustainable and effective growth must come along with social progress and equality, national resources and environment protection, socio-political stability, firm protection of independence-sovereignty-unification and territorial integrity of the country." It includes other objectives such as macro-economic stability, food energy and financial security, to transform the growth model, low-carbon economic development, a democratic and civilized society, national identity, happiness, socio-political stability, sovereignty, and science and technology as a major driving force. It also includes mitigation objectives such as on exploitation of natural resources or prevention of environmental pollution or forest and bio-diversity protection. In terms of adaptation the objective is to reduce harmful effects of natural disasters, actively and effectively respond to climate change, especially sea level rise.

Socio-Economic Development Plan (SEDP) for 2011-2015. Was approved by the National Assembly (Resolution No. 10/2011/QH13) and is executed by the Ministry of Planning and Investment (MPI). The plan emphasizes actions to cope with climate change, promote the increase of forest coverage, improve water supply coverage, improve treatment of industry waste, improve treatment of solid waste and prosecute pollution violators. It also emphasizes the response to sea level rise and vulnerability of low-lying coastal regions.

Strategic Orientation for Sustainable Development in Vietnam (Agenda 21). The main objective of this document is to develop the institutional system supporting sustainable development in Vietnam, as well as to develop and implement the Agenda 21 at the local and sector level. In that sense, Agenda 21 is being piloted in 6 provinces: Son La, Thai Nguyen, Ninh Binh, Quang Nam, Lam Dong and Ben Tre; and in 4 sectors: agriculture, fisheries, industry and construction (ADB,2013).

Second National Strategy and Action Plan for Disaster Mitigation and Management 2001-2020. Was approved by the Prime Minister (Decision No: 172/2007/QĐ-TTg) in 2001 and prepared by the Standing Office, Central Committee for Flood and Storm

Control and the MARD-UNDP Disaster Management Unit (VIE/97/002). The strategy stress the importance of coexistence with floods, establishes disaster forecast centres, constructs flood corridors and flood retention areas in the Mekong Delta, and address short-term extreme weather events. This strategy contributed to the development of the Disaster Risk Reduction and Management Law that was approved in 2013. The State Budget Law No 01/2002/QH13, states that the central budget and the budgets of the local administration of all levels shall be entitled to include a reserve of between 2% and 5% of the total expenditure for prevention, combat and overcoming of consequences of natural calamities, fires, on the performance of important defence and security tasks and other urgent tasks, which arise beyond the estimates.

There are other additional strategies and plans, such as: the **Strategy on cleaner industrial production to 2020** (Decision 1419/QĐ-TTg) , mostly focused on climate change mitigation and environment protection; the **National Biodiversity Action Plan to 2010 and Orientations towards 2020** (Order No. 15/2012/L-CTN) that contributed to the development of the Law on Water Resources; or the **National Strategy on Disaster Risk Management to 2020;** and the **Ordinance of Flood and Storm Control,** that creates provincial and other sub-national DRR strategies and plans, and establishes provincial and district committees for flood and storm control.

Other laws

- Law on Urban Planning No 30/2009/QH12 dated 17 June 2009
- Law on Dyke No 79/2006/QH11

Other national regulations:

- Decree No. 120/2008/ND-CP on River Basin Management
- Ordinance on Prevention and Control of floods and storms and implementation provisions No 09-L/CTN
- Decision No. 172/2007/QĐ-TTg To Approve the National Strategy for Natural Disaster Prevention, Response and Mitigation to 2010
- Decree No. 181/2004/NĐ-CP on Implementation of the Land Law
- Decree No. 08/2005/ND-CP on construction planning
- Decision No. 581-TTg of July 25, 1997 promulgating the Regulation on Flood and Storm Warning
- Decree No. 14/2010/NĐ-CP on the Organization, Tasks, Powers and Coordination Mechanism of Central Steering Committee for Flood and Storm Prevention and Control, Committee for Flood and Storm Prevention, Control, Search and Rescue of Ministries, Agencies and Localities
- Decree No. 120/2008/ND-CP on River Basin Management
- Decision No.1002/QD-TTg To approve Project on Community Awareness Raising and Community Based Disaster Risk Management (CBDRM)
- Ordinance No. 27/2000/PL-UBTVQH10 amending and supplementing a number of articles of the ordinance on flood and storm prevention and combat.
- Prime Minister’s Decision No. 63/2002/QD-TTg of May 20, 2002 on the work of flood and storm prevention and combat as well as natural disaster reduction

- Decision No.312/QD-PCLBTW on regulations on reporting and information sharing for dealing with floods and storm
- Decree No 179/1999/ND-CP guiding the implementation of the Law on Water Resources (based on 1998 Law of Water Resources).

Other key documents

- Vietnam Communications to the UNFCC. First Communication 2003. Second Communication 2010. (MONRE, 2003; MONRE, 2010)
- IPCC Assessment Reports (AR). AR1 in 1990, AR2 in 1996, AR3 in 2001, AR4 in 2007, AR5 in 2014 (IPCC, 1990; IPCC, 1996; IPCC 2001; IPCC, 2007; IPCC, 2014)
- Rapid Assessment of the Extent and Impact of Sea Level Rise in Vietnam (Carewo-Reld, 2007)
- Mekong River Basin Water Resources Assessment. Impacts of Climate Change (Eastham, 2008)
- Study on climate change scenarios assessment for Ca Mau province (SIWRP, 2008)
- Vietnam Assessment Report on Climate Change (ISPONRE, 2009)
- Climate Change Sea Level Rise Scenarios for Vietnam (MONRE, 2009; second version MONRE 2012)
- Impacts of Climate Change on Water Resources and Adaptation Measures (IMHEM, 2010)
- Viet Nam special report on managing the risks of extreme events and disasters to advance climate change adaptation (IMHEM/UNDP, 2015)

Other key laws related to climate change and the WASH sector

Law on Water Resources. Was approved in 2012 (Decree 17/2012/QH13) and clarifies and strengthens the system of water licenses. The Law stipulates the rights and duties of water extraction and use, and designates MONRE and the Provincial People´s Committees (PPC) to carry out the granting, renewing, adjusting, suspending and revoking of licenses on water resources. The Law also stipulates that MONRE is responsible for carrying out basic surveys of water resources in strategies and plans. Those surveys must "*assess and give warnings and forecasts about the impacts of climate change on water resources, extraordinary developments in the quantity and quality of water resources and harmful effects caused by water" (Art. 12)*. Water Resources Strategy and Master Plans also have to consider the "forecasts of climate change on water resources " (Art 14). The Law requires climate change to be considered on reservoir construction, exploitation and use (Art 53).

National Target Program to Respond to Climate Change (NTP-RCC) Was adopted in 2008 (Decision No.158/2008/QD-TTg) and identifies climate change trends in Viet Nam as well as broad regional and sector vulnerabilities, and sets out legislative, planning, and investment priorities in response to climate change. The NTP-RCC identifies eight objectives for 2009–2015, providing financial and technical support for climate change planning across all sectors.

- To identify the extent of climate change in Vietnam due to global climate change and assess climate change impacts on every sector, area and locality;
- To identify measures to respond to climate change;
- To promote scientific and technological activities to establish the scientific and practical basis for climate change response measures;
- To consolidate and enhance the organizational structure, institutional capacity and the development and implementation of policies to respond to climate change;
- To enhance public awareness, responsibility and participation; and develop human resources to respond to climate change;
- To promote international cooperation to obtain external support in response to climate change;
- To mainstream climate change issues into socio-economic, sector and local development strategies, plans and planning;
- To develop and implement action plans of all ministries, sectors and localities to respond to climate change; to implement projects, and first of all pilot projects to respond to climate change

According to MONRE (2008), NTP-RCC contains few concrete policy commitments and rather constitutes a first step in directing ministries and provinces to formulate specific sector and regional plans of action based on more detailed impact assessments, and is predominantly focused on adaptation measures.

According to the NTP document, the budget for the period of 2009 - 2015 (excluding funds for the implementation of the Action Plans of Ministries, sectors, and localities) is estimated at 1,965 billion VND (93 million USD), of which 50% is expected to be ODA, 30% central budget, 10% local budget, and 10% private sector contributions. The total budget seems too low to carry out all the ambitious activities included in the NTP-RCC.

The GGBP website reported that six donors were funding NTP-RCC with USD 140 million for 2010, USD 220 million for 2011 and USD 260 million for 2012, which implies more ODA funding in one single year than what the government forecasted for the entire 6-year period.

That boost of funds contributed to the development of several policies and strategies, such as: the National Strategy on Climate Change (approved in 2011), the National Strategy on Green Growth (approved in 2012), the National Action Plan on Climate Change (approved in 2012), or the Party Central Committee Resolution on responding to climate change (approved 2013).

The NTP-RCC makes some references to water resources when analysing impacts: "Water resources are put under additional risks due to ever increasing droughts in some regions and seasons. This will directly affect agriculture, water supply for rural and urban areas as well as electricity generation". It also defines a list of tasks and projects to be implemented by 9 different ministries during the period, including developing and implementing action plans to respond to climate change in the three WASH-related ministries (MARD, MoH, MoC).

Ministry and Sub-national Action Plans on Climate Change

Since the approval of the National Strategy on Climate Change in 2009, most ministries have adopted sector Action Plans on Climate Change. A number of provinces have done it as well, and the main cities, such as HCMC, also adopted city Action Plans.

Ministry of Agriculture and Rural Development (MARD) Action Plan on Climate Change. Was approved in 2008 (Decision No: 2730 /Q-BNN-KHCN) and seeks to minimize its adverse impacts and to ensure sustainable development of the agriculture and rural development sector. In particular, there is a focus on:

- Ensuring the stability and safety of residents in cities and different zones and regions, especially the Cuu Long and Red River deltas and the central and mountainous areas;
- Ensuring stable agriculture production and food security in an agricultural area of 3.8 million ha with two seasonal rice crops;
- Ensuring the maintenance of dyke and infrastructure systems, as meets disaster prevention and mitigation requirements.

The specific objectives of the Action Plan includes:

- Develop a policy system integrating climate change into development programmes in the agricultural and rural development sector (hereafter called the sector). Define responsibilities of relevant agencies, funding sources and management mechanisms for the implementation of the Action Plan for Adaptation and Mitigation of Climate Change (hereafter called the AP);
- Develop an AP and propose support policies to regions affected by CC to ensure sustainable development of the sector;
- Strengthen research and CC impact projections in agriculture, water resources, forestry, salt production and rural development to provide scientific foundations for formulating policies, strategies and solutions for adaptation and mitigation to CC;
- Strengthen international co-operation, promote the linkage with international and regional programmes and receive technical and financial assistance from international communities in CC adaptation and mitigation;
- Develop human resources for implementing adaptation and mitigation policies;
- Enhance awareness of government officials, staff and communities in CC adaptation and mitigation in the sector;
- Ensure that rural communities receive equal benefits when implementing CC adaptation and mitigation policies.

The Decision includes a long list of activities that are part of that Action Plan; however in the field of water supply and sanitation there are only general activities for improved Integrated Water Resources Management (IWRM) and other activities such as:

- Study to forecast CC impacts on the performance of irrigation, drainage, saltwater intrusion, water supply, and river and sea dyke systems. Recommend solutions for planning the upgrading of those structures
- Study to forecast impacts of CC and adaptation measures on water balance in different economic zones and to identify potential areas of water stress
- Map out hazardous zones where flash floods, river and sea bank slides, storms, sea level rises, earthquakes, tsunamis and droughts may occur.
- Study impacts of CC on residential distribution, water supply and sanitation infrastructure development and recommend adaptation solutions

As can be seen, the “action” plan includes more research and studies, rather than actual adaptation measures.

Ministry of Agriculture and Rural Development (MARD) National Target Program for Rural Water Supply and Sanitation for period 2012-2015. Commonly known as NTP-3, was approved in 2012 (Decision No: 366/QĐ-TTg) and is the main governmental programme to "improve the situation of water supply and sanitation, increase the awareness of people, change behaviour and minimize the environment pollution, in contribution to improve health and living standards of rural people". The main objectives included in the third phase of the NTP are:

- Water supply: 85% of rural population have access to hygienic water, 45% of which have access to clean water according to Standard QCVN 02-BYT of MoH with provision of at least 60 litres/person/day.
- Environment sanitation: 65% of rural households have hygienic latrines; 45% households have hygienic livestock pens; 100% kindergartens, schools, clinics in rural areas have hygienic latrines.

Those percentages reflect an ambitious target to provide "hygienic water" (based on JMP standards) to 4.6 million people, or "clean water" (based on the National Standards) to 5.1 million people. Besides, plans to promote construction of 1.7 million of additional toilets, 5,500 school sanitation facilities, and 1.450 sanitation facilities in health centres.

The NTP-3 includes a reference to climate change in its principles: "Ensure the sustainable operation and proved effectiveness of upgraded or newly built RWSS facilities in the situation of climate changes and on the way to ensure supply of qualified water".

Mekong Delta Plan (MDP). Although is not technically a "strategy", the Mekong Delta Plan, approved in December 2013 after more than 3 years of research and discussions is, as stated in the front page, "*a long-term vision and strategy for a safe, prosperous and sustainable delta*". The strategic importance of the Mekong Delta in Vietnam, and the high vulnerability of the delta towards climate change, makes this document very relevant to address the challenges of climate change adaptation.

The Mekong Delta Plan is not fully compatible with several regional and sector master plans that have been developed in recent years such as the following Master Plans, related to the WASH sector:

- Master Plan of Drainage infrastructures for Mekong Delta toward 2020 (Decision 2066/QD-TTg 12/11/2010). Valid until 2020
- Master Plan of water supply infrastructures for Mekong Delta toward 2020 (Decision 2065/QD-TTg 12/11/2010). Valid until 2020
- Master Plan of water resources and irrigation systems for Mekong Delta in climate changes and sea level rise conditions (Decision 1397/QD-TTg 24/09/2012). Valid until 2020, with vision towards 2050:

Climate Change Adaptation Provincial Action Plans. It is difficult to estimate the number of provinces that currently have climate change adaptation plans, as Provincial People´s Committees only provide Vietnamese versions of its documents. According to "Green Growth Best Practice" website, in 2011, 6 out of 58 provinces had developed climate action plans. At the moment (July 2015), Winrock, a private firm, is developing climate change adaptation of provincial action plans in 5 coastal provinces located in the North of the country; Nam Dinh, Ninh Binh, Hai Phong, and Quang Ninh.

Climate Action Plan for Hue city. Several cities have also developed Action Plans and Strategies to adapt to climate change. In the case of Hue, a city of 1 million inhabitants located in central Vietnam, the action plan was developed with financial support from USAID in September 2014. The main goal is to strengthen resiliency in the city through the main objectives:

- Identify priority issues related to the vulnerability of agents and systems, and identify priority interventions for the short, medium and long term;
- Improve the awareness and capacity of related organizations, departments, agencies and civil society organizations and the community on climate change impacts, and assist them in developing and implementing Action Plans to respond to climate change;
- Prepare guidelines and promote the integration of climate resilience into policies and plans, such as sectorial development plans, urban development plans and city socio-economic development plans;
- Reinforce institutional structures and regulations related to climate change; and
- Establish mechanisms for sharing information across levels and sectors, and develop a systematic climate change database.

In particular for the WASH sector, the municipality plans to upgrade drainage works, dredge and re-enforce the Huong, Nhu Y and An Cuu rivers, install a new rainwater drainage system and built new pumping stations and floodwater retention lakes.

The Action Plan includes some specific adaptation measures such as:

- Develop and implement plans to build awareness of climate change and its impacts on vulnerable communities
- Adapt technical information on urban planning and climate change for public communication
- Build capacity in development and implementation of the climate action plan and integration of climate change into socio-economic development plans for provincial-level department staff and the People´s Committee of Hue city.
- Allocate annual budget for climate change in the city
- Establish synchronized mechanisms for planning, and develop transportation and water supply systems
- Establish a provincial-level climate change coordination office
- Review and develop measures to respond to problems arising in reservoir management and operation, and organize annual drills
- Review and adjust the new urban plan with consideration for climate change and its impacts on flooding in the city
- Institutionalize climate change integration into the process of construction planning, sector development planning and local development planning
- Apply new material and technologies in transportation infrastructure development to increase durability and tolerance to flood impacts
- Develop a floodway plan for the city and update the drainage plan with consideration of climate change
- Upgrade and dredge the drainage system and balance lake distribution in the Citadel area
- Develop flood control infrastructure for the city
- Establish an early flood warning system

Other cities, such as HCMC, Can Tho, Da Nang, Qui Ngon or Hanoi, also have similar instruments to guide the municipality to adapt to climate change. In this case, as those Action Plans have been recently developed, it is too early to confirm if the specific adaptation measures included in the plans will/can be put in place. Most of people interviewed fear that, without external support, municipal budget constraints might limit the real implementation of those Action Plans.

Action Plan on Disaster Risk Management and Climate Change Adaptation in Rural Water Supply and Sanitation in Dien Bien province horizon 2020. This Action Plan was supported by UNICEF and approved in 2014 (Decision #*:643/QD-UBND). It's goal is to* improve the capacity of disaster risk management and adaptation to climate change in the sector of Rural Water Supply and Sanitation until 2020. The provincial action plan has the main objectives:

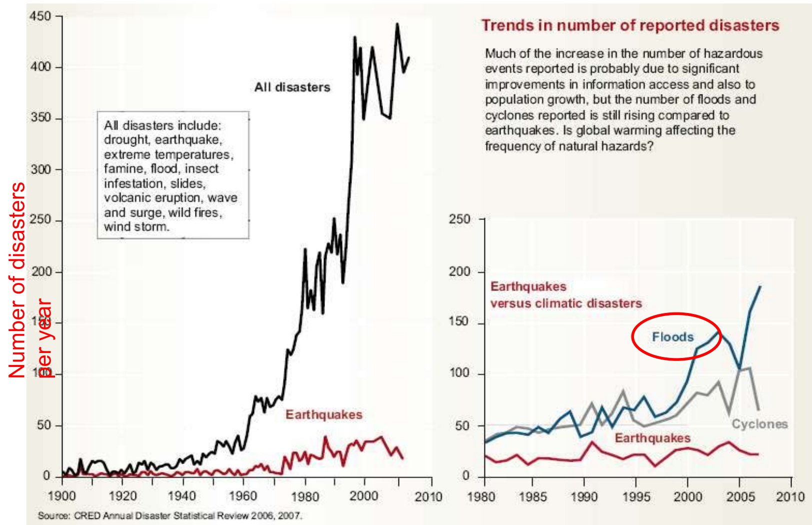
- Consolidating and strengthening the organizational, institutional, policy capacity of the provincial agencies, units on disasters management and climate change adaptation in the sector of rural water and sanitation.
- Training, improving the capacity of the agencies, units related to the disaster prevention and climate change adaptation in the sector of rural water and sanitation in Dien Bien province.
- Upgrading the rural water supply schemes (new construction and renovation) of Dien Bien province to withstand natural disasters. Until 2020, the following targets will be achieved:
  - Ensuring the supply of sufficient domestic water to the residents in the areas where droughts and water shortage usually occur in dry season;
  - The water supply schemes in mountainous areas are upgraded to be resistant to flooding rain, with management, operation and repairing processes in place after disasters to ensure their operation and that they not be destroyed by annual natural disasters, floodings;
  - The people have accessibility to clean water under the conditions of natural disasters.
- Maintaining and developing sustainable rural sanitation under the conditions of natural disasters and climate change. Until 2020, the following targets will be achieved:
  - Disseminating, instructing the building of hygienic latrines and sanitary livestock barns to all villages, 95% of mountainous households use latrines, the rate of access to hygienic latrines ranks above 75%.
  - 90% of rural livestock households with regulatory sanitary livestock barns.
  - 100% of the population in the areas where natural disasters often occur are aware of and guided on the best skills to display for personal hygiene and sanitation.
- Communication for awareness, and raising community participation.

This action plan is aligned with the Action Plan on Response to Climate Change of Dien Bien province approved by the Provincial People's Committee in 2012. The WASH Action Plan has been promoted by UNICEF, which is developing similar action plans in 8 provinces.

The WASH Action Plan includes a very detailed list of activities and expected budget, however the targets are extremely ambitious for the province´s capacities. The total budget for the period 2015-2020 is VND 250 billion (USD 11.9 million); while the estimated annual budget for sanitation is more than 600 times lower, around VND 400 million (USD 19,000). (verbal communication of Dien Bien DoH, 2012).

Annex 4: Understanding the impact of climate change in the WASH sector

The figure below shows how disasters related to extreme weather events are increasing its frequency. The IPCC is expecting this tendency to continue in the years to come, with more potentially damaging water-related disasters (e.g. floods).



Slide from S. Maskey (2010)

Figure 16: Trends in the number of reported disasters. Source: UNESCO-IHE, 2012

Dealing with uncertainty

Climate change scenarios are based on different scenarios that consider population projections, economic development, energy use and land use changes in the world. It is extremely complicated to make a proper forecast on how those variables will evolve in the next decades, and thus affect global emissions. It is also extremely complicated to make accurate climatic predictions.

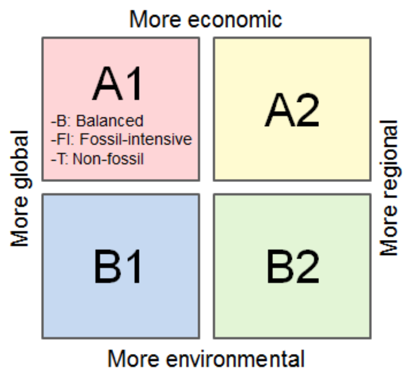


Figure 17: Representation of the main climate change scenarios, A1B, A1FI, A1T, A2, B1, B2 based on the different variables considered. Source: climate4impact.eu website

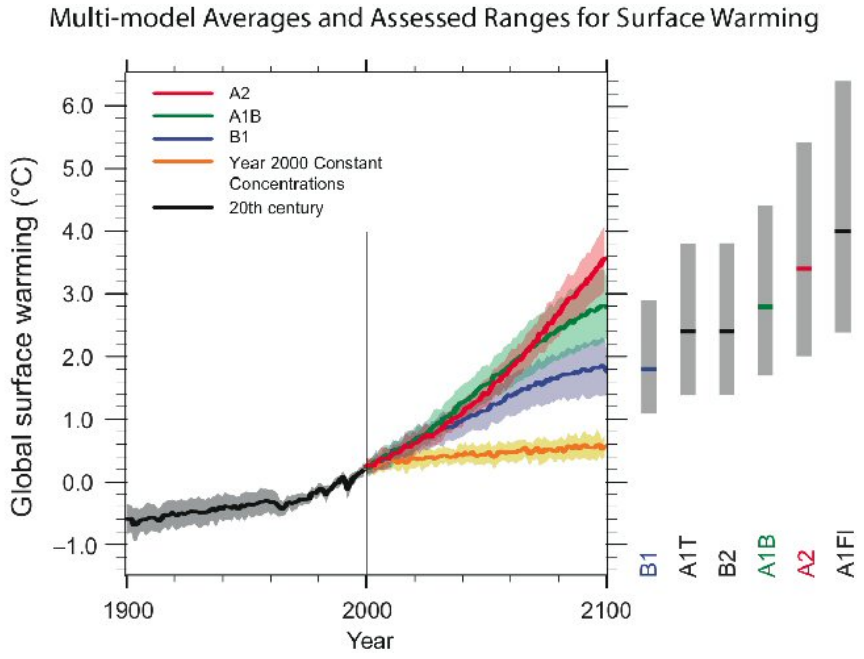


Figure 18: Predictions of global surface warming under different climate change scenarios: B1, A1T, B2, A1B, A2, A1F1 (Source: Nakicenovic et al, 2000)

The comparison between the sophisticated models such as those currently in use to make predictions, evidence significant variability that increases the level of uncertainty, even at the local level. In Vietnam, IMHEM has used different models to predict the different scenarios. The following figure highlights the high level of variability from one model to another for the North East region in Vietnam.

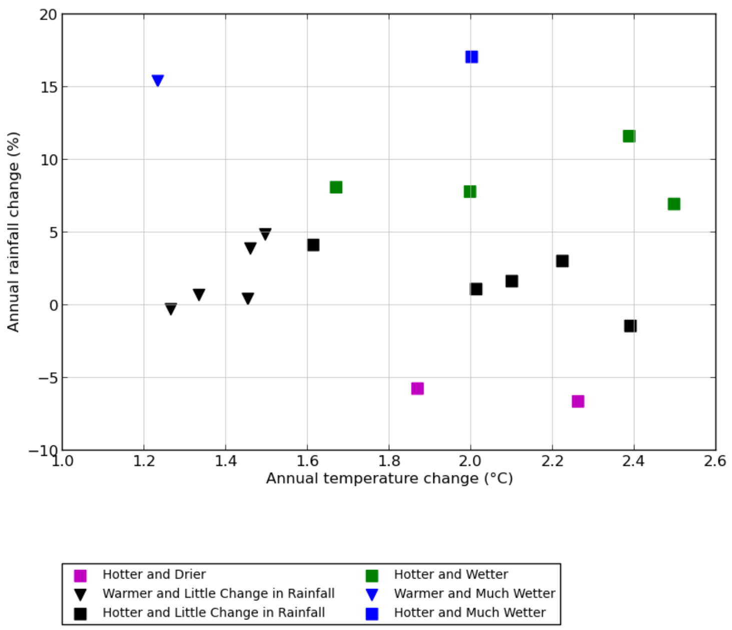


Figure 19: North East Vietnam climate futures for a A1B Medium emissions scenario by 2055. Source: VN Climate Website (IMHEM)

In this case, the different models used show a great variation, from a reduction of annual rainfall change of -7% to a +17% increase.

Taking into consideration all the models, the mean is a +4% of annual rainfall change, with a standard deviation of 6.2.

But that figure only shows the variation between the different models within a similar climate change scenario. Other scenarios further increase the variability:

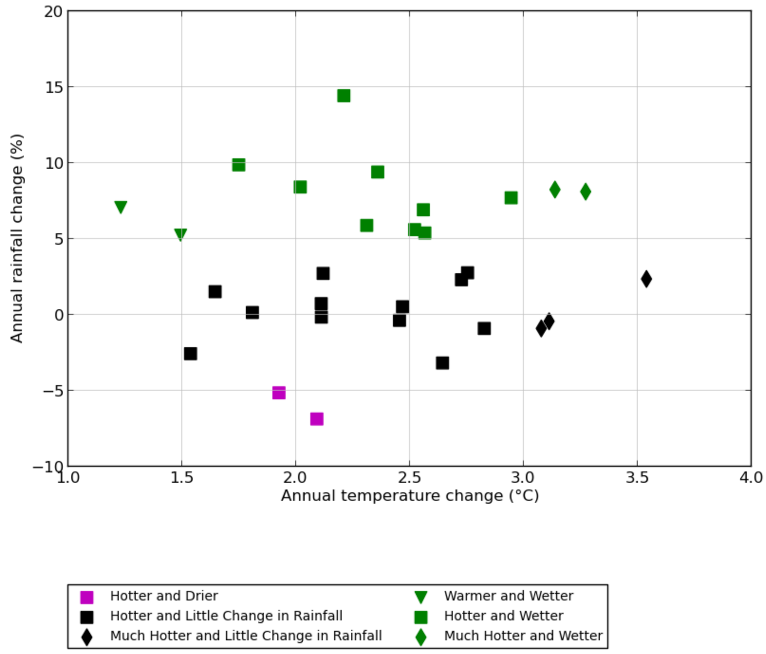


Figure 20: North East Vietnam climate futures for a RCP 8.5 very high emissions scenario by 2055. Source: VN Climate Website (IMHEM)

In that case, the variation of annual rainfall change would be between -7% to +15%. The mean is a +1.9% of annual rainfall change, with a standard deviation of 5.6.

The following example might lead the reader to two wrong preliminary conclusions:

- There is too much uncertainty; therefore we cannot deal with it
- The changes on annual rainfall mean are relatively small (e.g. +2.4%) and are even lower than the average rainfall variation between one year to another

The first statement is partially right. There is uncertainty, but we have to deal with it! In fact, engineering practice has always had to deal with many uncertainties, and the design process requires carrying out some assumptions and including some safety factors (SF) to deal with those uncertainties.

The second statement does not take into consideration that for engineering purposes, the annual rainfall mean might not be as relevant as the extremes. In that sense, maximum rainfall intensity might be more relevant on infrastructure design than annual rainfall.

The figure below shows how rainfall intensity is expected to suffer significant variations. In some NMP areas, between 20-30% increased rainfall intensity is expected.

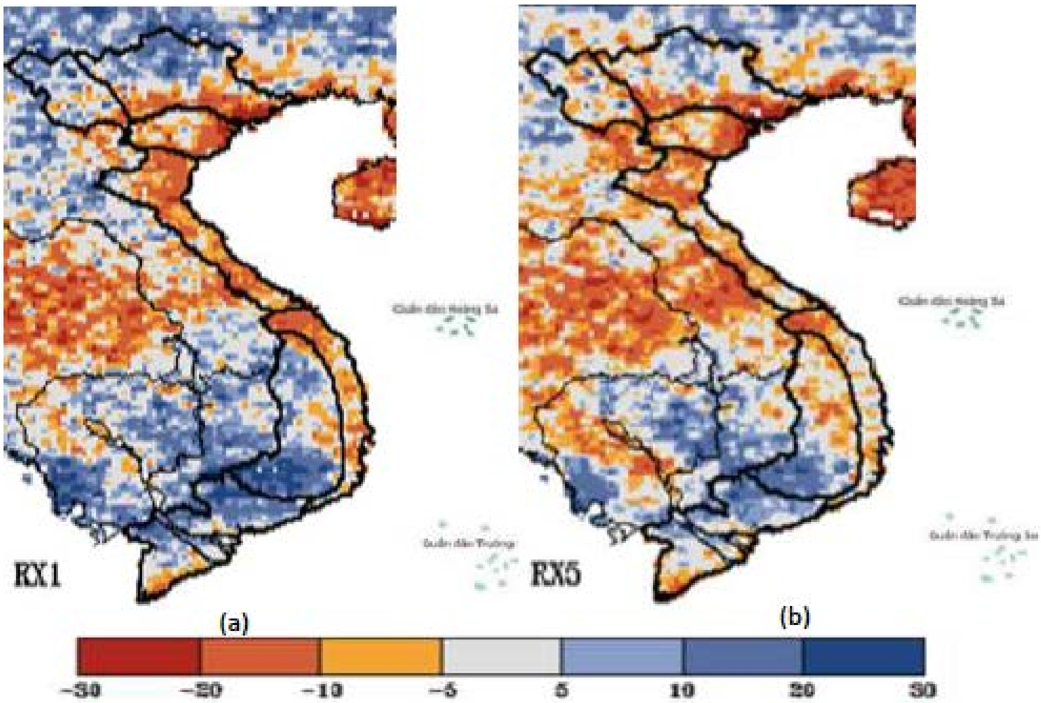


Figure 21: Projected change in (a) one day highest rainfall (RX1), (b) 5-days highest rainfall (RX5), by the end of the 21st century under a high greenhouse gas concentrations scenario (RCP 8.5) (%). Source: SREX Vietnam, 2015

The following example illustrates how a 20% increase of 1-day maximum rainfall intensity could affect rural infrastructures.

One easy and common method to calculate water discharge is the Rational Method:

$$\text{Rational Equation: } Q = 0.28\ c\ i\ A$$

The Rational equation requires the following units:

Q = Peak discharge, m3/s

c = Rational method runoff coefficient

i = Rainfall intensity, mm/h

A = Drainage area, km2

According to the historic rainfall data (1963-2012), the maximum rainfall intensity in Chợ Mới district (Bắc Kạn Province) is 264.05 mm/day for a 100 years return period.

For a small basin (50 km2) in a forested area (c=0.2) the estimated peak discharge would be:

$$Q = 0.28\ c\ i\ A = 0.28 \times 0.2 \times 264.05 \times 50 = \mathbf{740.6\ m3/s}$$

A 20% increase of the maximum rainfall intensity (based on SREX climate change predictions) would be of 316.86 mm/day, hence:

$$Q = 0.28\ c\ i\ A = 0.28 \times 0.2 \times 316.86 \times 50 = \mathbf{887.2\ m3/s}$$

In this specific case[5], the expected average annual rainfall increase for the region is +1.9%, while the expected one day highest rainfall intensity is expected to be +20%. Excluding other external enhancers (such as deforestation), the peak discharge for any specific basin would be +20%[6]. Hence, the relatively low change of average annual rainfall does not reflect the expected impact on important aspects of hydraulic infrastructures design, such as the peak discharge.

[5] RCP 8.5 scenario and predictions for 2055 in Cho Moi district according to IMHEM (VN Climate data), and SREX Vietnam 2015.
[6] Using the Rational Method for peak discharge.

Annex 5: Vulnerability analysis of water and sanitation infrastructures in Vietnam using CAM methodology

The methodology chosen to analyse the vulnerability of water and sanitation services is the Climate Change Adaptation Methodology *(CAM). The International Centre on Environmental Management (ICEM) has developed The CAM*. ICEM is an Australian firm specializing in climate change adaptation in the field of infrastructures in developing countries.

The CAM impact and vulnerability assessment process includes six steps as shown in the figure below.

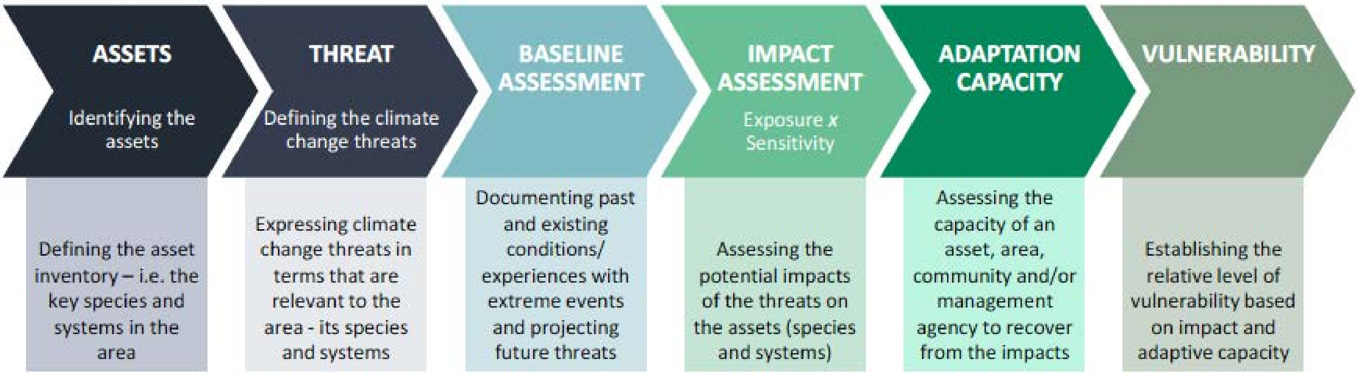


Figure 22: The CAM impact and vulnerability assessment process. Source: ICEM, 2013

Step 1: Assets

The first step will be the definition of “assets”. For this exercise, assets are defined as the main parts in which water and sanitation infrastructures are defined. It is important to mention that, the exercise is a generalisation of the most common water and sanitation infrastructures in Vietnam.

- Water sources:
  - Surface water from springs or small rivers
  - Surface water from dams or big rivers
  - Groundwater
  - Groundwater in coastal areas affected by seawater intrusion and subsidence (e.g. Mekong Delta)
- Treatment plants
- Supply/distribution:
  - Household/community water systems (e.g. wells, hand pumps)
  - Small water supply distribution systems (rural)
  - Large scale distribution systems (urban)
- Sanitation
  - On-plot sanitation (rural or urban)
  - City drains for rainwater evacuation exclusively (in separated sewerage systems)
  - Sewerage (in separated sewerage systems)
  - City sewerage (in combined sewerage systems)
  - Wastewater treatment plants
  - Wastewater treatment plants in coastal (or low-land) areas

Step 2: Threat

This step includes an analysis of all the threats that are related to climate change. In the case of Vietnam the main threats identified are:

- Floods: Either flash-floods or slow-onset, due to increased precipitation during extreme weather events. Floods threaten physical damage of infrastructures due to inundation, land erosion and destabilization or landslides. Floods are augmented due to other non-climatic factors such as deforestation[7].
- Droughts: Droughts threaten the availability of water sources, especially surface water, and in some areas intensive pumping because of irrigation can also affect groundwater resources[8].
- Typhoons and strong winds caused by typhoons: could cause physical damage to infrastructures, especially in exposed areas.
- Heat waves could cause physical damage to infrastructures, for instance expansion and cracking of pipes. Heat waves are also related to an increase of vectors and expansion of some diseases such as malaria or dengue, however this is not considered in this exercise.
- Sea level rise (SLR) threatens extensive areas of Vietnam, especially population living in the Mekong river delta and the Red river deltas, as well as population living in coastal areas. The Sea Level Rise Scenarios for Vietnam report (MONRE, 2010) estimates that 1 m SLR would inundate 86% of Hau Giang province, 62% of Kieng Gian or even 21% of HCMC (the biggest city in Vietnam).

Step 3: Baseline assessment

The baseline describes the past and existing situation, trends and drivers across each of the target systems, and analyses the changes to these systems that will occur irrespective of climate change (ICEM, 2013).

In the case of Vietnam, it is very difficult to make a proper assessment of past and existing situations, as disaster assessment reports and databases (such as Desinventar[9]) are not always complete or reliable. According to the Global Assessment Report on Disaster Risk Reduction (Oanh Luong Nhu et al, 2011) "there is no database on disaster events in Viet Nam that covers all types and magnitudes of disasters and also provides information that can be compared across different geographical regions".

Step 4: Impact assessment

In this document the term vulnerability of infrastructures is based on CAM methodology (ICEM, 2013), and is a function of exposure, sensitivity, impact and adaptive capacity.

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[7] Vietnam has the second highest rate of primary forest deforestation in the world (FAO,2005)
[8] Although the latest Assessment Report (AR5) produced by the Intergovernmental Panel on Climate Change (IPCC) does not consider that there is sufficient scientific proof of climate change impact on groundwater resources, in the specific case of Vietnam, it is possible to link reduced rainfall patterns with increased groundwater extractions (mostly for irrigation purposes) and a significant affect on groundwater resources (mostly in alluvial areas).
[9] http://www.desinventar.net/DesInventar/profiletab.jsp?countrycode=vnm

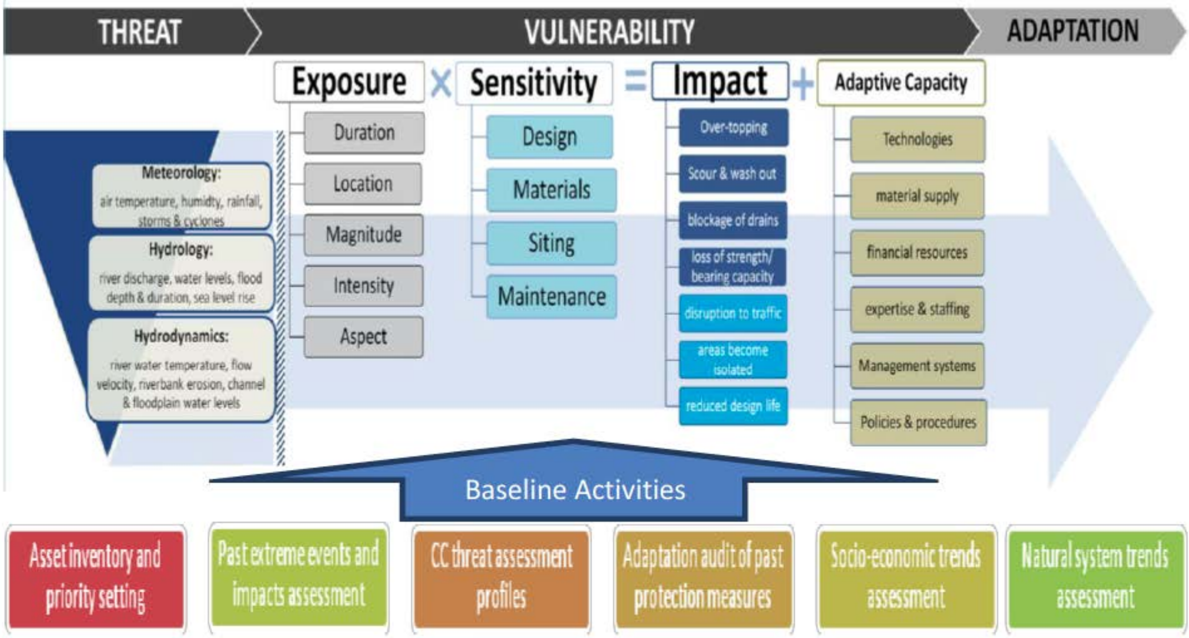

Figure 23: Parameters and issues considered in the baseline and vulnerability assessment process. Source: ICEM, 2013

Exposure is the extent to which a system is exposed to the climate change threat. The CAM rating system for exposure and other parameters uses a scoring from very low to very high and is applied based on expert judgment drawing from the best available scientific and factual evidence and where appropriate, community knowledge and experience.

Very low: very low intensity/severity and/or very infrequent and/or very short duration	**Low:** low intensity/severity and/or infrequent and/or short duration	**Medium:** medium intensity/severity and/or average recurrence and/or average duration	**High:** high intensity/severity and/or frequent and/or long duration	**Very high:** very high intensity/severity and/or very frequent and/or very long duration

Figure 24: Rating system for levels of exposure. Source ICEM, 2013

Sensitivity is the degree to which a system will be affected by, or responsive to climate change exposure. As in the case of exposure, the rating system uses a scoring from very low to very high.

Very low: very good integrity of design, materials and construction	**Low:** good integrity of design, materials and construction	**Medium:** average integrity of design, materials and construction	**High:** poor integrity of design, materials and construction	**Very high:** very poor integrity of design, materials and construction

Figure 25: Rating system for levels of sensitivity. Source ICEM, 2013

The potential **impact** (or level of risk) is a function of the level of exposure to climate change induced threats, and the sensitivity of the target assets or system to that exposure. In this case impact is determined from the following matrix

	Exposure of system to climate threat					
Sensitivity of system to climate threat		*Very Low*	*Low*	*Medium*	*High*	*Very High*
	Very High	*Medium*	*Medium*	*High*	*Very High*	*Very High*
	High	*Low*	*Medium*	*Medium*	*High*	*Very High*
	Medium	*Low*	*Medium*	*Medium*	*High*	*Very High*
	Low	*Low*	*Low*	*Medium*	*Medium*	*High*
	Very Low	*Very Low*	*Low*	*Low*	*Medium*	*High*

Table 10: Rating system for levels of impact. Source ICEM, 2013

Step 5: Adaptive capacity

Adaptive capacity is understood in terms of the ability to prepare for a future threat and in the process, increase resilience and the ability to recover from the impact. When impact and adaptation capacity are considered, a measure of relative vulnerability can be defined. (ICEM, 2009)

Very low: Very limited institutional capacity and no access to technical or financial resources	**Low:** Limited institutional capacity and limited access to technical and financial resources	**Medium:** Growing institutional capacity and access to technical or financial resources	**High:** Sound institutional capacity and good access to technical and financial resources	**Very high:** Exceptional institutional capacity and abundant access to technical and financial resources

Figure 26: Rating system for levels of adaptive capacity. Source ICEM, 2013

Step 6: Vulnerability

The vulnerability is a function of the adaptive capacity to climate change, and the impact, which is determined as a function of the level of exposure to climate change induced threats, and the sensitivity of the target assets or system to that exposure. In this case impact is determined from the following matrix:

Adaptive Capacity	Impact				
	Very Low *Inconvenience (days)*	*Low* *Short disruption to system function (weeks)*	*Medium* *Medium term disruption to system function (months)*	*High* *Long term damage to system property or function (years)*	*Very High* *Loss of life, livelihood or system integrity*
Very Low *Very limited institutional capacity and no access to technical or financial resources*	*Medium*	*Medium*	*High*	*Very High*	*Very High*
Low *Limited institutional capacity and limited access to technical and financial resources*	*Low*	*Medium*	*Medium*	*High*	*Very High*
Medium *Growing institutional capacity and access to technical or financial resources*	*Low*	*Medium*	*Medium*	*High*	*Very High*
High *Sound institutional capacity and good access to technical and financial resources*	*Low*	*Low*	*Medium*	*Medium*	*High*
Very High *Exceptional institutional capacity and abundant access to technical and financial resources*	*Very Low*	*Low*	*Low*	*Medium*	*High*

Table 11: Rating system for levels of vulnerability. Source ICEM, 2013

Results

The table below summarizes the vulnerability analysis carried out by the author, defining the levels of vulnerability of the different assets identified on step 1 of the CAM methodology.

It is important to note that this vulnerability assessment is a generalisation of the most common cases in Vietnam. However, in order to understand the specific vulnerabilities of individual infrastructures, this must be done on a case by case basis. Values given in this exercise are the sole responsibility of the author and shall be considered as estimative.

Asset	Threat	Interpretation of threat	Exposure	Sensitivity	Impact level	Impact summary	Adaptive capacity	Vulnerability
Surface water from springs or small rivers except in coastal areas)	Floods	Contamination of water sources. Physical damages affecting intake capacities	H	H	H	Floods are recurrent in many areas of the country. Flash floods occurring in mountainous areas and slow-onset floods in plains. Damages are relatively frequent in rural areas (although not always reported) and contamination (increased turbidity) persist during several months	VL	VH
	Droughts	Lack/insufficient water sources	M	H	M	There is insufficient data on the current impact of droughts in surface water (especially in rural areas). However, there seems to be a growing problem, especially in irrigated areas due to overexploitation of water resources. Due to lack of IRWM and control, the impact is medium but vulnerability is high.	VL	H
	Thyphoons	Limited impact on surface water (only when associated with heavy rains, see floods)	VL	VL	VL	Although damages on water sources are reported during typhoons, those damages (usually) are only related to intense rains but not typhoons	L	L
	Heat waves	Increased evapo-transpiration and potential reduction of water quantities	VL	VL	VL	Increased evapo-transpiration due to heat waves can be affected by other external causes (increased demand for irrigation) and thus affect water availability	L	L
	Sea Level Rise	Sea level intrusion in coastal areas. Impact of high tides in estuaries and rivers.	VL	VL	VL	No impact in the rest of the country.	L	L
Surface water from dams or big rivers (except in coastal areas)	Floods	Contamination of water sources. Physical damages affecting intake capacities	H	VH	VH	Floods are recurrent in many areas of the country. Slow-onset floods in big rivers. Damages are relatively frequent in small-medium storage dams. Contamination (increased turbidity) persist during several months	VL	VH
	Droughts	Lack/insufficient water sources	L	M	M	In general terms, droughts have less impact in rivers and dams. However, there could be some exceptions and there is a growing problem due to conflicts with other users (hydropower, irrigation). Due to lack of IRWM and control the impact is	VL	H

						medium but vulnerability is high.		
	Typhoons	Limited impact on surface water (only when associated with heavy rains, see floods)	VL	VL	VL	Although damages on water sources are reported during typhoons, those damages (usually) are only related to intense rains but not typhoons	L	L
	Heat waves	Increased evapo-transpiration and potential reduction of water quantities	L	VL	L	Increased evapo-transpiration due to heat waves could be relevant in some dams, and can be affected by other external causes (increased demand for hydropower and irrigation) and thus affect water availability	L	M
	Sea Level Rise	Sea level intrusion in coastal areas. Impact of high tides in estuaries and rivers.	VL	VL	VL	Potentially very high impact in coastal areas, estuaries and deltas. No impact in the rest of the country.	L	L
Surface water from rivers in coastal areas	Floods	Contamination of water sources. Physical damages affecting intake capacities	VH	VH	VH	Slow-onset floods are recurrent in plains and river deltas. Damages are relatively frequent in rural areas (although not always reported) and contamination (increased turbidity) persists during several months.	VL	VH
	Droughts	Lack/insufficient water sources. It can also increase sea intrusion and salinity	M	H	M	There is insufficient data on the current impact of droughts in surface water. However, there seems to be a growing problem, especially in coastal and irrigated areas due to overexploitation of water resources, thus increasing the effect of seawater intrusion. Due to lack of IRWM and control, the impact is medium but vulnerability is high.	VL	H
	Typhoons	Limited impact on surface water (only when associated with heavy rains, see floods)	L	VL	L	Although damages on water sources are reported during typhoons, those damages (usually) are only related to intense rains but not typhoons. However in coastal areas, typhoons might contribute to seawater intrusion.	L	M
	Heat waves	Increased evapo-transpiration and potential reduction of water quantities	VL	M	L	Increased evapo-transpiration due to heat waves can be affected by other external causes (increased demand for irrigation) and thus reduce water availability	L	M
	Sea Level Rise	Sea level intrusion in coastal areas. Impact of high tides in estuaries and rivers.	VH	VH	VH	Potentially very high impact in coastal areas, estuaries and deltas.	L	VH

Groundwater in coastal areas affected by seawater intrusion and subsidence (e.g. Mekong Delta)	Floods	Contamination of water sources. Physical damages affecting intake capacities	VH	VH	VH	Slow-onset floods are recurrent in plains and river deltas. Damages are relatively frequent in rural areas (although not always reported).	VL	VH
	Droughts	Lack/insufficient water sources. It can also increase sea intrusion and salinity	M	H	M	There is insufficient data on the current impact of droughts in groundwater. However, there seems to be a growing problem in coastal and irrigated areas due to overexploitation of water resources, thus increasing salinity due to seawater intrusion. Due to lack of IRWM and control the impact is medium but vulnerability is high.	VL	H
	Typhoons	Limited impact on surface water (only when associated with heavy rains, see floods)	L	VL	L	Although damages on water sources are reported during typhoons, those damages (usually) are only related to intense rains but not typhoons. However in coastal areas, typhoons might contribute to seawater intrusion and increased salinity of both surface and groundwater.	L	M
	Heat waves	Increased evapo-transpiration and potential reduction of water quantities	VL	M	L	Increased evapo-transpiration due to heat waves can be affected by other external causes (increased demand for irrigation) and thus reduce water availability	L	M
	Sea Level Rise	Sea level intrusion in coastal areas. Impact of high tides in estuaries and rivers.	VH	VH	VH	Potentially very high impact in coastal areas, estuaries and deltas.	L	VH
Groundwater in other areas (not in the coast or lowland areas)	Floods	Contamination of water sources. Physical damages affecting intake capacities	M	H	M	Flashfloods and slow-onset floods are recurrent in many areas of the country. However, damages in groundwater intakes (e.g. Flooded wells) seem to be less frequent.	L	M
	Droughts	Lack/insufficient water sources	L	M	M	In comparison with surface water, droughts should have less impact in groundwater. However, there seems to be a growing problem, especially in irrigated areas due to overexploitation of water resources. Due to lack of IRWM and control the impact is medium but vulnerability is high.	VL	H
	Typhoons	Limited impact on groundwater	VL	VL	VL	Although damages on water sources are reported during typhoons, those damages (usually) are only related to intense rains but not typhoons	L	L

	Heat waves	Increased evapo-transpiration and potential reduction of water quantities	L	VL	L	Increased evapo-transpiration due to heat waves should not affect groundwater. However, aquifers can be affected by other external causes (increased demand for irrigation) and thus affect water availability	L	M
	Sea Level Rise	Sea level intrusion in coastal areas. Impact of high tides in estuaries and rivers.	VL	VL	VL	No impact outside coastal (and low land areas)	L	L
Treatment plants (except in coastal areas)	Floods	Physical damages affecting intake capacities	H	H	H	Floods are recurrent in many areas of the country. Flash floods in mountainous areas and slow-onset floods in bigger rivers. However, it is difficult to estimate the level of damages caused by floods in treatment plants. Increased turbidity increases treatment costs.	L	H
	Droughts	Lack/insufficient water sources, but not affecting infrastructures	L	VL	L	In general terms droughts have impact in the water resources, but not in water treatment infrastructures.	L	M
	Typhoon s	Limited impact on infrastructures	L	L	L	There is insufficient data on the current impact of typhoons on infrastructures.	L	M
	Heat waves	Potential reduction of lifespan of certain components of the plant	VL	M	L	Impact on infrastructures seem to be very low	H	L
	Sea Level Rise	Sea level intrusion in coastal areas. Impact of high tides in estuaries and rivers.	VL	VL	VL	No impact (only in coastal areas)	H	L
Treatment plants in coastal areas	Floods	Physical damages affecting intake capacities	H	H	H	Floods are recurrent in coastal areas. However, it is difficult to estimate the level of damages caused by floods in treatment plants. Increased turbidity increases treatment costs.	L	H
	Droughts	Lack/insufficient water sources. It can also increase seawater intrusion and salinity But not affect infrastructures	L	VL	L	In general terms droughts have impact in the water resources, but not in water treatment infrastructures. However, in coastal areas droughts can increase sea intrusion and increase salinity. Thus affecting quality of water distributed.	L	M
	Typhoon s	Limited impact on infrastructures	M	L	M	There is insufficient data on the current impact of typhoons on infrastructures. However, in coastal areas typhoons could have larger impact than in the rest of the country.	L	M

	Heat waves	Potential reduction of lifespan of certain components of the plant	VL	M	L	Impact on infrastructures seem to be very low	H	L
	Sea Level Rise	Sea level intrusion in coastal areas. Impact of high tides in estuaries and rivers.	VH	VH	VH	Potentially very high impact in coastal areas, estuaries and deltas.	L	VH
Household and community water supply systems (e.g. wells, hand pump, community water supply schemes)	Floods	Physical damages affecting intake capacities	H	H	H	Floods are recurrent in many areas of the country. Flash floods in mountainous areas and slow-onset floods in bigger rivers. However, it is difficult to estimate the level of damages caused by floods in household or community water systems.	L	H
	Droughts	Lack/insufficient water sources, but not affecting infrastructures	VL	L	VL	In general terms droughts have impact in the water resources, but not in water infrastructures. In case of droughts, lack of water might lead communities to rely on other alternative (and sometimes unsafe) water sources.	L	M
	Typhoons	Limited impact on infrastructures	L	L	L	There is insufficient data on the current impact of typhoons on infrastructures.	L	M
	Heat waves	Increased demand for water, but no impact at infrastructure level.	VL	M	L	Impact on infrastructures seem to be very low	H	L
	Sea Level Rise	Impact only in coastal areas.	VL	VL	VL	No impact (only in coastal areas)	H	L
Household and community water supply systems (e.g. wells, hand pump, community water supply	Floods	Physical damages affecting intake capacities	H	H	H	Floods are recurrent in many areas of the country. Flash floods in mountainous areas and slow-onset floods in bigger rivers. However, it is difficult to estimate the level of damages caused by floods in household or community water systems.	L	H
	Droughts	Lack/insufficient water sources, but not affecting infrastructures	VL	L	VL	In general terms droughts have impact in the water resources, but not in water infrastructures. In case of droughts, lack of water might lead communities to rely on other alternative (and sometimes unsafe) water sources.	L	L
	Typhoons	Limited impact on infrastructures	M	L	M	There is insufficient data on the current impact of typhoons on infrastructures. Only in coastal areas, typhoons could affect those infrastructures.	L	M
	Heat waves	Increased demand for water, but no impact at	VL	M	L	Impact on infrastructures seem to be very low	H	L

schemes) in coastal areas		infrastructure level.						
	Sea Level Rise	Sea level intrusion in coastal areas. Impact of high tides in estuaries and rivers.	VL	VL	VL	Potential impact in coastal areas, estuaries and deltas. Some water points might be dysfunctional	H	L
Large scale distribution systems (urban)	Floods	Limited damages as most of the system is buried	VL	M	L	Floods are recurrent in many areas of the country. Flash floods in mountainous areas and slow-onset floods in bigger rivers. However, distribution systems might suffer only limited damages.	L	M
	Droughts	Lack/insufficient water sources could affect functionality of infrastructures (e.g. Water restrictions)	VL	M	L	In general terms droughts have impact in the water resources, but not in water infrastructures. In case of droughts, lack of water might lead communities to rely on other alternative (and sometimes unsafe) water sources.	H	L
	Typhoons	Limited damages as most of the system is buried	L	L	L	There is insufficient data on the current impact of typhoons on infrastructures. Only in coastal areas, typhoons could affect those infrastructures.	H	L
	Heat waves	Increased demand for water, but no impact at infrastructure level.	VL	L	L	Impact on infrastructures seem to be very low	H	L
	Sea Level Rise	No impact	VL	VL	VL	No impact (only in coastal areas)	H	L
Large scale distribution systems (urban) in coastal areas	Floods	Limited damages as most of the system is buried	L	M	M	Floods are recurrent in many areas of the country. Flash floods in mountainous areas and slow-onset floods in bigger rivers. However, distribution systems might suffer only limited damages.	L	M
	Droughts	Lack/insufficient water sources could affect functionality of infrastructures (e.g. Water restrictions)	VL	M	L	In general terms droughts have impact in the water resources, but not in water infrastructures. In case of droughts, lack of water might lead communities to rely on other alternative (and sometimes unsafe) water sources.	H	L
	Typhoons	Limited damages as most of the system is buried	L	L	L	There is insufficient data on the current impact of typhoons on infrastructures. Only in coastal areas, typhoons could affect those infrastructures.	H	L

	Heat waves	Increased demand for water, but no impact at infrastructure level.	VL	L	L	Impact on infrastructures seem to be very low	H	L
	Sea Level Rise	Sea level intrusion in coastal areas. Impact of high tides in estuaries and rivers.	H	M	H	Potential impact in coastal areas, estuaries and deltas. Some schemes might face difficulties in providing water	H	M
Sanitation								
On-plot sanitation (rural or urban)	Floods	Potential damages of septic tanks due to high water tables or flooded infrastructures	VH	M	VH	Floods are recurrent in many areas of the country. Flash floods in mountainous areas and slow-onset floods in bigger rivers.	L	VH
	Droughts	Lack/insufficient water sources could affect functionality of infrastructures (e.g. Pour flush toilets)	M	L	M	In general terms droughts have impact in the water resources, but not in water infrastructures. In case of droughts, lack of water might lead to problems of functionality of some infrastructures	L	M
	Typhoon s	Limited impact on infrastructures	L	L	L	There is insufficient data on the current impact of typhoons on infrastructures.	L	M
	Heat waves	Increased demand for water, but no impact at infrastructure level.	VL	M	L	Impact on infrastructures seem to be very low	H	L
	SeaLevel Rise	Impact only in coastal areas.	VL	VL	VL	No impact (only in coastal areas)	H	L
On-plot sanitation (rural or urban)in flooded areas	Floods	Potential damages of septic tanks due to high water tables or flooded infrastructures	VH	M	VH	Floods are recurrent in many areas of the country. Flash floods in mountainous areas and slow-onset floods in bigger rivers.	L	VH
	Droughts	Lack/insufficient water sources could affect functionality of infrastructures (e.g. Pour flush toilets)	M	L	M	In general terms, droughts have impact in the water resources, but not in water infrastructures. In case of droughts, lack of water might lead to problems of functionality of some infrastructures	L	M
	Typhoon s	Limited damages as most of the system is buried	L	M	M	There is insufficient data on the current impact of typhoons on infrastructures. Only in coastal areas, typhoons could affect those infrastructures.	H	M

	Heat waves	Increased demand for water, but no impact at infrastructure level.	VL	M	L	Impact on infrastructures seem to be very low	H	L
	Sea Level Rise	Sea level intrusion in coastal areas. Impact of high tides in estuaries and rivers.	H	M	H	Potential impact in coastal areas, estuaries and deltas. Some systems might not operate due to high water tables or flooding conditions.	M	H
City sewerage (either combined or separate)	Floods	Potential malfunctioning due to high water tables or flooded sewers	VH	M	VH	Floods are recurrent in many areas of the country. Flash floods in mountainous areas and slow-onset floods in bigger rivers.	L	VH
	Droughts	Lack/insufficient water sources could affect functionality of infrastructures (e.g. Water restrictions)	M	L	M	In general terms, droughts have impact in the water resources, but not in water infrastructures. In case of droughts, lack of water might lead to problems of malfunctioning and increase of load to the sewers	L	M
	Typhoons	Limited impact on infrastructures	L	VL	L	There is insufficient data on the current impact of typhoons on infrastructures.	H	L
	Heat waves	Increased demand for water, but no impact at infrastructure level.	VL	M	L	Impact on infrastructures seem to be very low	H	L
	Sea Level Rise	Impact only in coastal areas.	VL	VL	VL	No impact (only in coastal areas)	H	L
City sewerage (either combined or separate) in coastal areas	Floods	Potential malfunctioning due to high water tables or flooded sewers	VH	M	VH	Floods are recurrent in many areas of the country. Flash floods in mountainous areas and slow-onset floods in bigger rivers.	L	VH
	Droughts	Lack/insufficient water sources could affect functionality of infrastructures (e.g. Water restrictions)	M	L	M	In general terms droughts have impact in the water resources, but not in water infrastructures. In case of droughts, lack of water might lead to problems of malfunctioning and increase of load to the sewers	L	M
	Typhoons	Limited damages as most of the system is buried	L	L	L	There is insufficient data on the current impact of typhoons on infrastructures. Only in coastal areas, typhoons could affect those infrastructures.	M	M

	Heat waves	Increased demand for water, but no impact at infrastructure level.	VL	M	L	Impact on infrastructures seem to be very low	H	L
	Sea Level Rise	Sea level intrusion in coastal areas. Impact of high tides in estuaries and rivers.	H	H	H	Potential impact in coastal areas, estuaries and deltas. Some systems might not be able to evacuate sludge due to high water tables or flooding conditions. Increased O&M costs	L	H
Wastewater treatment plants (except in coastal areas)	Floods	Potential malfunctioning due to high water tables or flooded sewers	VH	M	VH	Floods are recurrent in many areas of the country. Flash floods in mountainous areas and slow-onset floods in bigger rivers.	L	VH
	Droughts	Lack/insufficient water sources could affect load of sludge	M	L	M	In general terms droughts have impact in the water resources, but not in water infrastructures. In case of droughts, lack of water might lead to increase of load to the WWTP	L	M
	Typhoons	Limited impact on infrastructures	L	VL	L	There is insufficient data on the current impact of typhoons on infrastructures.	M	M
	Heat waves	Positive impact on bacteria growth	VL	VL	VL	Impact on infrastructures seem to be very low	H	L
	SeaLevel Rise	Impact only in coastal areas.	VL	VL	VL	No impact (only in coastal areas)	H	L
Wastewater treatment plants in coastal (or low-land) areas	Floods	Potential malfunctioning due to high water tables or flooded sewers	VH	M	VH	Floods are recurrent in many areas of the country. Flash floods in mountainous areas and slow-onset floods in bigger rivers.	L	VH
	Droughts	Lack/insufficient water sources could affect load of sludge	M	L	M	In general terms droughts have impact in the water resources, but not in water infrastructures. In case of droughts, lack of water might lead to increase of load to the WWTP	L	M
	Typhoons	Limited damages as most of the system is buried	L	L	L	There is insufficient data on the current impact of typhoons on infrastructures. Only in coastal areas, typhoons could affect those infrastructures.	M	M
	Heat waves	Positive impact on bacteria growth	VL	VL	VL	Impact on infrastructures seem to be very low	H	L
	Sea Level Rise	Sea level intrusion in coastal areas. Impact of high tides in estuaries and rivers.	H	H	H	Potential impact in coastal areas, estuaries and deltas. Some systems might not be able to treat and evacuate treated water due to high water tables or flooding conditions. Increased O&M costs	L	H

Table 12 Vulnerability analysis of the different assets identified

Annex 6: List of people interviewed

Vice-Director of the Institute for Environmental Science and Engineering (IESE)- National University of Civil Engineering (NUCE) (co-supervisor of the research)
International Consultant. Main author of Ben Tre WASH Strategy for the Water and Sanitation Program (WSP).
PhD student at Chapel Hill University North Carolina (USA)
Chief of WASH at UNICEF Vietnam
Principal Water and Infrastructure at ADB (Asian Development Bank)
Technical Advisor at GIZ/MoC Wastewater Management Programme - Programme Management and Coordination, Advise to Ministry of Construction in the Wastewater Sub-Sector
Water and Sanitation Specialist at WSP (Water and Sanitation Program; World Bank Group)
Policy Advisor Climate Change at UNDP Vietnam
Resident Project Manager at Vitens Evides International
Assistant resident Project Manager at Vitens Evides International
Water Supply Expert- Climate Change at Vitens Evides International
Head of the Climate Change Coordination Office at Can Tho province
Senior Research Scientist, Project Leader. Urban Water Systems Engineering Program at CSIRO
Head of Department, Lecturer. River modelling and waterscape management at Can Tho University
Environmental Health National Professional Officer at WHO (World Health Organisation)
Regional WASH coordinator at Plan International
Project Manager at Oxfam Vietnam

Community Based Adaptation Technical Advisor at CARE
Rural Water Supply and Sanitation Partnership (RWSS) Coordination Unit
Water Resources Specialist at the World Bank
Department of Science and Technology (DOSTE) at Ministry of Construction (MOC)
Communications Adviser at the Water and Sanitation programme for small towns in Vietnam. Development cooperation between governments of Vietnam and Finland
Deputy Head of Standing office NTP (National Target Program on Rural Water Supply and Sanitation). Directorate of Water Resources. Department of Water Resources and Rural Water Supply Management. Ministry of Agriculture and Rural Development.
Senior Project Formulation Advisor at JICA (Japan International Cooperation Agency)
Deputy Director of Vietnam's Institute of Meteorology, Hydrology and Environment (IMHEN) Ministry of Natural Resources and Environment (MONRE)

Table 13: List of people interviewed

Annex 7: Format of Semi-structured interview for key resource people at national level

Used for: Interviews with key informants at national level, including representatives from donor agencies and/or representatives from NGOs and other private stakeholders that provide support to the government of Vietnam**.**

Estimated duration:

- 1-2 hours

Objectives:

1. Overview of CCA in the WASH sector in Vietnam, including the following sub-topics :
    - Policy
    - Implementation
    - Capacities
2. Comparison of the case of Vietnam with other countries
3. Specific recommendations on who to interview and key documents

WARM UP/INTRODUCTION:

Hello, my name is Jorge Alvarez-Sala and I´m a student of Loughborough University in the United Kingdom. I am doing a master's thesis research on climate change in the water and sanitation sector in Vietnam. As part of this research I would like to ask you a few questions that will last around 1[10] hour. The information that you will provide will be used only for the production of an academic document and your comments will be kept confidential unless you allow me to mention your name.

- Do you agree to participate in the interview? Yes/No
- Do you agree to mention your name and organisation in the document? Yes/No

CONTACT/GENERAL INFORMATION

Interview date:

Respondent name:

Position:

Gender:

Telephone:

Email:

Introductory question:

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[10] Duration can change depending on the interviewee availability

- What is your experience on climate change adaptation in the water and sanitation sector in Vietnam (example)

Policy:

- How do you evaluate the policy framework in climate change adaptation in Vietnam
- How do you evaluate the policy framework in water and sanitation, with respect to climate change adaptation in Vietnam
- What do you think are the main constraints at the policy level, and the main recommendations to improve it

Implementation:

- What good examples on climate change adaptation in the water and sanitation sector do you know, and why
- What are the lessons learned from previous water and sanitation interventions and how to improve them
- What are the main priorities (geographical, sub-sectors, etc) in the WASH sector and in CCA.

Capacities:

- How do you evaluate the existing capacities in CCA in the water and sanitation sector, at the government and also in your institution
- Where are the main gaps and how to address them
- How important are those capacities in comparison with other aspects such as infrastructure, the environmental threats, etc.

Comparison with other countries:

- How do you think Vietnam is addressing the challenge of CCA in the WASH sector in comparison with other countries
- What experiences from other countries can be applicable for Vietnam

Stakeholders/information:

- Who are the key stakeholders responsible for the coordination, policy, implementation, etc.
- What key documents/publications do you recommend that I search for

Recommendations:

- What are the main recommendations that you suggest, at policy/institutional level, implementation, infrastructure, capacity development, and others
- What are the main lessons learned from the existing experience, and the opportunities

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