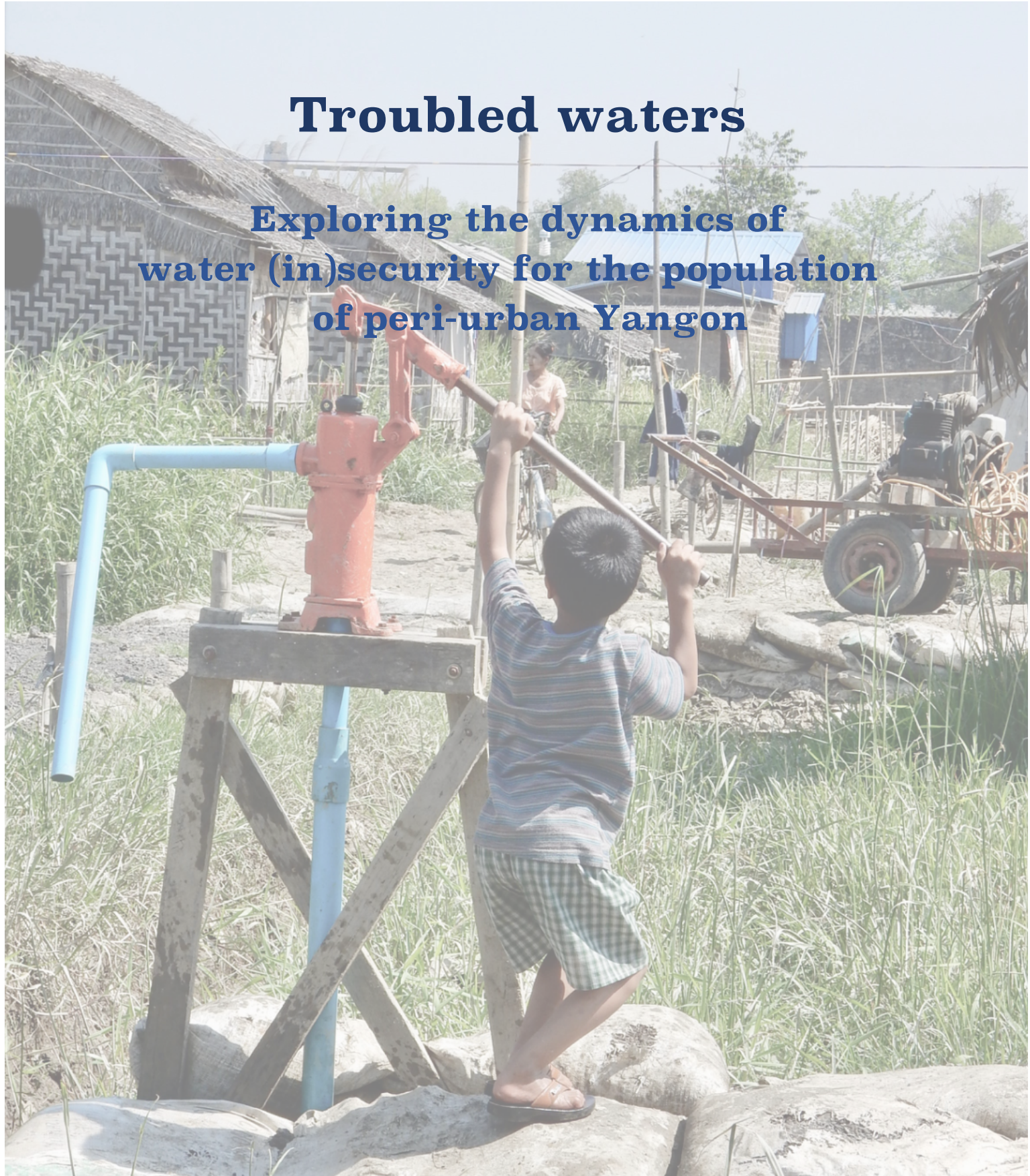


Troubled waters

Exploring the dynamics of water (in)security for the population of peri-urban Yangon



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Master Thesis – MSc Sustainable Development

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Abbreviations

ALARM	Advancing Life and Regenerating Motherland
BOD	Biological Oxygen Demand
FDI	Foreign Direct Investment
HTIZ	Hlaing Tharyar Industrial Zone
IFC	International Finance Cooperation
JICA	Japan International Cooperation Agency
MMK	Myanmar Kyat
MOALI	Ministry of Agriculture, Livestock & Irrigation
MONREC	Ministry of Natural Resources & Environmental Conservation
NEPS	National Engineer & Planning Services
NLD	National League for Democracy
NWRC	National Water Resources Committee
WHO	World Health Organization
USD	United States Dollars
YCDC	Yangon City Development Committee
YCDC PCCD	Yangon City Development Committee Pollution Control and Cleansing Department
YCDC R&B	Yangon City Development Committee Engineering Department Roads and Bridges
YCDC W&S	Yangon City Development Committee Engineering Department Water and Sanitation
YTU	Yangon Technological University

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Conversion rate

Conversion rate of 1 USD = 1359,75 MMK (as on 07/06/2017)

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Rebecca Groot
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Utrecht, the Netherlands

Summary

Providing access to safe water supply for all and assuring sustainable management of water resources is considered a major development challenge, as articulated in SDG6 (UN, 2017a). This challenge is visible in rapidly growing urban hubs in the global South, where population growth, a lack of infrastructure, industrialization and poor regulation result in a high risk for water pollution and limit access to safe water resources (UN-Habitat, 2012). Another major risk for cities in developing countries is flooding, caused by a lack of proper waste management or coastal and tidal flooding. These urban water governance challenges can be considered major obstacles for increasing wellbeing and development in urban hubs, especially so for the urban poor.

Whereas water governance is generally described as the process and systems in place to manage water resources and water services (Rogers & Hall, 2003), the relatively new concept of water security is considered a desirable outcome of this process. Water security can be defined as both the access to safe water supply as well as the exposure to water-related risks (Bakker, 2012). Both institutional as well as household barriers are found to prevent the urban poor from achieving water security (Bakker et. al., 2008). The implications of the inability to achieve water security have also been studied and are often linked to further impoverishment for already vulnerable groups (Kingsbury, 2012; Harvey, 2008).

This study aims to explore the dynamics of water security on a local level in order to identify water-related challenges as well as drivers and outcomes of these challenges. The socio-economic hub of Myanmar, Yangon city, has been chosen as the research site, and more specifically a peri-urban industrial zone within this city: Hlaing Tharyar Industrial Zone (HTIZ). HTIZ is an area with a high density of industry and human settlements, resulting in various water governance challenges. In order to explore the dynamics and different dimensions of water security within this locality, this study aimed to answer the following research question:

To what extent is water security achieved for the local population in HTIZ and what are the drivers and livelihood outcomes of identified water insecurities?

These results indicate that water security in HTIZ is achieved for the majority of the formal settlers in HTIZ, whereas this is not the case for the majority of the informal settlers, especially the informal riverbank settlers. Although a relatively well-organized informal system of local water vendors supplies water to the local population, E. Coli contamination and industrial pollution degrade the quality of the water whereas water shortage and flooding can problematize the access to sufficient quantities of water. Furthermore, the exposure to water-related risks such as industrial and domestic water pollution and flooding, especially among informal settlers.

The identified water insecurities are mainly driven by the lack of capacity and priority given to supply and protect informal settlers on the institutional level, whereas on the household level the lack of resources and the living conditions and location are the main drivers. The identified water insecurities for informal settlers can result in further impoverishment due to the associated health hazards, costs and limitation of mobility.

1. Introduction

‘Access to safe water and sanitation and sound management of freshwater ecosystems are essential to human health and to environmental sustainability and economic prosperity.’

- *SDG6 (UN, 2017b)*

1.1 Problem analysis

Providing access to safe water supply for all and assuring sustainable management of water resources is essential to achieve sustainable development, as articulated in SDG6 (UN, 2016). Although progress has been made over the past decades, over 1.1 billion citizens still lack access to safe water resources (UN, 2017a). This issue is expected to grow even further, especially in urban hubs in developing countries where rapid population growth, poor regulation and lack of basic infrastructure further increase the challenge of supplying access to safe water for all (UN-Habitat, 2012). Especially the urban poor are often unable to access safe water supply, resulting in serious health risks and consequently undesirable impacts on education and economic activities (UN-Habitat, 2012). Other major water-related challenge faced in many urban hubs in the global South is flooding, which becomes an even bigger risk in the context of rising sea levels and climate change, or the pollution of water resources due to industrial and domestic waste. Again, the urban poor are often most affected by these water-related risks due to poor living conditions and living in hazard prone areas (Winsemius et. al., 2015; Satterthwaite, 2003).

The challenges of governing urban water use and supply are also visible in Myanmar, a country experiencing rapid economic growth, industrialization and urbanization. This is particularly true for the former capital city Yangon, the largest city and economic hub of the country. The Asian Development Bank (ADB) concluded that there has been ‘chronic underinvestment in the urban infrastructure over decades, particularly in water supply and environmental infrastructure, including drainage, wastewater, and solid waste management’ (2013). Data from 2011 indicates 60% water supply coverage in Yangon, however these networks rarely extend to the most vulnerable groups living in informal settlements of the city (ADB, 2013). Furthermore, pollution of domestic and industrial sources degrades the quality of water resources in Yangon, posing a threat to both humans as well as ecosystems. Another major water-related risk in Yangon is urban flooding, which is often the results of blocked drainage systems, heavy rainfall or tidal flooding. All these water-related risks and the lack of urban infrastructures for safe water supply result in increased health threats for Yangon’s residents, a low quality of life for the urban poor, rapid environmental degradation and is supposed to halt economic growth and sustainable urban development (ADB, 2013).

Hlaing Tharyar Industrial Zone (HTIZ), located in North-Western Yangon and bound by the Pan Hlaing River in the South, is one of the areas in which many of these water challenges come together. As the largest industrial zone of Yangon, it covers over 1000 acres and different industries operate in this area, including garment, plastics and food & beverages (Myanmar Industries Association, 2012). Next to the industrial use, HTIZ is inhabited by an estimated 60.000 formal and informal settlers, living in apartment blocks or huts along the roads or the Pan Hlaing riverbank. Where some of these settlers are the original farmers living in this area for already long before the establishment of the industrial zone, others migrated to HITZ during the past decade in search of economic opportunities, cheap housing or were forced to move due to the devastating Nargis cyclone in 2008. As there is a lack of official water supply

in HTIZ and other basic infrastructure is also limited, access to safe water is a challenge. The ability of accessing safe water resources is closely linked to other features of the settlers' livelihoods, such as poverty and land tenure security. Another water-related risk faced by the local population is the occurrence of flooding, influencing mobility and driving up costs of acquiring water and for housing construction. Furthermore, despite some legislation on industrial wastewater treatment, the area is said to be highly polluted due to the discharge of untreated industrial wastewater of factories in HTIZ (ALARM, 2016), posing a high risk for both humans as well as the ecosystem.

1.2 Research aim

Effective water governance is essential in achieving sustainable and inclusive development for the growing urban population in the global South. The question then is what good and effective water governance actually is and what it aims for; has the water governance process proven to be effective when access to improved drinking water for all is achieved? Or does it also involve building resilient communities that are able to cope with flooding? Although the interpretation of what is 'desirable' as a water governance outcome differs, within this study the concept of water security is used as the desired outcome. This holistic concept encompasses both the right to access water as well as the right to be safe from water-related risks, providing an alternative to other concepts solely focussing on the use of water.

Within this study, the water security concept will be applied on the community level, where different stakeholders shape the governance and use of water resources, herewith influencing the level of water (in)security. Additionally, different barriers to achieve this water governance outcome will be explored. Furthermore, the necessity of effective water governance will be highlighted by looking at the outcomes of water insecurities as well; what are the implications of limited access to safe water supply or regular flooding for different urban population groups? Overall, the aim of this study is thus to enhance knowledge on the local dynamics of water security. This will be studied in the context of HTIZ as a highly dynamic setting in which the challenges to achieve water security at a local level are clearly visible.

1.3 Research questions

The guiding research question for this study has been defined as following:

To what extent is water security achieved for the local population in HTIZ and what are the drivers and livelihood outcomes of identified water insecurities?

This overarching question will be answered by addressing the following four sub-questions:

- 1. What are the characteristics of the different stakeholders involved in the use and governance of water in HTIZ?*
- 2. To what extent does the local population in HTIZ have access to safe water supply?*
- 3. What other water-related risks for the local population are to be found in HTIZ?*
- 4. What are the drivers and livelihood outcomes of identified water insecurities in HTIZ?*

1.4 Relevance

Studying the dynamics of water security in HTIZ is relevant for policy and practice for different reasons. First, collecting detailed and reliable data on the current level of water security is highly necessary in the context of limited available data in this area and in Yangon and Myanmar in general. Furthermore, enhancing knowledge on the underlying causes and exploring the implications of water (in)security among the urban poor can help to develop more effective policy, regulations and interventions to increase water security. Although this case study focuses on a specific area within Yangon city, it is representative for challenges faced within Yangon and in many other growing and developing cities in the global South. Hence, better understanding of dynamics in this locality can also contribute to more general knowledge on sustainable and inclusive urban water governance.

This study also aims to contribute to the scientific water governance debate, specifically focussing on the emerging water security concept. By applying this concept on the local level, it will be possible to further enhance knowledge on the dynamics of achieving, shaping and negotiating water security, defined as the access to safe water supply as well as the exposure to water related risks. Different causes of identified water insecurities will be explored by looking at both institutional as well as household level barriers to achieve water security. Furthermore, the outcome and effects of these water insecurities will be studied. Thereby, this study will enhance the understanding of the interplay of factors influencing and shaping water security on the local level.

1.5 Outline

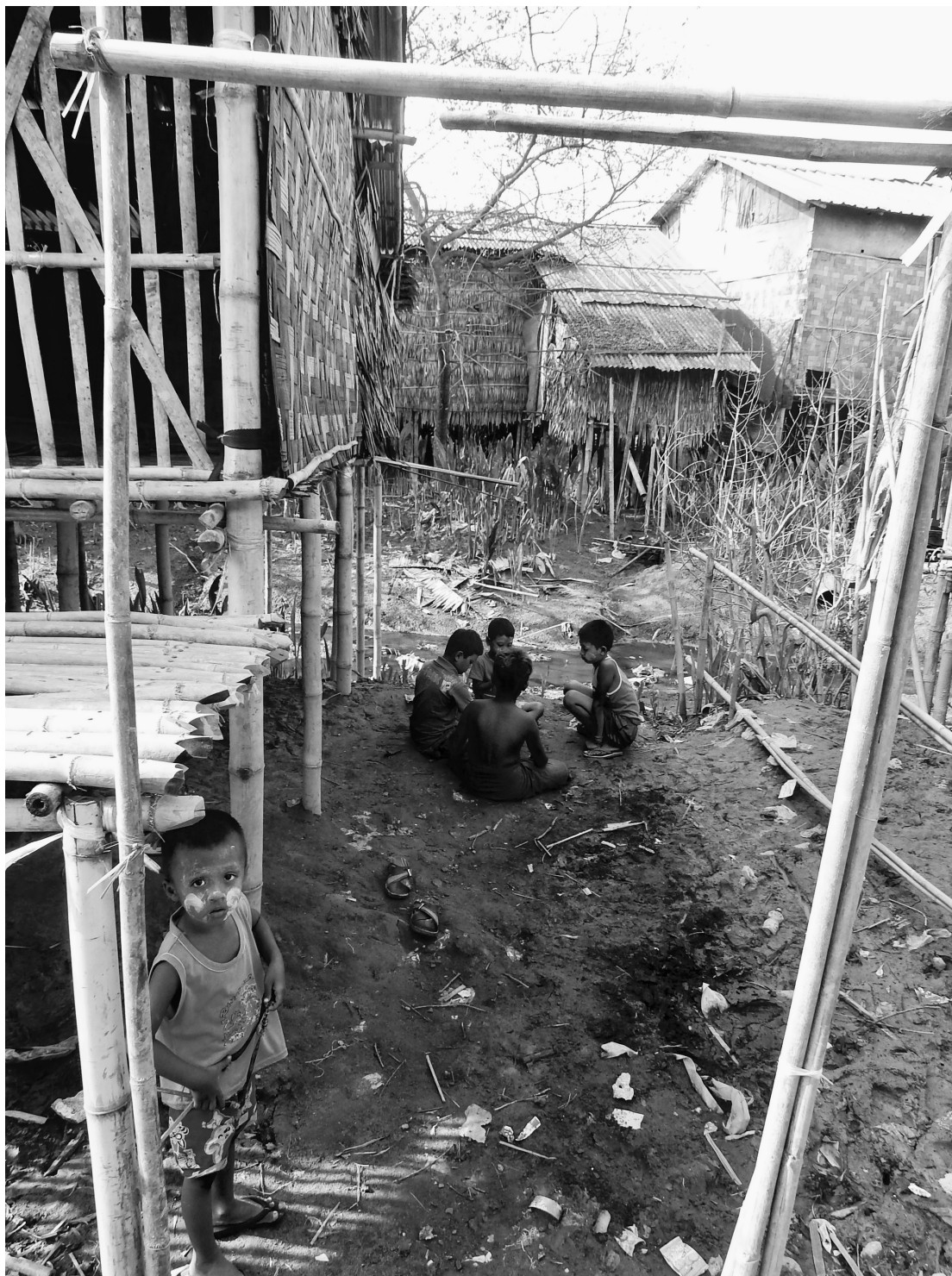
This report can be divided into four sections. In Part I, the research framework is presented; relevant theories and concepts will be discussed in Chapter 2, followed by the methodological framework in Chapter 3. In Chapter 4, an overview of the regional context will be given.

Part II deals with sub-question 1, as the stakeholders governing and using the water resources in HTIZ are introduced. In Chapter 5 the main governmental institutions are described, followed by the characteristics of the industry in HTIZ in Chapter 6. The different population groups inhabiting HTIZ are introduced in Chapter 7 and their livelihood characteristics are discussed.

The findings on water security in HTIZ are outlined in Part III, dealing with sub-question 2, 3 and 4. In Chapter 8 the access to safe water for the local population will be described, as well as the challenges of achieving this and the livelihood outcomes of not being able to access safe water. Chapter 9 describes the two main water-related risks in HTIZ, namely water pollution and flooding. Again, the drivers and outcomes of the identified risks are discussed as well.

Part IV comprises of the discussion on the limitations and implications of the findings of this study in Chapter 10, followed by the conclusion in Chapter 11.

Part I: Research framework



2. Theoretical framework

Within this chapter, an overview of the relevant literature on water governance in general and water security specifically will be provided. Furthermore, the use of these concepts within this research is discussed and the conceptual framework will be presented.

2.1 Water governance

The discussion on the nature and dynamics of water governance can be linked to the popularity of the 'good governance' paradigm in development literature and policy debates. Although there is a wide range of literature on good governance and its characteristics, the water governance concept is explored to a much lesser extent; whereas many scholars and policy makers use this concept, only a few aim to clarify on what good and effective water governance actually comprises of (OECD, 2015; Franks & Cleaver, 2007; Rogers & Hall, 2003).

In general, water governance can be defined as 'the range of political, social, economic and administrative systems that are in place to develop and manage water resources, and the delivery of water services, at different levels of society' (Rogers & Hall, 2003: 7). Following this definition, water governance is thus the process through which water resources are governed more than the outcome of this political process. However, within the water governance literature the outcome of this process is analysed as well. Especially the concepts of integrated water resources management (IWRM) and water security are increasingly seen as desired outcomes of the water governance process, both in science as well as in practice (Bakker, 2012; Cook & Bakker, 2011; Rogers & Hall, 2003). However, relatively little attention is given to how these outcomes can be achieved and what barriers prevent to achieve the desired water governance outcome. Although there is a high degree of overlap between both IWRM and water security, the later will be the focus of this study as a relatively new framework with limited studies on the factors shaping water security on the local level.

2.2 Water security

Within the water governance framework, the concept of 'water security' has gained more momentum over the past decade. This concept is concerned with the access to and risks of water for both humans as well as ecosystems. It is used within a variety of disciplines and studied on various scales; whereas some studies focus more on water security on the national or international scale, others apply it to a more specific community or location (Bakker, 2012; Cook & Bakker, 2011; Grey & Sadoff, 2007; Xia et. al., 2007). Furthermore, there is a difference in thematic focus; whereas some scholars focus on water security in terms of availability and demand (Falkenmark et. al., 2007), others focus more on the access to water for humans and the water-related risks humans are exposed to (Cook & Bakker, 2011; Rijsberman, 2006). In an attempt to acknowledge the importance of the ecosystem health for water security, other scholars and organizations have interpreted the water security concept in terms of sustainability of the natural system and therewith also the human system (Norman et. al., 2013; Cook & Bakker, 2011).

Within this study, the definition of Bakker (2012) of water security as 'an acceptable level of water-related risks to humans and ecosystems, coupled with the availability of water of sufficient quantity and quality to support livelihoods, national security, human health, and ecosystem services' (2012: 914) will be followed. This definition is most holistic in the sense that it recognizes both the risks induced by water as well as the needs for water of different

actors and systems, instead of focussing only on one of these aspects of the water security concept. However, within this study the holistic definition is applied on the community level, herewith mainly focussing on the human system in order to get in-depth knowledge on the dynamics that shape water security for local communities; to what extent are people able to access water and exposed to water-related risks? To what extent are people able to influence the local water security through alternative systems? And what are the causes and effects of limited water security?

As water security is defined as both the access to safe water supply as well as the exposure to water related risks, the themes of water supply but also water pollution and flooding as risks will be discussed in more detail.

2.2.1 Water supply

Assuring access to safe water supply is a main topic within water governance literature. This topic is studied from various disciplines and perspectives; whereas access to water is sometimes framed as a human right, other scholars argue for water as a marketable good. This distinction also forms the basis of the public versus private water provision debate, in which the relatively advantages of providing water through public means or market mechanisms are discussed (Bakker et. al., 2008; Galiani et. al., 2005). Although this is a central debate within water governance literature, some scholars argue that the public – private distinction is too narrow and highlight the wide range of formal and informal arrangements of water supply (Bakker et. al., 2008; Allen et. al., 2006). Figure 1 shows this wide spectrum of different water supply systems as drafted by Allen et. al. (2006). In many urban hubs in the global South, water is supplied through a mix of policy and needs driven systems, which can also be characterized as ‘formal’ and ‘informal’ water supply systems. Research shows that especially in peri-urban and urban periphery areas, the formal water supply system (consisting of public and private sector water supply) is not able to cover the water needs, resulting in a mix of formal and informal water supply systems (Bakker et. al., 2008; Allen et. al., 2006). These alternative systems are the result of various institutional and household barriers that prevent the urban poor from accessing formal or ‘policy driven’ water supply (Bakker et. al., 2008; Satterthwaite, 2003). The specific mix of water systems in place can be considered the outcome of the water governance process in which both governmental institutions as well as local actors such as water vendors play a role.

Within this study, the framework of Allen et. al. (2006) will be used to characterize the mix of water supply systems found in the research area. Furthermore, the challenges for water security of the different supply systems will be outlined; whereas policy driven water supply is easier to regulate and monitor, different barriers often result in an inability to supply water through this ‘formal’ system, especially to peri-urban areas. Whereas the needs-driven system provides an alternative to provision these areas, the informal character of these systems make it difficult to control the quality of water supplied.

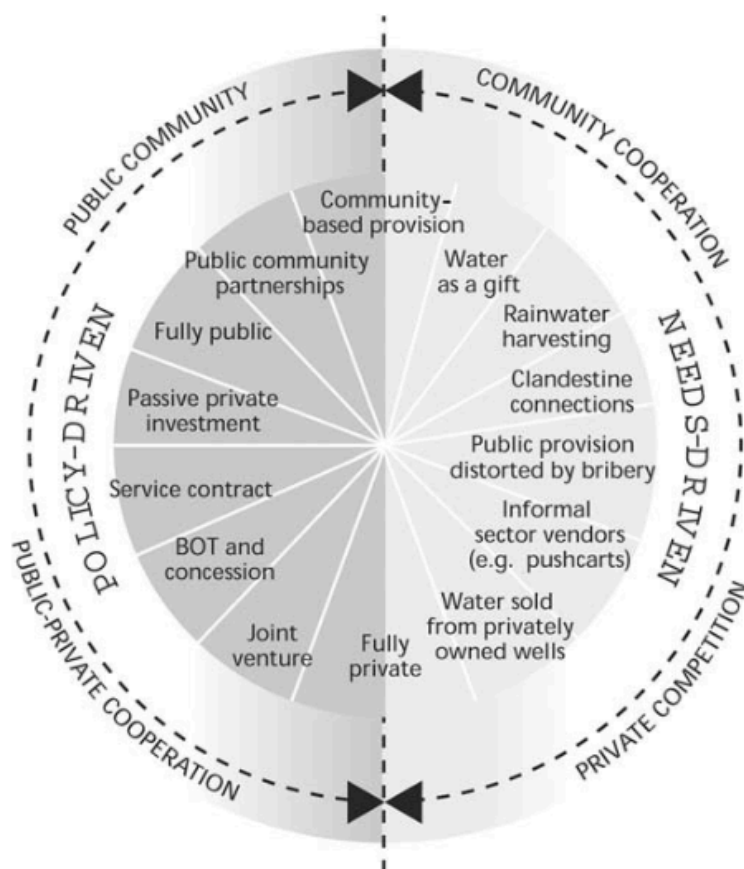


Figure 1: The 'water supply wheel' (Source: Allen et. al., 2006)

2.2.2 Water pollution

Next to access to safe water supply, water pollution is considered a major water governance challenge especially in highly populated and industrial urban hubs (Satterthwaite, 2003). Water pollution is often the result of rapid urbanization and industrialization and a lack of effective governance to control these potential sources of pollution. Increased population numbers often put the existing sanitation, sewage and waste collection system under pressure, resulting in the discharge of solid and liquid domestic waste and hence 'domestic' pollution of water resources. Especially the lack of sanitary facilities is a source of various water-borne diseases and hence poses a serious health risk. The provision of sanitary services and the resulting degree of water pollution in urban areas is the outcome of the governance process and the different development priorities, perceptions and values of actors involved in this process (Allen et. al., 2006). As sanitary facilities and sewage systems are still lacking in many (peri-) urban hubs in the global South, alternative 'needs' driven systems are often used. Figure 2 depicts these different forms of sanitary facilities used, ranging from 'policy' driven improved sanitation facilities to 'needs' driven alternative sanitation methods. Within this study, the categorization of these different sanitation systems is used and the water pollution consequences of the lack of policy driven systems is touched upon.

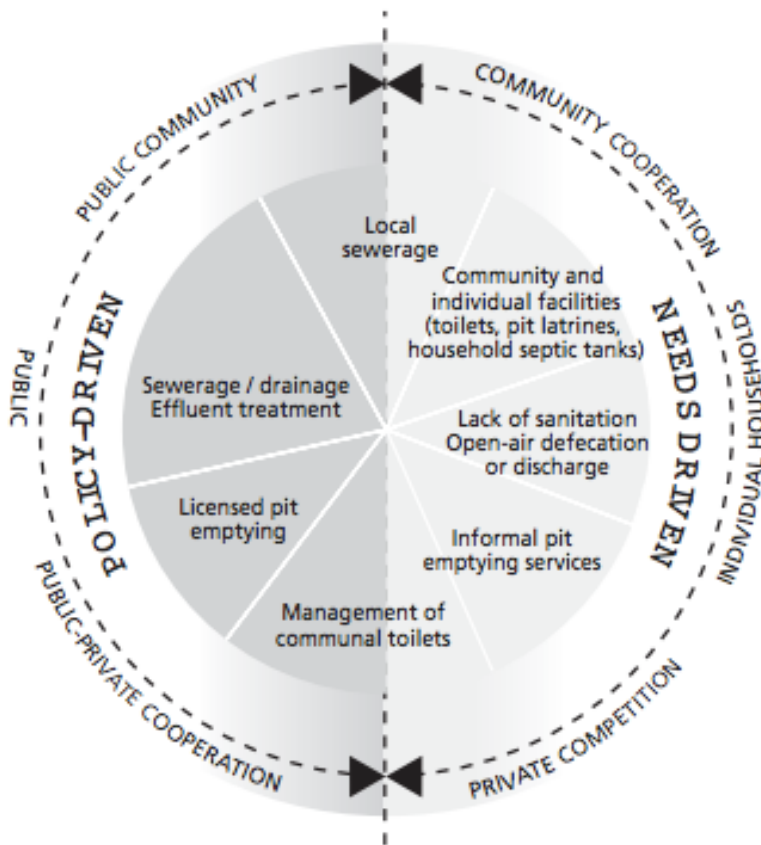


Figure 2: The 'sanitation wheel' (Source: Allen et. al., 2006)

Next to domestic water pollution, industrial water pollution is a main water governance challenge in many urban hubs. Increased industrialization and poor regulation often increases the risk of water pollution, as the discharge of untreated industrial waste, often containing various hazardous chemicals and heavy metals, is a serious threat to both human as well as ecosystem health (Karn & Harada, 2001).

Both industrial as well as domestic water pollution can be characterized as a governance issue; a lack of infrastructure in the form of sewage, sanitation and wastewater treatment facilities and a lack of enforcement and monitoring are considered major causes for the pollution of fresh water resources in urban areas (Allen et. al., 2006; Satterthwaite, 2003; Karn & Harada, 2001).

2.2.3 Urban flooding

Within many cities in developing countries, flooding is considered a major challenge. Different types of urban flooding can be distinguished; localized flooding due to inadequate drainage systems, localized flooding of small streams, flooding of major rivers and coastal flooding (Douglas et. al., 2008). The exposure to these different urban flooding types can be attributed to a variety of factors; climate change, high population density, expansive informal settlements and a lack of adequate infrastructure all contribute to the risk of urban flooding (Tanner et. al., 2009).

Within urban centres, the poor are often disproportionately affected by flooding events, as slum settlements tend to be in flood-prone areas and are characterized by poor housing structures. Furthermore, the impact of flooding is also significantly higher for the urban poor, as they often lack the resources to restore or rebuild their house and livelihood, causing further impoverishment (Winsemius et. al., 2015; Satterthwaite, 2003).

The vulnerability of a city and its citizens to urban flooding cannot merely be attributed to natural processes; it is the outcome of a complex interplay of natural, social and political factors. The governance processes within cities are a major determinant for the relative risk and impact of urban flooding; decentralization, transparency, flexibility, inclusion and experience are found to be defining factors in the governance of urban flood risk (Tanner et. al., 2009).

2.3 Drivers of water (in)security

The level of water security achieved within a specific area or for a specific group is often determined by various factors or complicated by different barriers. Especially the urban poor are often unable to access safe water supply and are more at risk of facing various environmental hazards (Winsemius et. al., 2015; Satterthwaite, 2003). Causes explaining this lack of water security can be found on both governance as well as the individual or household level. A few scholars have studied the barriers to achieve water security in urban and peri-urban areas in developing countries (Bakker et. al, 2008; Satterthwaite, 2003). Table 1 provides an overview of various barriers found on both the institutional as well as the individual level (Bakker et. al, 2008; Satterthwaite, 2003).

Table 1: *Barriers to achieve water security for urban poor*

Institutional barriers	Individual barriers
<ul style="list-style-type: none"> • Lack of effective governance to ensure adequate housing • Lack of basic infrastructure provision • Lack of health-care provision and emergency services to limit the impacts of water insecurities • Lack of economic incentives to connect to urban poor • Lack of consumer entitlements to basic services • Governance culture 	<ul style="list-style-type: none"> • Low income • Lack of property rights • Lack of skills • Cultural beliefs • Tariff structure

The institutional barriers can be the result of the refusal, inability or lack of priority of the (local) government or non-governmental agencies to provide in the need of citizens in a specific area or from a specific group (Bakker et. al., 2008; Satterthwaite, 2003). Hence, this is directly related to the wider social, economic and political context. On the household level, characteristics related to the living conditions can form a barrier to achieve water-security. However, these household-level barriers are directly related to the wider governance structure as well, as this influences the social, political and economic context in which these urban poor households can operate.

2.4 Implications of water (in)security

The importance of improving water security is highlighted by studies indicating the negative impacts of water-related risks and limited access to safe water supply on living conditions, especially for poor and vulnerable groups in the global South. The link between health-hazards and limited water security is well established within research throughout various disciplines. The lack of safe water supply and sanitation often result in a high occurrence of water-borne diseases such as diarrhea, malaria and typhoid (Karn & Harada, 2002). The lack of access to safe water can thus be considered a main contributing factor to illness in the global South, which in turn influences the capacity to work or go to school, which decreases the development possibilities (Kingsbury, 2012; Harvey, 2008). Herewith, water insecurity can indirectly impact the poverty level and hence the livelihood conditions of people.

Some scholars explore this relation between poverty and limited water security. This link is often recognized to be a two-way street; poverty can be the cause as well as the result of limited water security. Various scholars studied the effects of water-related hazards and a lack of water and sanitation infrastructure on poverty (Harvey, 2008; Allen et. al, 2006; Satterthwaite, 2003). The lack of water security impacts various aspects of often already poor households, such as health, productivity, economic and education opportunities and mobility, resulting in increased inequality due to further impoverishment. Harvey (2008) proposes a framework that explains the relation between access to safe water supply and poverty through various factors, as depicted in Figure 3. According to this scholar, access to safe water influences poverty through health (expenditures), productive time, education and economic opportunities. Within this study, these factors are expected to be only partly the same, as the focus is on a peri-urban area and on water security in a broader sense. Although the factors proposed by Harvey (2008) are thus considered and explored, this study also aims to gain new insights in order to achieve a better understanding on the dynamics between water security and poverty in peri-urban areas.

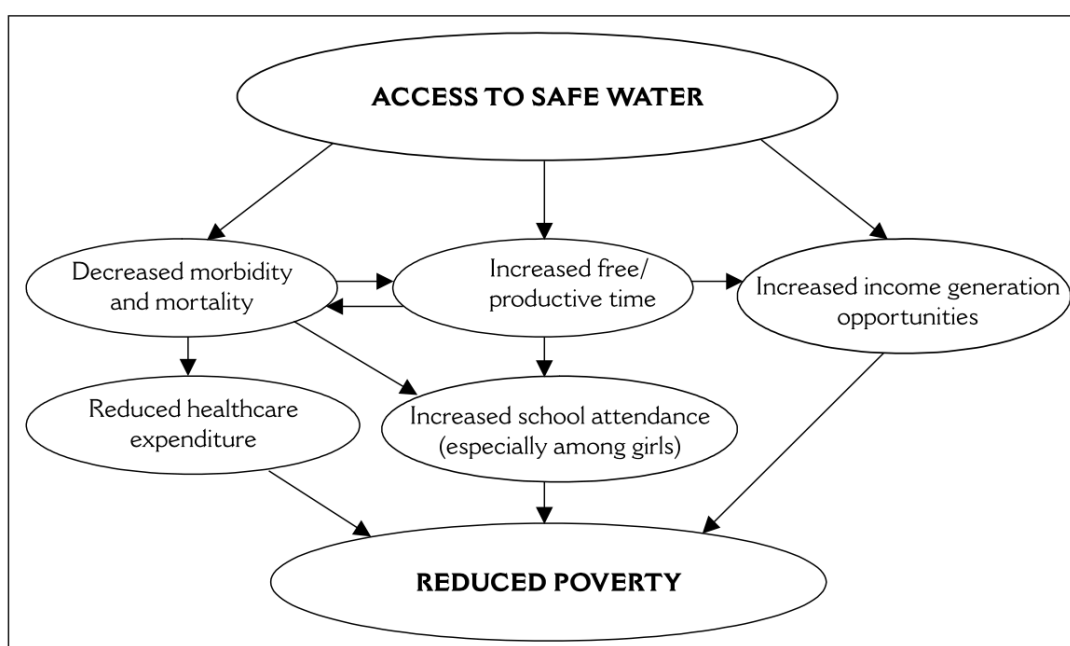


Figure 3: Relationship between water & poverty (Source: Harvey, 2008)

2.5 Conceptual framework

Based on the literature and theories discussed, the conceptual framework has been developed as depicted in Figure 4. The level of water security, defined as the access to water supply and exposure to water-related risks (pollution and flooding) will be analysed, next to the drivers for certain water insecurities by identifying both individual and institutional barriers. Finally, the effects on the livelihood conditions of people, influenced by factors such as health and economic opportunities, will be explored. These livelihood outcomes in turn influence the barriers again, as further impoverishment can in turn become a barrier for achieving water security. Although this conceptual model incorporates existing theoretical ideas, it was foremost developed in such a way that it allows for exploring different factors that shape and are shaped by water (in)security on the local level.

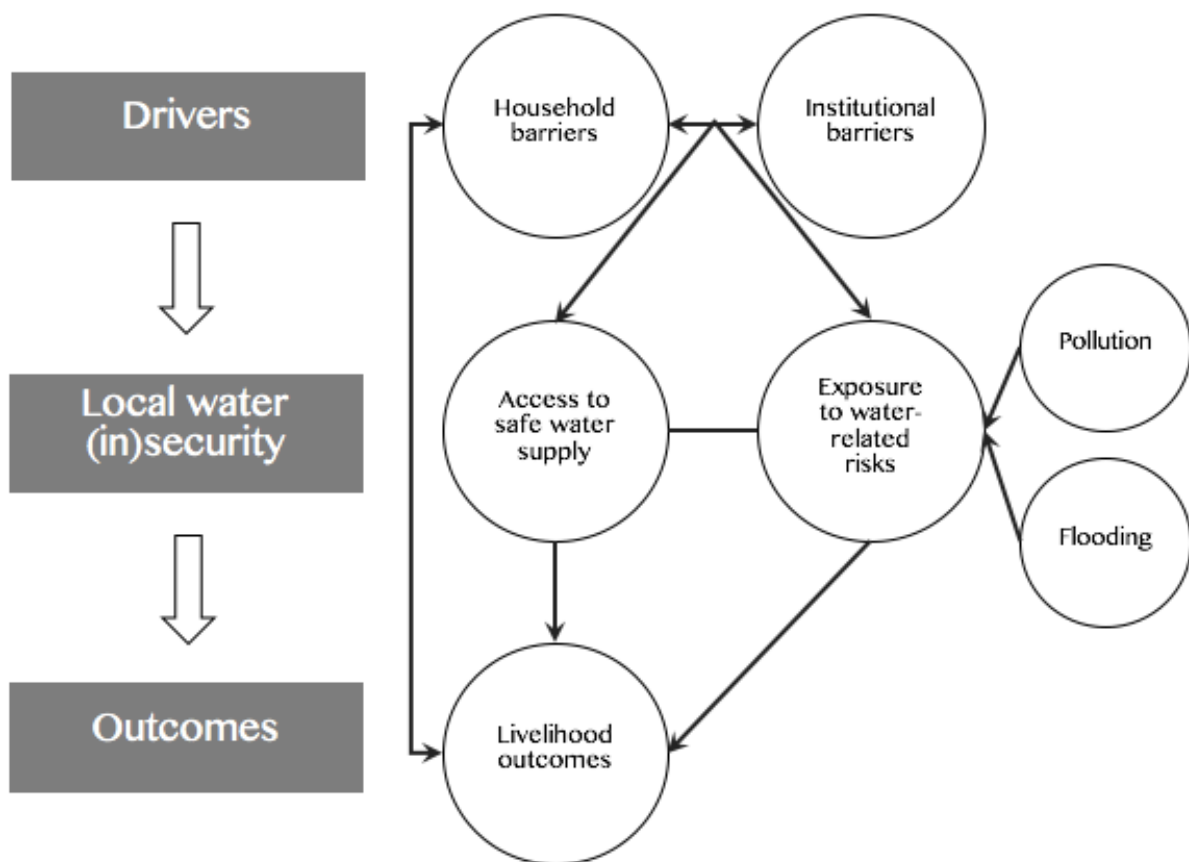


Figure 4: Conceptual framework

2.6 Conclusion

Water governance is a highly complex and political process involving different institutions and actors who shape and negotiate the use and allocation of water resources. The desired outcome of this process is subject to different priorities and perceptions on 'good' and fair water governance. However, within policy and practice the relatively new concept of water security, defined as the access to safe water as well as minimal water-related risks, is considered a desirable aim. The challenges of achieving water security in urban hubs in the global South are both found in ineffective governance processes as well as the relative vulnerability of poor groups. The resulting water insecurities have implications for the livelihood outcomes of these urban poor, which can further complicate achieving water security.

3. Methodology

Within this chapter, the different research strategies and methodologies used will be outlined. First, the operationalization of the different variables and indicators used within this study will be discussed. Furthermore, the research strategy and research area are introduced, followed by an outline of the data collection and analysis methods. Finally, the methodological and practical limitations of this study will be discussed.

3.1 Operationalization

In order to conduct the study as outlined in the conceptual framework, the variables of interest need to be operationalized. Table 2 indicates the different indicators used to measure the different concepts as well as the data collection methods.

Table 2: Operationalization of research variables

Main concept	Dimensions of concept	Indicator(s)	Method(s)
<i>Water security</i>	Access to safe water supply	<ul style="list-style-type: none"> • Sources of water used • Quality of water • Quantity of water • Affordability of water 	<ul style="list-style-type: none"> • Survey • Focus group • Secondary data
	Water pollution	<ul style="list-style-type: none"> • Experienced water pollution • Solid waste collection system • Liquid waste collection system • Water pollution parameters 	<ul style="list-style-type: none"> • Survey • Focus group • Secondary data
	Flooding	<ul style="list-style-type: none"> • Incidences of flooding • Height of flooding • Impact of flooding 	<ul style="list-style-type: none"> • Survey • Focus group
<i>Water security barriers</i>	Household barriers	<ul style="list-style-type: none"> • Income & expenditure level • Education level • Gender • Living location • Land tenure security 	<ul style="list-style-type: none"> • Survey • Focus group • Interviews
	Institutional barriers	<ul style="list-style-type: none"> • Governance structures • Policies / regulations • Capacity of institutions • Development priorities • Perception of informal settlements 	<ul style="list-style-type: none"> • Interviews • Secondary data
<i>Livelihood outcomes</i>	Health	<ul style="list-style-type: none"> • Experienced health issues • Expert view on health risks 	<ul style="list-style-type: none"> • Survey • Focus group • Secondary data
	Mobility	<ul style="list-style-type: none"> • Limitations in mobility during flooding 	<ul style="list-style-type: none"> • Focus group
	Poverty	<ul style="list-style-type: none"> • Income & expenditure level • Extra costs induced by water supply / water-related risks 	<ul style="list-style-type: none"> • Survey • Focus group

3.2 Research strategy

The aim of this study is to gain more knowledge on the dynamics of water security by studying the process through which water security is shaped, looking at both the drivers and livelihood outcomes of water (in)security on the local level. As such, this study is both deductive as well as inductive in nature; building on existing theories, it aims to identify new relationships and patterns out of observations and data collected (Bryman, 2008). The research design can be characterized as a cross-sectional design, as it consists of different observations among different groups of people at one point in time (Bryman, 2008). One of the limitations of this research design is that no causal relations but only associations can be established, limiting the internal validity of the study. This is not considered to be a major obstacle for this study, as the aim is to identify some related factors instead of establishing causal relations. Furthermore, external validity might be limited as the research is relatively small in sample size and the sampling strategy was not completely random. However, due to the large heterogeneity within the sample, the level of external validity is assumed to be acceptable.

3.3 Research area

The research area of this study is Hlaing Tharyar Industrial Zone (HTIZ), which is located in Hlaing Tharyar township, the most highly populated township located in North-West Yangon. In 2012, the total population of this township was estimated to be 488,768 people (JICA, 2012). However, due to the large number of informal settlements in the area, this number is likely to be even higher in practice. UN-Habitat (2017) estimated that 124,325 people live in informal settlements in Hlaing Tharyar, which makes it the township with the highest degree of informal settlers.



Figure 5: Map of Hlaing Tharyar township & location of HTIZ (Adjusted from: Google Maps)

Hlaing Tharyar township can be roughly divided into three parts; the Shwe Lin Ban Industrial Zone in the upper-North, the domestic area in between this zone and the Yangon-Pathein highway, and finally the Hlaing Tharyar Industrial Zone bound by the Yangon – Pathein highway in the North and the Pan Hlaing river in the South. The location of HTIZ within Hlaing Tharyar township is depicted in Figure 5. HTIZ was chosen based on criteria that are generally considered to be challenging environments to ensure water security; high population density, the existence of different ‘settlement’ types (including informal settlements), a high degree of industrialization and low infrastructure coverage.

HTIZ is one of the largest industrial zones in Yangon covering 1401.44 acres in total (of which 1087.98 is industrial area) (MIA, 2012). The industrial zone can be divided into 6 zones, namely zone 1, 2, 3, 4, 6 and 7. This study will solely focus on HTIZ zone 1, 2, 3 and 4, the area highlighted in Figure 6, as zones 6 and 7 are located further north of the township. The research area includes the formal village of Yay Oakkan, four informal villages on the riverbank of the Pan Hlaing river and informal settlers living along the roadside in these four zones. This local demarcation is applied in order to be able to study the villages and settlements within these zones in more detail and to create the possibility of comparing three different groups within this research area: citizens living in 1) formal settlements, 2) informal settlements along the road and 2) informal settlers living on the Pan Hlaing riverbank. More details on these three different groups are provided in Chapter 7.

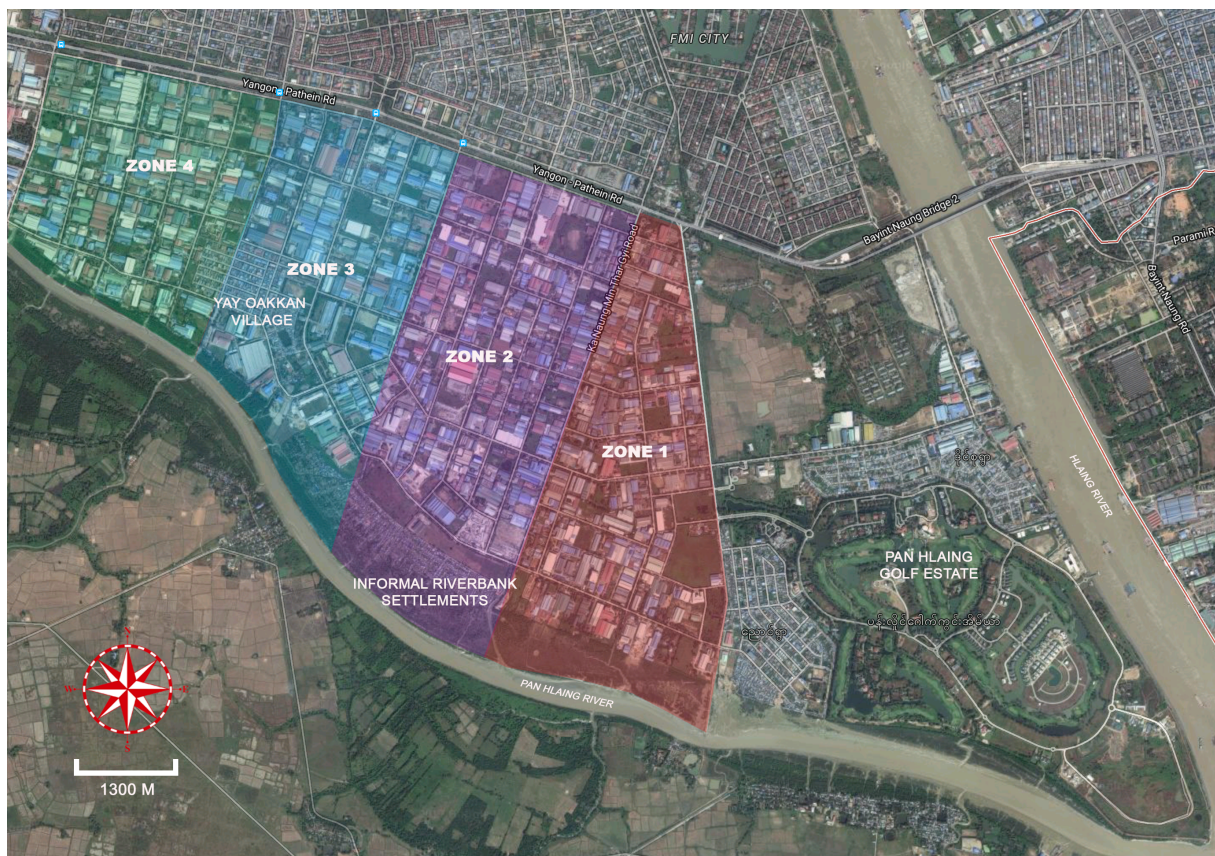


Figure 6: Detailed map of the research area HTIZ (Adjusted from: Google Maps).

3.4 Data collection

The data for this study is collected through a mixed-method approach, combining both qualitative and quantitative research methods; interviews, a focus group and household surveys have been conducted. Combining these different methods allows for triangulation to increase the validity of the results. Furthermore, applying a mixed-method approach helps to increase the contextual understanding and to better interpret findings (Bryman, 2008).

Within this research both primary as well as secondary data has been used. The secondary data used was mainly found within reports of NGOs and from data sources of the national or regional government (national policies, YCDC regulations / reports). Primary data has been collected through household surveys, interviews with different stakeholders and a focus group discussion.

3.4.1 Household surveys

In order to acquire detailed data of the local population in HTIZ, a total of 65 household surveys have been conducted within a time-span of 4 weeks. In an attempt to get a heterogeneous mix of respondents, the surveys were conducted on different weekdays as depicted in Table 3.

Table 3: *Dates of conducting the household survey*

Date	Day of the week	Nr. of respondents
10/03/2017	Friday	2
12/03/2017	Sunday	5
14/03/2017	Tuesday	5
15/03/2017	Wednesday	5
22/03/2017	Wednesday	6
25/03/2017	Saturday	4
26/03/2017	Sunday	6
27/03/2017	Monday	7
01/04/2017	Saturday	6
02/04/2017	Sunday	6
07/04/2017	Friday	6
08/04/2017	Saturday	7
Total		65

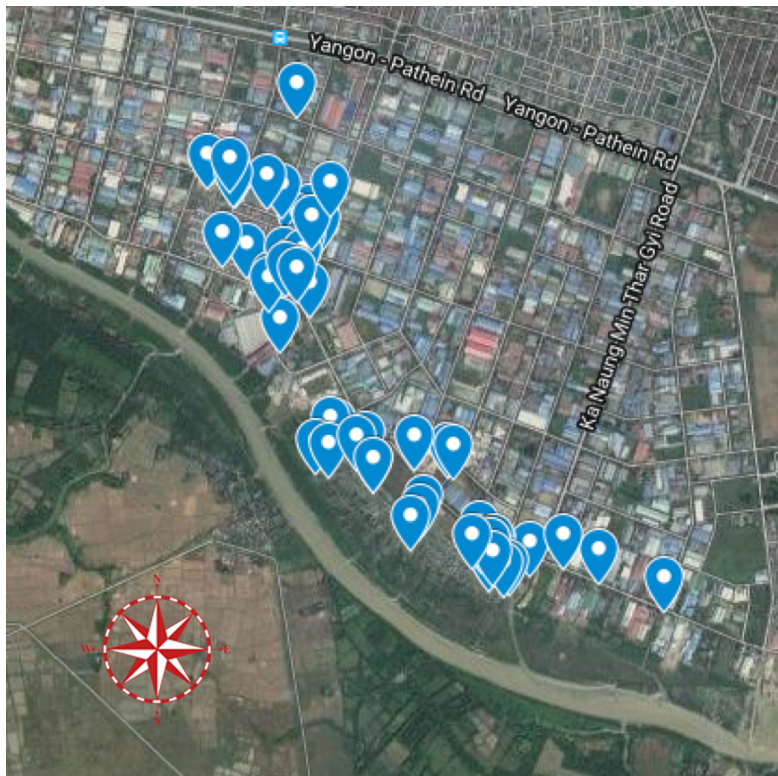
The household surveys have all been conducted by Banyar Oo, a graduate student from Yangon Technological University (YTU) and the author. The survey consisted of 26 questions, both open and closed (see Appendix I for the full survey). Completing the survey took between 25 to 45 minutes per respondent. All surveys were conducted in interview form; the questions were asked face-to-face and the answers were written down by either Banyar Oo or Rebecca Groot. Although the surveys were targeted at one of the household members, it regularly happened that other interested neighbours or family members were also partly answering, especially regarding open questions on flood levels in the area or the main challenges during a specific season.

3.4.1.1 Sampling strategy

For the surveys, a quota sampling strategy has been applied in order to be able to compare different groups of settlers in HTIZ. The following three groups have been targeted:

1. Formal settlers living in apartments in Yay Oakkan
2. Informal settlers living along the roadside in HTIZ
3. Informal settlers living on the Pan Hlaing river bank in HTIZ

A total of 20 households from group 1 and 2 have been selected, whereas 25 households were selected from group 3. This distinction has been made as the group of informal settlements on the riverbank is estimated to be slightly bigger than group 1 and 2. However, as there is no accurate data on the number of households living in these areas, it remains a difficult task to select a representative sample for the survey. Hence, this needed to be based



on estimations of the relative group size. The selection of specific households within these three groups was initially based on geographical location, as the aim was to create a geographically dispersed set of data. The distribution of the different survey locations is depicted in Figure 7. Within a certain geographical area, the households were randomly selected by approaching people living in every fifth house. In case of non-response due to absence or unwillingness to participate, the household next-door was approached.

Figure 7: Distribution of survey locations in HTIZ (Adjusted from: Google Maps)

3.4.1.2 Characteristics of sample

When looking at the balance of the sample, the gender distribution of the respondents was found to be relatively unequal; 29.2% of the respondents were male, whereas 70.8% were female. This difference can be explained by the fact that most of the surveys were conducted during the day (8am – 2pm), a time in which most of the men are at work. Due to security reasons, it was not possible to go to the research area at night; hence, the sample of respondents remained relatively unbalanced. However, as most of the questions were asked on the household level, the gender of the respondent and the resulting imbalance in the sample is not considered highly problematic. The age of the respondents ranged from 17 to 72 years, with a mean of 43.2 years. The average household consisted of 4.3 members, varying from 1 up to 9. A large majority of 95.4% of the respondents was of Bamar ethnic decent, whereas 4.6% was Kayin. Buddhism was the main religion (96.9%), followed by Christianity (3.1%). More specific information on the households surveyed can be found in Chapter 7.

3.4.2 Focus group discussion with households

A two-hour long focus group discussion was organized in HTIZ on Sunday the 30th of April. The focus group discussion was organized in one of the informal riverbank villages, as the results from the household survey indicated that this respondent group was most heavily affected in terms of water-related challenges and risks. The aim of this session was to fill existing knowledge gaps and to further clarify some findings, for example on the impacts of certain water-related challenges. A question list of the focus group is provided in Appendix II.

Three local graduate students from YTU facilitated the focus group discussion, which was organized in the monastery of the village. The focus group discussion was attended by an estimated 40 villagers, with a relatively equal gender division. Although the initial set up of the focus group discussion was to hold two separate discussions (one for men, one for women), this changed due to practical circumstances. In order to still have a gender-sensitive focus group discussion, the men and women were separated and sometimes separately asked to answer certain questions. Furthermore, some questions required group brainstorming and writing down the answers on paper, which was then also done separately between men and women.



Figure 8: Focus group discussions with households in HTIZ

3.4.3 Stakeholder & expert interviews

The different interviews conducted with stakeholders and experts are presented in Table 4. The duration of the interviews ranged from 15 to 60 minutes and they were all conducted in Yangon. Most of the interviews can be characterized as semi-structured, herewith creating room for flexibility and possibly relevant additional information. Due to the variety of stakeholders and experts interviewed, the specific questions and topics discussed varied as well. However, a list of general interview topics is provided in Appendix III. The information acquired through the interviews was used to answer the research question and as input for making the household survey.

Table 4: *List of conducted interviews*

Organization	Date
MOALI – Irrigation Department	03/03/2017
YCDC- Water & Sanitation Department	08/03/2017
YCDC- Pollution Control & Cleansing Department	08/03/2017
NEPS	09/03/2017
H&M	13/03/2017
Cordaid	23/03/2017
NLD Hlaing Tharyar	25/03/2017
NLD Hlaing	25/03/2017
JICA	28/03/2017
Solidaridad	04/04/2017
ALARM	05/04/2017
HTIZ management committee	05/04/2017
YCDC – City Planning & Land Administration Department	06/04/2017
SMART Myanmar	06/04/2017
Village head informal settlements	06/04/2017
Oxfam Myanmar	06/04/2017
Coca-Cola Myanmar (HTIZ)	06/04/2017

3.5 Data analysis

The qualitative data collected through interviews and the focus-group discussion and the secondary data from reports and policies has been analysed by coding it in Word. The data collected through the household surveys was entered into SPSS, followed by cleaning the dataset and sorting the answers to the open questions in Word. The quantitative data in SPSS was analysed by using descriptive statistics, frequency tests, Pearson’s R and ANOVA tests.

3.6 Limitations

Several methodological and practical challenges were encountered throughout the research process, which are discussed below.

3.6.1 Sample

The sampling method used within this research has its limitations. As it was not possible to select randomly beforehand due to a lack of data on the inhabitants of the area, it was only possible to randomly select the individual households in a later stage by choosing every fifth house within a certain geographical area. Furthermore, due to time constraints it was not possible to revisit households that were not home at the time of surveying. This adjusted sampling method could have created a bias, as it cannot be considered completely random. However, random sampling is almost impossible within this research context as the documentation of informal settlements is very limited. Another methodological limitation is the relatively small sample size of 65 respondents. Due to the limited scope of this research, it was not possible to increase this number. However, this limitation is less problematic as the main aim of this research is to quantitatively map the water security dynamics in HTIZ, and not so much to establish causal relations.

3.6.2 Availability & access of data

The amount of (reliable) data available in Myanmar is still relatively limited. Although efforts have been made for more structural and large-scale data collection (e.g. census data) during the past decades, data on more specific areas or topics is still minimal. Furthermore, acquiring the data or specific information has proven to be a challenge in some cases. This was a limitation for this study in the sense that it could only build upon and use a few other reports and sources of information, which might make it more explorative in nature than it would have been if more data and information were available and accessible. Furthermore, some estimations had to be made if data was lacking, for example on population estimates in HTIZ.

3.6.3 Language

All household surveys were conducted in Burmese, as well as some of the interviews and the focus group discussion. This implies the step of translating the information from Burmese to English, which always comes with risks as translation is a matter of subjective understanding and interpretation. However, this risk might be mitigated due to the good English skills of the YTU graduate student Banyar Oo and the fact that Rebecca was present during all the surveys / interviews / focus group discussion, which created the possibility to ask for clarification or more specific translation if there seemed to be an error or misunderstanding.

3.6.4 Trust

While conducting the household surveys, it was sometimes challenging to win trust of the respondents as to what the aim and the context of the study was. Some respondents were frightful of our intentions or asked whether the government was in any way involved, which could also be related to their 'informal' settlement status. Hence, the role of Banyar Oo in explaining our intentions and the fact that data would be handled confidentially was critical.

3.7 Host organization

The host organization for this study was Royal HaskoningDHV, an international engineering and project management consultancy firm. Due to a common interest in the specific research area and the topic of urban water governance in Yangon, the collaboration was initiated; Royal HaskoningDHV has plans for several infrastructural water projects near HTIZ. The role of Royal HaskoningDHV in this study was facilitating in terms of providing the researcher with a working location in Yangon and with its network of private, public and civil society actors in Myanmar. Furthermore, Royal HaskoningDHV provided input or feedback on the research proposal and the interim report. In order to ensure no conflict of interest, the research activities were not funded or conducted by Royal HaskoningDHV. The results of this study will be shared with Royal HaskoningDHV by providing the thesis and through a presentation of the findings.

3.8 Conclusion

A mixed-methods approach has been used within this study in order to acquire valid and detailed data on the current water security situation, as well as the drivers and outcomes. Both qualitative and quantitative data has been collected through secondary data analyses, interviews, household surveys and a focus-group discussion. The data was analysed by coding it in Word and analysing it in SPSS. The collection of data was limited by different methodological as well as practical challenges, such as the language barrier, the lack of trust and the limited time, resources and data available. Royal HaskoningDHV was the host organization in Yangon, taking on a facilitating role.

4. Regional framework

Myanmar is a rapidly changing country, especially during the last decade when the country moved to more political and economic openness. The aim of this chapter is to give a general regional overview of this dynamic country in which this study has been conducted, followed by a more specific overview of water governance policies and institutions in Myanmar. Furthermore, Yangon as socio-economic urban hub of will be introduced by looking at a few relevant developments and challenges within this city.

4.1 Myanmar at a glance

The political and the socio-economic landscape in Myanmar changed dramatically since the National League for Democracy (NLD) took office in April 2016 under the leadership of Daw Aung San Suu Kyi, moving the country towards more political and economic openness. The projected economic growth is 8.2% per year, reflecting the newly created opportunities derived from economic, political and social reforms (World Bank, 2017). However, this is a long-term process; Myanmar is still one of the poorest countries in the region. Compared to other ASEAN countries, Myanmar has the lowest life expectancy of 66 years and one of the highest infant and child mortality rates (50 per 1000 births). Furthermore, there is a widespread lack of access to basic infrastructures such improved water sources, which is only 80.6% and also improved sanitation facilities (79.6%). Furthermore, as a delta country Myanmar is especially vulnerable to flooding, resulting in high human and economic costs every year (World Bank, 2017).

Despite the major changes induced by the recent transition agenda, initially limited gender specific aims were defined in order to assure the equal benefits for women and girls from the socioeconomic reforms. However, the National Strategic Plan for the Advancement of Women (2013-2022) is a step forward in establishing a gender agenda in Myanmar. This is necessary to further enhance gender equality; although women are legally equal and many conventions on the rights of women and children have been ratified, in practice a gap remains. For example, gendered occupation segmentation, women's concentration in the informal sector, women's responsibility for unpaid care work and the low participation rates of women in the parliament highlight the gender inequality still prevalent in Myanmar (ADB, UNDP, UNFPA & UN-Women, 2016).

With regards to income and consumption inequality, Myanmar is performing better than its regional neighbours; the Gini-coefficient has been estimated between 0.21 and 0.29, however higher for Yangon with 0.36. Although income inequality is thus relatively low, Myanmar remains one of the poorest countries of Asia; 66.9% of the population can be categorized as 'working poor', meaning that they earn below the poverty line of 2 USD/day (Webster & Therkildsen, 2016).

Ethnicity is another major source of inequality and conflict in Myanmar. There are over 135 different ethnic groups in the country, with the majority being the Bamar ethnic group. The seven largest minority groups live in separate 'states', often controlled by the ethnic institutions and own military forces. Other smaller ethnic groups also live in border areas, often in the resource rich hills of Myanmar (Oxford Burma Alliance, n.d.). Despite the increase in ceasefires and peace negotiations over the past decade, ethnic conflicts and human rights violations are still regularly reported (Walton, 2013).

4.2 Governing Myanmar's water resources

Myanmar is a country with abundant fresh water resources that are used to supply for domestic, agricultural and industrial purposes, offer possibilities for transportation and are increasingly used for the generation of hydropower. Various recently established institutions are responsible for the governance of water resources and for drafting various regulations on the use and conservation of water in Myanmar.

4.2.1 Institutions

Over the past decades, the institutional arrangements in Myanmar changed rapidly; new ministries were established, others merged or reorganized. Currently, the three most important institutions on the national level governing water resources are the National Water Resources Committee (NWRC), the Ministry of Natural Resources and Environmental Conservation (MONREC) and the Ministry of Irrigation, Agriculture and Livestock (MOALI).

The NWRC was initially established in 2013, however after a short-term abolishment at the start of 2016 it was reinstalled in June 2016 (Myanmar Times, 2016). The NWRC consists of 20 members from various ministries, regional committees and other water experts. These members are responsible for drafting the National Water Policy Framework and are working on a National Water Law.

MONREC was founded in 2016 by combining two superseding agencies, namely the Ministry of Environmental Conservation and Forestry (MOECAF) and the Ministry of Mines (MOM). MONREC is responsible for the governance and conservation of Myanmar's natural resources and for drafting regulations and guidelines on these topics. Within MONREC, there is a specific body for environmental issues named the Environmental Conservation Department (ECD). This department is responsible for establishing national guidelines and policies to counter resource pollution and to promote conservation.

Following the Ministry of Livestock, Fisheries and Rural Development, MOALI was officially established in 2016. Within MOALI, the Department of Irrigation is the national organ responsible for the management of water resources for agricultural purposes in Myanmar. This department is also responsible for dividing the national water resources to local city committees such as YCDC.

4.2.2 Policies & regulations

Various policies and regulations that are concerned with the governance and conservation of water resources have been drafted in Myanmar over time. Especially during the last decade, new laws and guidelines on environmental conservation have been developed.

The National Water Policy was drafted in 2014 by the NWRC. The goal of the national water policy is to 'develop, share and manage the water resources of Myanmar in an integrated, holistic and socially inclusive manner, to contribute significantly to the poverty alleviation, to the green growth and sustainable development of the nation, by providing access to water of equitable quantity and safe quality for all social, environmental and economic needs of the present and future generations (National Water Policy 2014, Chapter 2 (2.1)). The policy touches upon various topics, including water supply, floods and urban and industrial water use.

The 2012 Environmental Conservation Law aims to provide a framework for environmental conservation and sustainable use of natural resources in Myanmar. The law outlines various duties and tasks of governmental bodies, indicates environment specific regulations and lists prohibitions and the corresponding penalties. Furthermore, the Environmental Conservation Law indicates that national environmental standards should be established, which resulted into the Environmental Guidelines in 2015.

The Environmental Guidelines drafted in 2015 'provide the basis for regulation and control of noise and vibration, air emissions, and liquid discharges from various sources in order to prevent pollution for purposes of protection of human and ecosystem health' (National Environmental Quality (Emission) Guidelines 2015, Chapter 1(1)). The guidelines provide a specific section on wastewater, indicating the effluent standards of industrial wastewater for 28 different parameters. Furthermore, industry specific guidelines indicate the parameter values allowed for the water- and air pollution of various sectors, e.g. petroleum refining and garment.

4.3 The city of Yangon

Yangon has been the capital city of Myanmar until 2006 and is still considered the socio-economic hub of Myanmar. The city is located in the South of Myanmar, as depicted on Figure 9. An estimated 5.2 million citizens live in Yangon city, with an average growth rate of 1.9% per year from 2006 onwards (Forbes, 2016). Yangon is the most highly populated region and knows an average household size of 4.4 people. Furthermore, 91.9% of the households in Yangon have access to improved sanitation facilities, 77.3% of the households can access improved sources of drinking water and life expectancy at birth is 71.2 (Department of Population Myanmar, 2015). Despite the relative wealth in Yangon compared to other areas, the city faces many challenges; rapid urbanization rates and increased economic and industrial activity create new challenges for this dynamic city (Forbes, 2016). One of these challenges is the rapid growth of informal settlement pockets in Yangon city, as places where the urban poor settle and where infrastructure is lacking.



Figure 9: Map of Myanmar with the location of Yangon (Adapted from: Google Maps)

4.3.1 Informal settlements in Yangon

The growth of informal settlements in Yangon went hand in hand with the recent industrialization and urbanisation of Myanmar. Up until now, relatively limited information has been available on these settlements. A recent report from UN-Habitat highlights the widespread existence of informal settlements in Yangon, who are expected to only grow in the future. UN-Habitat identified a total of 423 informal settlements in Yangon city, which in total cover 1.23% of the land area. These informal settlement pockets are estimated to house 365,000 people, which equals 6-8% of the population of Yangon (UN-Habitat, 2017). Figure 10 shows the distribution of informal settlements in Yangon (the red marks).

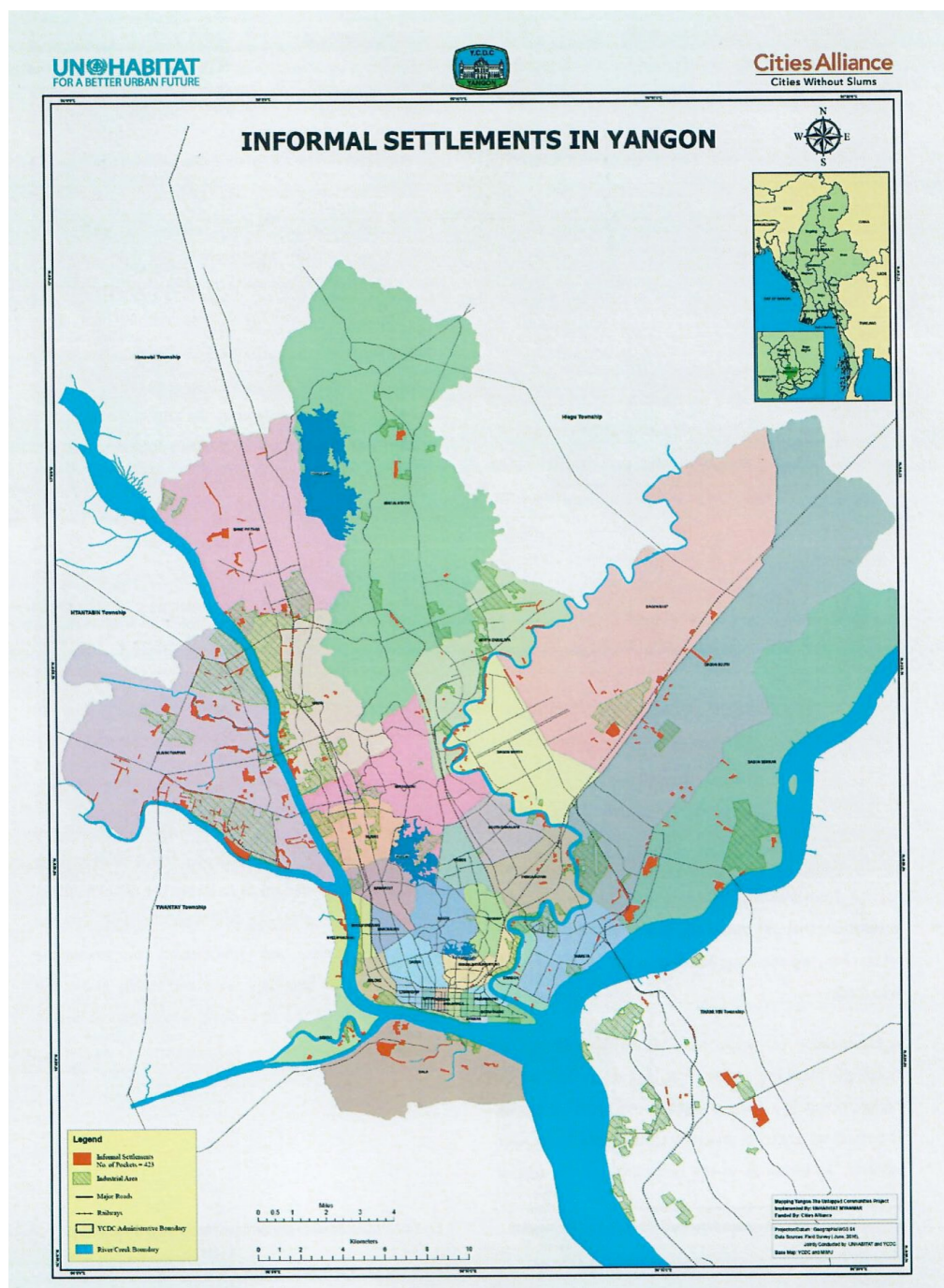


Figure 10: Map of informal settlements in Yangon city (Source: UN-Habitat, 2017)

As also visible on the map, Hlaing Tharyar is the township with the highest number of informal settlers; an estimated 181 informal settlement pockets are located in this township, home to about 120,000 people (UN-Habitat, 2017). Most of the informal settlements in Yangon developed relatively recently; 270 out of 423 informal settlements were formed after 2010. This can be explained by various push- and pull factors: Cyclone Nargis in 2008 and the high housing prices in central Yangon have pushed people towards life in peri-urban settlements. The main pull-factor is the newly created economic opportunities due to the influx of industries and business in (peri-urban) Yangon (UN-Habitat, 2017). According to UN-Habitat (2017), major problems in informal settlements are the lack of municipal services and the high occurrence of flooding and water logging.

No specific regulations or policies in Yangon or Myanmar in general have been dedicated towards the issue of informal settlements, also called 'squatters' in popular use. The only specific mentioning of 'squatters' can be found in the City of Yangon Development Law, drafted in 1990. It describes the formation of the Yangon City Development Committee (YCDC) and the duties and responsibilities of this committee. One of the duties specified in this law is the 'demolition and re-settlement of squatter huts, squatter buildings and squatter wards' (The City of Yangon Development Law 1990, article 7e). However, in practice demolition of squatter houses is not always coupled with resettlement; a recent case of June 2017 shows that the demolition of 400 houses in Hlegu township was not combined with relocation efforts (The Irrawaddy, 2017). This is mainly the result of the categorization of squatters into two broad categories: 'real' squatters, who have occupied these lands due to poverty and 'professional' or 'landlord' squatters, who occupy and then sell or rent out these governmentally owned lands. In public perception, most of the squatters are thought to be 'professional' squatters, however it is not clear to what extent this reflects reality. However, the YCDC is currently trying to map and register these different types of squatters, allegedly to also make plans for resettlement.

4.3.2 Water security in Yangon

In the context of rapid expansion, providing access to safe water supply to citizens of Yangon city is considered a major challenge, now and in the future. 90% of the water supply in Yangon city comes from reservoirs supplied through pipelines, of which 2/3 is distributed without any treatment (YCDC, 2014). The reservoir water is supplemented by tube wells. Most of the reservoirs are located North of Yangon city, which creates some challenges with water pressure as these pipelines are extended far into the townships. Hlaing Tharyar township is supplied with water from the Hlawga reservoir as well as from the Thaephyu water treatment plant, which treats water sources from 6 tube wells.

The water supply in Yangon city faces some major issues; technical issues due to the inadequate facilities in place, organizational issues as a result of weak planning and monitoring, institutional issues due to a lack of effective and detailed regulations and laws and finally financial issues as a result of a tight budget and an inadequate tariff structure (YCDC, 2014). In order to improve the current water supply system, the YCDC aims to construct new reservoirs and become less reliant on groundwater resources. Furthermore, the aim is to increase the quality of the water by upgrading the treatment plants and establishing a water quality control centre (YCDC, 2014).

4.4 Conclusion

After the instalment of the new government in 2016, economic growth accelerated in Myanmar. Although offering new opportunities, challenges remain in this dynamic country; poverty, inequality and a lack of infrastructure all complicate the pathway towards sustainable and inclusive development. The increased use and exploitation of Myanmar's natural resources, such as the fresh water sources available in the country, spurred the establishment of new ministries, institutions and regulations to govern and protect this precious resource.

Within Myanmar, the former capital city of Yangon can be considered the socio-economic hub of the country. Rapid industrialization and urbanization further spurred the development of this city, however also creating new challenges; the explosive development of informal settlements and the lack of infrastructure to supply services such as water are considered major challenges.

Part II: Stakeholders in HTIZ



5. Governmental institutions

The use of water resources in Hlaing Tharyar Industrial Zone (HTIZ) is governed by various actors and institutions. All these stakeholders contribute to the highly complex water governance process and all shape and reshape the way in which water as a natural resource is managed on the local level. The main body responsible for service provision within Yangon city is YCDC. As HTIZ is located in Hlaing Tharyar township, one out of 33 townships of Yangon city, this area also falls under the responsibility of the YCDC. The provision of various water-related services is thus mainly organized by YCDC.

5.1 Yangon City Development Committee

The Yangon City Development Committee (YCDC) is the administrative body responsible for 33 out of 45 townships in Yangon region, which together form Yangon city (UNDP Myanmar, 2015). Next to the union government agencies and the region government ministries, the YCDC can be considered the direct service provider for Yangon city, although responsibilities are not always clearly divided between these three actors.

The YCDC was created in 1990 and currently consists of 20 departments, responsible for a variety of tasks. The institution is headed by the YCDC chairman, which is also the mayor of Yangon city, a secretary, a joint secretary and 20 committee members all responsible for one of the departments. On the local level, every YCDC department has one or more township offices that are responsible for implementation and regulation on the local level. Figure 11 gives an overview of the organizational structure of the YCDC.

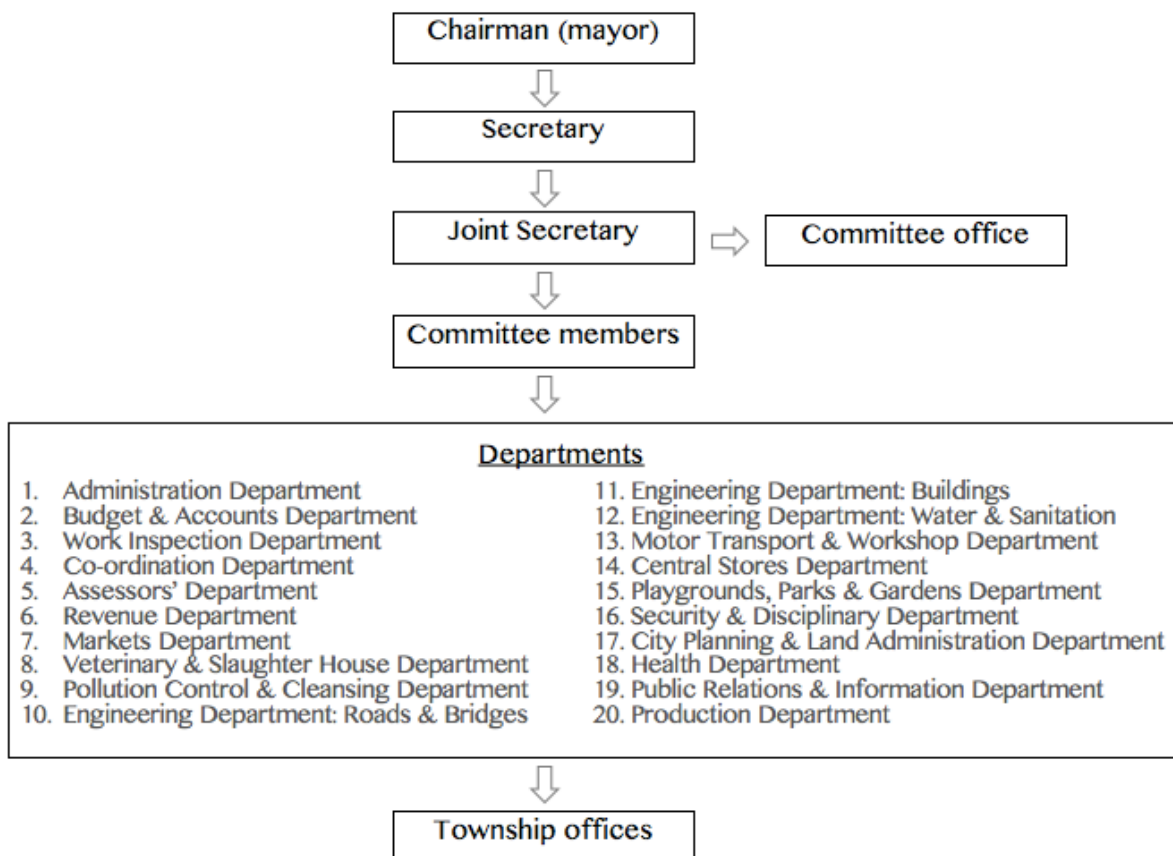


Figure 11: Organizational structure YCDC (constructed by author, information from YCDC, 2014)

5.2 Domestic water supply

The supply of water for domestic purposes falls under the responsibility of the YCDC Water & Sanitation (W&S) department. In addition, this department is concerned with sanitation and hence the sewage systems of domestic areas in Yangon. The official water supply network of YCDC W&S also extends to the suburb of Hlaing Tharyar; a cutout of the official water pipeline network map in this township is depicted in Figure 12. The whole map including legend can be found in Appendix IV.

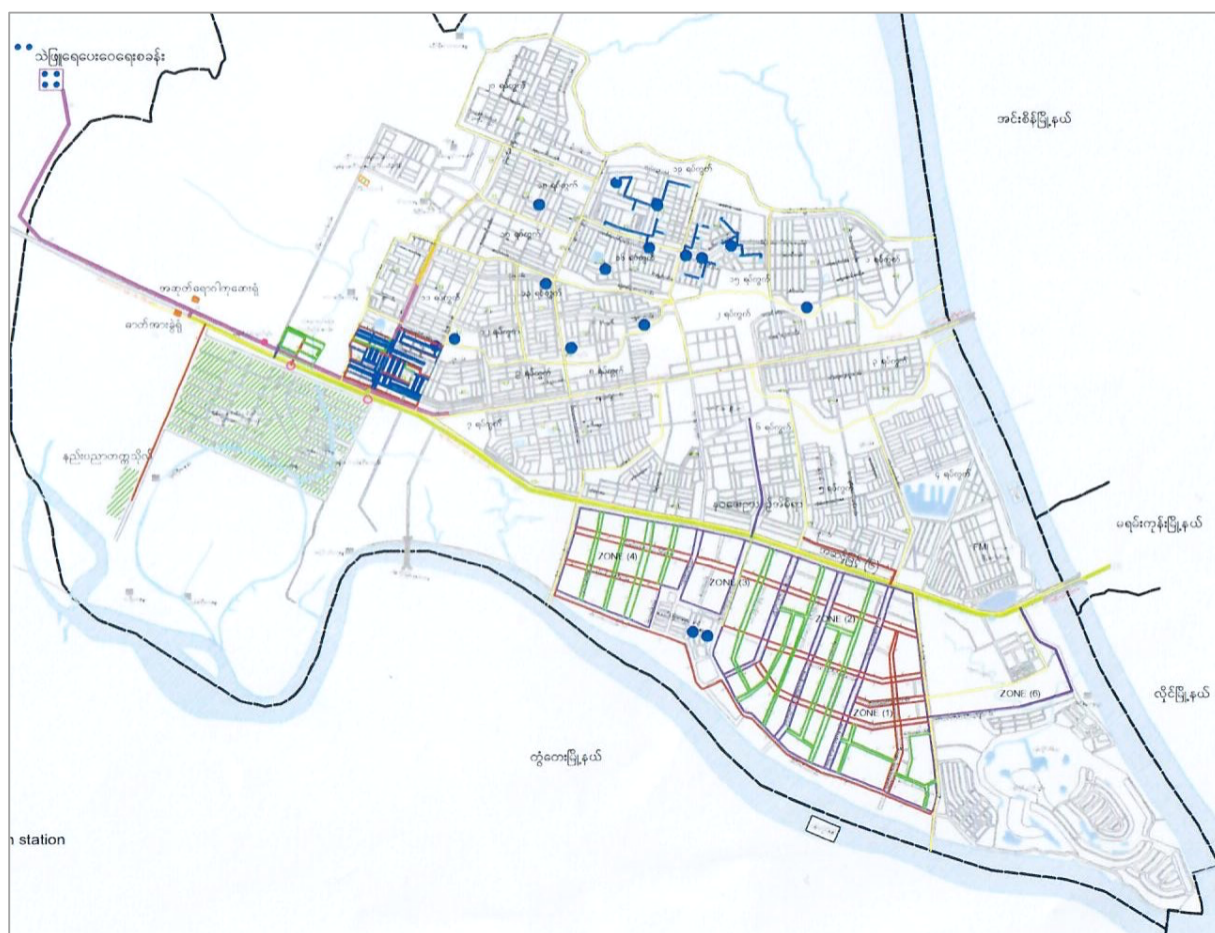


Figure 12: Water pipeline map of Hlaing Tharyar township (Source: YCDC W&S, 2017)¹

The map indicates 13 different tube wells located in the township (the blue dots); eleven are located in the domestic area above the Yangon-Pathein highway, whereas two are located in Yay Oakkan village in HTIZ. Due to the low quality and quantity of the groundwater from the official YCDC tube wells, this water resource is not the main source used by residents of HTIZ. Instead an alternative system of water supply has appeared, which is described in more detail in Chapter 8. Next to the tube wells, the map indicates a water pipeline network (coloured lines, indicating different diameters) in HTIZ to supply the different factories in this area. The water supplied through these pipelines comes from the Hlawga reservoir and the Thaephyu water treatment plant. However, due to the decreasing pressure of water supply over time due to the extension of the pipeline network, the large majority of factories in HTIZ do not use the official water supply network for their production processes.

¹ This is a cut-out of the full map, which can be found in Appendix IV.

This lack of official water supply to Hlaing Tharyar township can be attributed to various challenges. According to the YCDC W&S, there is a lack of capacity and resources within the department. This is reflected in the limited water reservoirs and an ineffective water pipeline network, as articulated by a government official working within YCDC W&S:

‘Our city once started as a small area [now downtown] and then expanded as a very long city [towards the North]. So when we supply water to the city from the [Northern] reservoirs, the pressure decreases and decreases and in the end there is a very low pressure. This is our main challenge. In our future plan we want to make new reservoirs so that the Eastern and Western part can also be supplied, like a ring system. Now our system is very centralized, but in the future we would like to move to a more decentralized system.’ (Interview with government official of YCDC W&S, 2017).

The lack of capacity results in an inability to actually serve the water supply needs of the residents of Yangon in terms of quantity. Instead, many alternative and private water supply systems (e.g. private tube wells) have been the source of water supply, which also poses a risk for the sustainability of Yangon city as continued groundwater extraction can result in land subsidence and saline water intrusion (Interview with government official YCDC W&S, 2017). In Hlaing Tharyar township, only the domestic groundwater extraction is already estimated to range between 35,000 to 65,000m³ per day, the highest within Yangon (Van der Horst, 2017). Furthermore, assuring the quality of water supply is another main challenge according to the YCDC W&S, as pipelines are old and water quality monitoring capacity is limited. A lack of financial and technical resources is the main causes of these challenges. However, with financial help of JICA, the YCDC W&S is trying to expand its capacity by establishing new water reservoirs to supply to different townships in Yangon city. One of these new reservoirs that is being explored and developed to supply water for Yangon city is a reservoir upstream of the Kokkowa river, located North-West of Yangon.

Next to the lack of capacity of the YCDC W&S, another challenge is the fact that HTIZ is not considered a priority area for water supply; even when the water supply capacity will expand after the completion of the Kokkowa reservoir, the current plans indicate that this water will be mainly used to supply the city’s downtown area as well as the planned new town on the Southern riverbank of the Pan Hlaing river. This lack of priority seems to reflect the perception of HTIZ as an industrial area and not a domestic area. However, this perception does not reflect reality anymore, as the estimated 60,000 formal and informal settlers living in HTIZ changed the character and hence also the services needed within this area. Not recognizing these needs can also be related to the persistent perception of informal settlers as ‘illegal’ and hence temporary residents, which decreases the feeling of responsibility to actually supply services to this group.

5.3 Liquid & solid waste management

The YCDC Pollution Control & Cleansing Department (PCCD) is responsible for the ‘practice of environmental protection and waste management, including collection and treatment of waste, management of landfills, prevention of water and air pollution’ (YCDC, 2014) in Yangon city. Hence, they are also responsible for the monitoring and inspection of water pollution, following the Environmental Guidelines of 2015. In Hlaing Tharyar township, the YCDC PCCD has one local office responsible for the implementation of regulations. In order to control water pollution in HTIZ, the YCDC PCCD is responsible for giving out and renewing the licences of the factories in this area, which needs to be done on a yearly basis. According to the YCDC PCCD, control measures to ensure compliance have recently become stricter:

'A few months ago, the regional government ordered to the YCDC that every factory should have an effluent according to the national guideline [Environmental Guidelines 2015]. If they don't follow the guidelines, the first time they will get a penalty and the second time the factory will be closed. So now they need a proper treatment plant.' (Interview with government official YCDC PCCD, 2017).

However, according to the HTIZ management committee the process of checking the effluent on parameters specified in the 2015 Environmental Guidelines is flawed; the effluent samples are not collected by the YCDC PCCD through surprise visits but factories are asked to bring in the samples themselves, which makes it highly vulnerable to fraud (Interview with HTIZ management committee member, 2017). According to the YCDC PCCD, the lack of effective monitoring and enforcement to counter illegal wastewater discharge of factories is the result of the limited capacity and resources of the department, reflected in a lack of man power, budget, technical skills and good testing facilities to monitor water pollution.

Next to the control of pollution, the YCDC PCCD is also responsible for the waste collection in HTIZ. According to YCDC PCCD and the management committee of HTIZ, solid waste from the factories is collected twice a week (Tuesday and Friday). The price of waste collection depends on the size of the garbage bin; the smaller version of 240 litres costs 0.74 USD, whereas the bigger one of 660 litres costs 1.84 USD per collection round. Furthermore, the collection of hazardous waste is only done by an on call basis. Although there thus is a waste collection system in place in HTIZ, the YCDC PCCD does not systematically collect domestic waste. The lack of domestic waste collection is the result of a lack of capacity and priority; as HTIZ is considered an industrial area on paper, there is no priority to extend the waste collection system to also service the inhabitants of this area.

5.4 Conclusion

The water governance responsibilities in HTIZ are shared among the YCDC W&S and the YCDC PCCD. YCDC W&S is responsible for the supply of domestic water and sanitation systems, however due to a lack of capacity and low priority to supply to citizens in HTIZ there is a lack of useable official water supply in this area. YCDC PCCD is the institution responsible for liquid and solid waste collection, and hence also for preventing water pollution. A lack of effective monitoring and control measures results in a high risk of industrial water pollution. However, the solid waste of the industry is collected. This waste collection system is not extended to the inhabitants of HTIZ due to a lack of resources and a lack of priority to service this group.

6. Industry

The industry, embodied in the different factories operating in HTIZ, is another essential stakeholder in the governance and use of water resources in HTIZ. Organized and represented in the HTIZ management committee, the industry performs various governance tasks as outlined in this chapter. Furthermore, the industry of HTIZ is a major consumer and hence the use and interaction of factories with different water resources will also be discussed.

6.1 HTIZ management committee

The HTIZ management committee was established by the YCDC in 1997 and consists of land and factory owners operating in the area. It can thus be characterized as a group of industry representatives that have been appointed to perform some of the governance tasks in HTIZ. The committee is concerned with the maintenance of the infrastructure of industrial zone, which includes the roads, the drainage system and industrial water supply. Furthermore, the HTIZ management committee forms a 'bridge between the government and the industry' (Interview with HTIZ management committee member, 2017), as it creates a possibility to communicate and mediate between these two stakeholders. Although YCDC and the HTIZ management committee thus represent different interests, they also collaborate in terms of governing and maintaining HTIZ. However, whereas YCDC is responsible for drafting policy and regulations, the HTIZ management committee can only implement them and articulate their concerns and challenges as found in the industrial zone.

6.1.1 *Industrial water supply*

The water supply to factories in HTIZ falls under the responsibility of the HTIZ management committee. According to the committee, water pipelines were constructed in 2000 as a way to assure official water supply from YCDC for factories in this area. This was financed by the factory owners themselves, who established a fund to make the extension of the water supply network towards HTIZ possible. However, over the years this water pipeline network became of limited use for the factories:

'As the population of Hlaing Tharyar expanded, YCDC connected the pipelines to other areas in Hlaing Tharyar, such as FMI city [high class residential area]. So the pressure decreased a lot and now only factories close to the highway [Yangon-Pathein highway] can use it.' (Interview with HTIZ management committee member, 2017).

As a result, most of the factories now rely on groundwater or private supply of premium water for production purposes, which will be further elaborated on in paragraph 6.3.

6.1.2 *Drainages*

The management of the drainage system in HTIZ is also considered the responsibility of the management committee and hence the industry itself. The network of drainages runs throughout HTIZ and finally runs out into the Pan Hlaing river through seven drain outlets, as depicted in green on the map in Figure 13. According to the HTIZ management committee, every factory is responsible for the maintenance of the drain next to its property. However, the main challenge is the fact that drainages in HTIZ are regularly blocked due to solid waste; the red lines on the map in Figure 13 indicate the locations in HTIZ that are regularly blocked by solid waste. According to the management committee, this can be attributed to the influx of (informal) settlers and the lack of a domestic solid waste collection system.

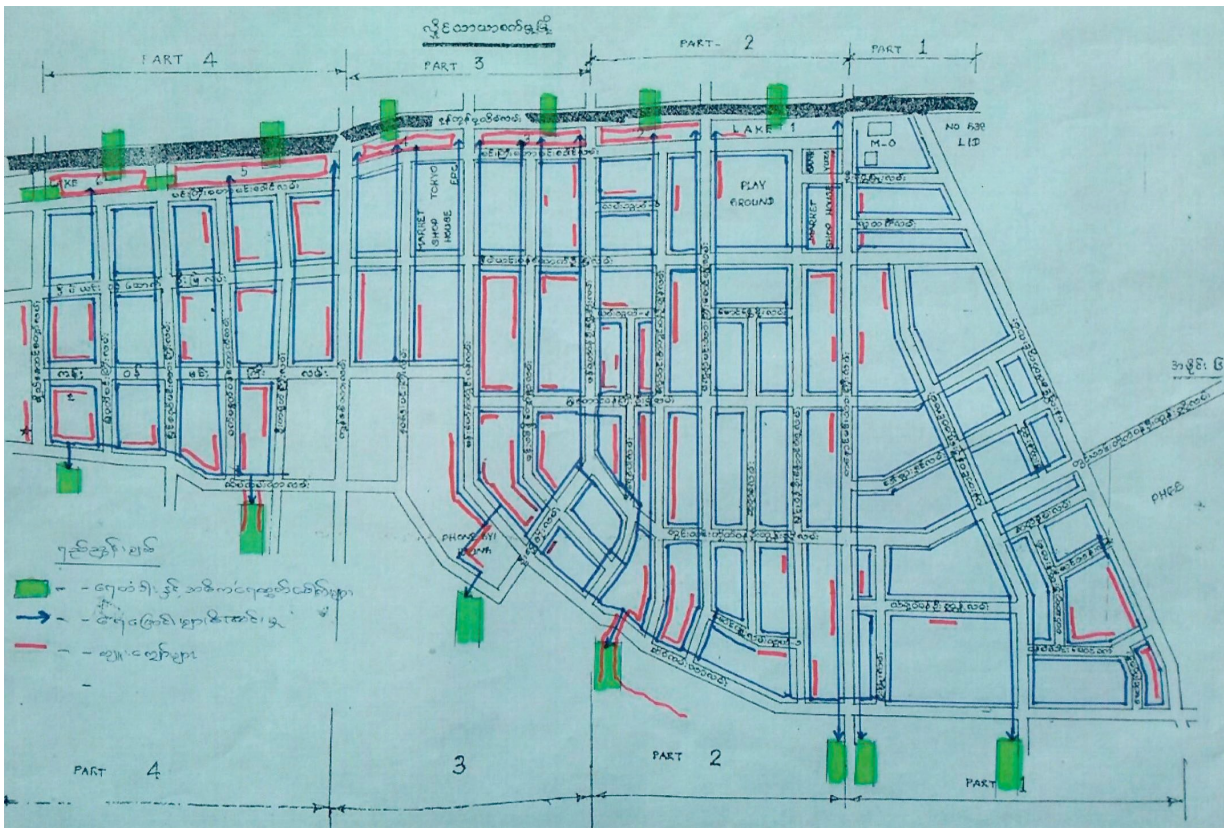


Figure 13: Map of drainage system and outlets in HTIZ (Source: HTIZ management committee, 2017)

In order to counter this problem, the HTIZ management committee has taken some measures:

‘ The committee spends about 10.000 USD per year to clear the waste from the drainages and the area. But this is not a solution as the amount of waste keeps on growing’ (Interview with HTIZ management committee member, 2017).

Although this problem of solid waste in drainages is also indicated and known within YCDC, no effective solution has been found yet and herewith this remains a main challenge for the HTIZ management committee.

6.2 Development of the industrial zone

According to the management committee of HTIZ, the history of the industrial zone can be traced back to 1995 when the area was officially designated to be an industrial zone by the Myanmar government. Zone 1 and 2 were the first to be established. However, as the influx of industries grew, HTIZ further expanded towards the West in 2003, as Zone 3 and 4 were established. In 2005 the industrial zone grew further towards the East when Zone 6 and 7 were added, which are located along the Hlaing river. The current outlay of the industrial zone is depicted in Figure 6.

HTIZ currently consists of 695 factories from a wide variety of sectors: garment, food & beverages, paper & pulp and plastics are one of the largest sectors operating in HTIZ. An extensive list of the different sectors operating in HTIZ is provided in Appendix V. Although initially there was some zoning per industry in HTIZ, this diffused after a few years due to the in- and outflow of different industries. Currently, the garment sector is one of the largest with approximately 91 factories in HTIZ, mainly sewing but also some dyeing, printing and shoe

factories. Especially after the trade sanctions of the US were lifted again approximately four years ago, the labour-intensive industries such as garment and food & beverages came into HTIZ. An estimated total of 60 factories can be labelled as FDI, mainly from Asian countries such as Japan, China and Korea.

As most of the land in HTIZ is already occupied, there is not much room for expansion in the future according to the management committee of HTIZ. The only option could be to convert the approximately 200 warehouses now located in the industrial zone. This possible expansion highly depends on the infrastructure improvements; compared to the newer industrial zones and special economic zones (SEZ) in Yangon, the infrastructure in HTIZ, such as energy and water supply, is very poor. Hence, it is more difficult to attract FDI even though the location is attractive in terms of transportation possibilities.

6.3 Water use of factories

Due to the lack of a useable official water supply in HTIZ, the main source of water used by the factories is groundwater. Most of the factories have constructed deep tube wells on their plots, often over 30 metres deep. In general, there is currently no problem with the quantity of water as there is (still) sufficient ground water available in the area. However, in most cases the quality of the groundwater is described to be low due to high iron content. This is problematic for some factories, especially in the food and beverages sector. Hence, the second biggest source of water currently used by factories is premium water supplied by private companies. Another way to counter the problem of the relatively low quality of groundwater in HTIZ is the instalment of purification systems, which is done by some of the factories. Furthermore, the high dependence on groundwater creates a risk of land subsidence and saline intrusion, which was also indicated by both government officials as well as the industry as a future risk.

6.4 Wastewater treatment

Next to accessing water resources for production, the factories in HTIZ also need to find ways to discharge the wastewater after the production process. Unlike other newer industrial zones in Yangon, there is no central industrial wastewater treatment plant for the factories in HTIZ. Hence, regulations require every factory to have their own wastewater treatment plant on their plot in order to treat the effluent before discharging it into the drain and eventually into the Pan Hlaing river. According to the HTIZ management committee as well as the YCDC, this is challenging for many factories:

‘This was a big challenge for many factories as they were already constructed and they do not have enough space on their plots to construct a wastewater treatment plant. And it is also very costly. [...] It would be better to relax the guidelines a bit for now and then increase the strictness step by step.’ (Interview with HTIZ management committee member, 2017).

Other barriers mentioned were the lack of technical skills on industrial wastewater treatment but also awareness on the impacts of water pollution are limited. Finally, the lack of effective control measures creates a lack of incentive for factories to actually invest in a relatively costly wastewater treatment plant. These challenges create a high risk of industrial pollution, a topic that will be discussed in more detail in Chapter 9.

6.5 Conclusion

Since the establishment of HTIZ in 1995, the industrial zone expanded towards a total of 695 factories within a wide variety of sectors. The HTIZ management committee was established and made responsible for the maintenance of the infrastructure in HTIZ, such as the industrial water supply and the drainages. However, due to the low pressure of the official water pipeline network and the constant blockages of drainages, most factories are dependent on their own sources to assure water supply and unblock drainages to discharge wastewater. The lack of official water supply is currently not considered a main challenge by the industry due to the abundance of (cheap) fresh water resources. The main source of water used by the industry is groundwater, extracted by private deep tube wells, and premium water supplied by private companies. On the long term the high dependence on groundwater is considered a risk for land subsidence and saline intrusion.

The lack of centralized infrastructure for wastewater treatment forms a major challenge for many of the factories in HTIZ, as it requires land and financial resources. This increases the risk of discharge of insufficiently treated effluent, leading to industrial pollution of fresh water resources. This risk is also identified by some of the factories in HTIZ; the pollution of groundwater resources can pose a major threat to the sustainability of the ecosystem in the area and hence also the ability of factories to use this water resource for production.

7. Local population

The local population of HTIZ is another major stakeholder who use and interact with the different water resources in the area and are depend of this natural resource for living. However, the local population cannot be considered a homogenous group; some people only moved in recently, whereas others already life there since long before the establishment of the industrial zone. Furthermore, there is a significant difference in the living conditions of citizens in HTIZ; whereas some people live in 'formal' settlements in Yay Oakkan village, others live in the 'informal' settlements along the roadside or riverbank. The history and characteristics of the population living in these different settlements will be outlined in this chapter. Finally, the role of the local population in the governance process will also be addressed by looking at their influencing- and decision making power.

7.1 Human settlements in HTIZ

Although HTIZ is considered an 'industrial' area of Yangon, ever since its establishment in 1995 it also has been home to a growing number of citizens. Whereas the first villages were 'formally' established by the government, the later influx resulted in an expanding number of 'informal' settlement pockets, both along the roadside as well as along the Pan Hlaing riverbank. Although the estimations vary, the number of 'formal' settlers living in Yay Oakkan is estimated to be 30,000 people, which are about 7317 households when assuming an average households size of 4.1 (as found in the survey). The number of informal riverbank settlers in HTIZ was recently estimated by UN-Habitat (2017) to be 1800 households. However, interviews with the village head of one of the informal riverbank villages indicates that this number is likely to be much higher; the smallest village of the four currently inhabits 647 households, while the other three are estimated to inhabit over 1000 households. Hence, the number of households living in these riverbank settlements is likely to be around 4000. With an average household size of 4.1 in the survey, this comes down to 16,400 people. The total of informal settlers in the research area (HTIZ 1, 2, 3 and 4) was estimated to be between 5000 to 8000 households; as the average household size for these groups combined is found to be 4.4, the total number of informal settlers is estimated to range between 22,000 and 35,200. For this study, the number of formal as well as informal settlers is hence estimated on 30,000 people per group, which brings us to a local population of 60,000 people in total.

7.1.1 Formal settlements

Before the establishment of HTIZ, the area was mainly used for agricultural purposes. In the light of the formation of the industrial zone, three resettlement villages were established in 1995 as designated domestic areas: Yay Oakkan, Nyaung U and Daing Zu. The farmers living on these lands were resettled to the three villages, according to the HTIZ management committee by offering compensation in the form of land and money. As they were officially granted to live in this area and on these lands, the resettlement villages are categorized as 'formal settlements' within this study.



Figure 14: 'Formal' apartment block in HTIZ

The resettlement villages initially consisted of wooden and bamboo houses. However, during the past decade most of the houses in Yay Oakkan village have been replaced by concrete apartment blocks as depicted in Figure 14. Within Yay Oakkan village, a distinction can be made between hostels, in which workers of factories are housed with no or minimal payment and apartments, which are for rent or privately owned by families. Both in the hostels as well in the apartments, the density of people living in one location is relatively high, often 4 or 5 people per bedroom. A common set up is an apartment with 3 or 4 bedrooms, where every room is inhabited by one family and the kitchen, bathroom and living room are shared. Also within the hostels, most small rooms are inhabited by a whole family and toilet and washing facilities are shared with other inhabitants.

Although Yay Oakkan was initially established as a resettlement village for farmers living in this area, the population currently consists of a mix of these original inhabitants, migrants from outside of Yangon or people who migrated from different Yangon townships towards this peri-urban area.

7.1.2 Informal roadside settlements

The population influx into HTIZ was initially slow as up until a decade ago, internal migration was still minimal in Myanmar. However, when the Ayeyarwadday Delta region of Myanmar was hit by Cyclone Nargis in May 2008, almost 2.4 million people were affected (IFRC, 2011). This tragic event resulted in large migration flows towards Yangon and especially Hlaing Tharyar township. In the years following Cyclone Nargis, rural-urban migration increased and even migration within Yangon grew as a result of rising land prices within the more central townships of Yangon.

Although some migrants had the resources to move into the apartments in the 'official' villages, most of the migrants started to settle along the roadside or along factories in HTIZ. As these settlers were never officially granted permission to occupy these lands, they are categorized as 'informal settlers' or 'squatters'. The most common housing structure is a wooden floor (70%) and a corrugated sheet roof (50%) or a palm leave roof (45%). Figure 15 depicts a substandard housing structure of a family living on a roadside in HTIZ. This house consisted of a corrugated sheet roof, plastic sheet walls and a wooden plate as a floor. Many roadside huts are also closely located to drains or waste dumping sites, resulting in a very bad smell and considerable health risks.



Figure 15: Informal roadside settlement in HTIZ

Whereas some informal roadside settlement pockets are relatively small consisting of only a few huts along a factory or road, some other settlements pockets have taken the shape of small villages, especially the informal settlement pocket that grew along the borders of Yay Oakkan village. Therewith, the borders between 'formal' and 'informal' settlements are sometimes not as clear cut and more hybrid; some informal settlers managed to build concrete houses in Yay Oakkan, whereas others were forced to move out of their 'formal' settlement due to a lack of resources and now inhabit an 'informal' hut on the roadside of Yay Oakkan.

7.1.3 Informal riverbank settlements

Next to the informal roadside settlements, a new pocket of informal settlements developed along the Pan Hlaing riverbank in HTIZ from the end of 2013 onwards. As depicted on Figure 16, up until the end of 2013 the riverbank was covered with mangrove forests. Satellite images from previous years show that due to sedimentation of the Pan Haling river, the riverbank gradually grew and therefore becoming a more attractive 'empty' land for people to settle down. At the end of 2013, there was a relatively sudden influx of large amounts of people into these riverbank lands, as depicted on the satellite images in Figure 17, 18, 19 and 20.



Figure 16: Satellite image of Pan Hlaing riverbank on 25/01/2013 (Source: Google Earth)



Figure 17: Satellite image of Pan Hlaing riverbank on 16/11/2013 (Source: Google Earth)



Figure 18: Satellite image of Pan Hlaing riverbank on 15/02/2014 (Source: Google Earth)



Figure 19: Satellite image of Pan Hlaing riverbank on 19/03/2015 (Source: Google Earth)



Figure 20: Satellite image of Pan Hlaing riverbank on 29/01/2017 (Source: Google Earth)

Currently, these informal settlements on the Pan Hlaing river bank can be divided into 4 villages; San Pya, 555, Sayar San and Aung Chan Thar (some of the names are confirmed by key informants, others are the most commonly mentioned name in the household survey). As indicated before, the information provided of key informants indicates an estimated total of 4000 households that currently inhabit these riverbank villages. The majority of the inhabitants live in houses made out of bamboo (76%) and have a palm leaf roof (68%) as depicted in Figure 21; only the wealthier settlers can afford a wooden floor (24%) or a roof made out of corrugated sheets (32%). The location of the houses on the river banks is often far away from the paved road; although some huts are located only a few minutes away, others are up to 25 minutes away from any paved road. Within the informal settlements, the houses are connected by 'dikes' made from the river sediment sand and in some cases also from bamboo pipes, especially in locations further towards the Pan Hlaing river.



Figure 21: Informal riverbank settlement in HTIZ

7.2 Migration history

Although some residents of HTIZ were born in this area, the large majority (93.8%) moved into the region after 1995. After moving into Hlaing Tharyar township, 58.5% of the respondents moved again into another house. The average years of living in Hlaing Tharyar and in the current house are depicted in Table 5. This table indicates that the informal settlers on the riverbank represent the most recent influx of people, as the average of years living in Hlaing Tharyar township is 7. Furthermore, this group is also the one with the shortest average of living in their current home, namely 3 years, which is ever since the informal riverbank villages were established.

Table 5: Years of living in Hlaing Tharyar township & current house

Group	Mean of years living in Hlaing Tharyar ¹	Mean of years living in current house ¹	N
Formal settlers	12	7	20
Informal settlers (road)	13	9	20
Informal settlers (river bank)	7	3	25
All	11	6	65

¹ Reference year is 2017

The place of origin of the inhabitants of HTIZ is depicted in Figure 22; most of the residents come from Ayeyarwaddy Division, followed by Yangon Division and Bago Division. The main place of origin being the delta region (Ayeyarwaddy Division) holds for all three groups.

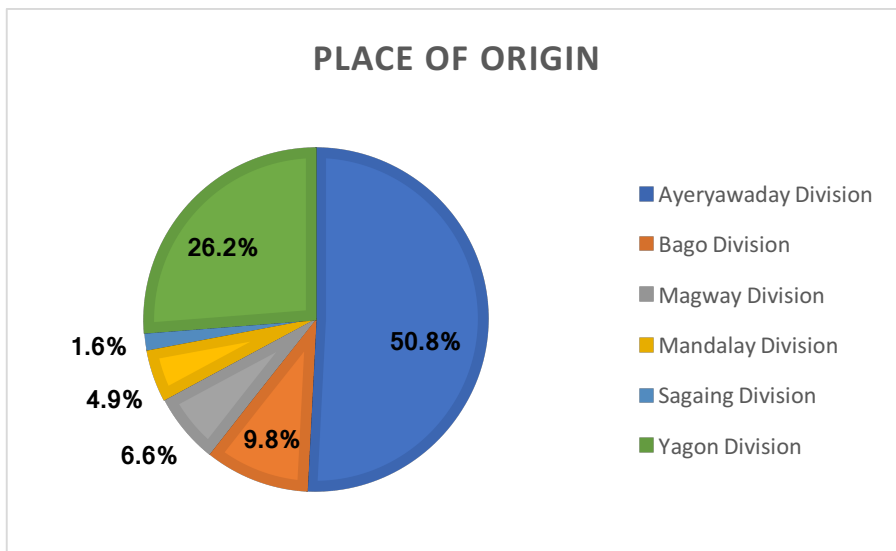


Figure 22: Place of origin of migrants to HTIZ

The main motivation for people to move to Hlaing Tharyar township is for work opportunities (80.3%); most of the people said there were no jobs available in their hometown or they were offered a job in this area, which is why they decided to move to HTIZ. Another reason mentioned was natural disaster; 3.8% (living in the riverbank settlements) said to have moved into this area after cyclone Nargis, whereas 4.9% migrated because of flooding or riverbank erosion in their former place of living. Destruction of the house due to the fire and high rent costs within Yangon were also mentioned as drivers for migration.

As indicated before, most of the people moved at least one time within Hlaing Tharyar township itself. For formal settlers, the main reason was that the owner sold the old house or that they moved location for a new job. For informal settlers, both on the roadside but especially on the riverbank, the main reason for moving into another house was due to the height of the living costs in the former house; many respondents lived in the area North of the Yangon-Pathein highway and indicated that they moved away as they were not able to pay the rent anymore. Another reason was the fact that the landowner decided to sell the land or moved back in. Finally, some informal settlers needed to move due to destruction or flooding of their homes.

7.3 Land tenure

Although the population can be roughly divided into ‘formal’ and ‘informal’ settlements, within this distinction there is a wide range of land tenure systems found throughout HTIZ. Whereas some inhabitants do not have to pay at all as they moved onto the land or are provided with housing from their factory, others pay rent or bought the land and / or house, both in the informal as well as the formal village. An overview of the most common land tenure arrangements is depicted in Figure 23, which indicates that renting the house and/or land is the most common situation when looking at the whole population in HTIZ.

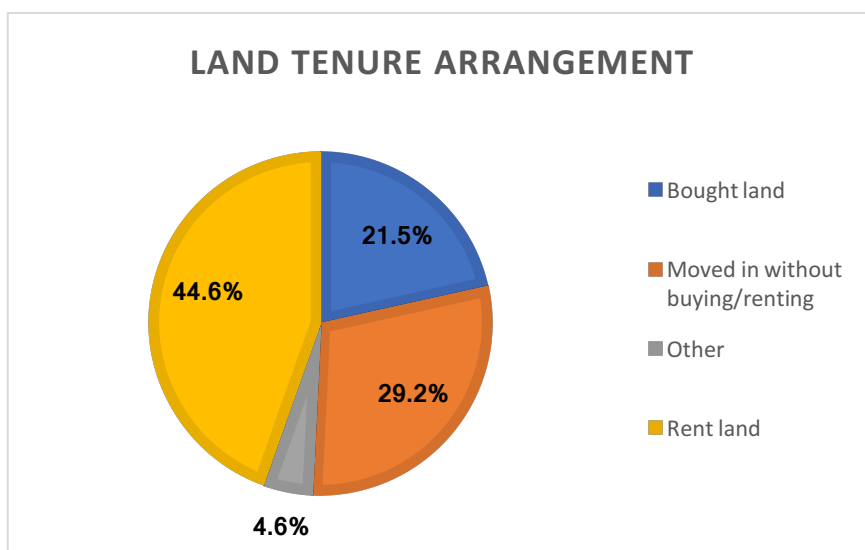


Figure 23: Land tenure arrangements in HTIZ

When looking at the land tenure arrangements per group as depicted in Table 6, it is noticeable that there is a difference between the informal settlers on the roadside and the riverbank. Whereas among the first group, the majority moved in without buying or renting, almost half of the informal settlers living on the riverbank rent their land and / or house. Although this indicates the existence of an ‘informal’ land and housing market in HITZ, the informal settlement houses are mainly rented from relatives, and sometimes from a local owner or from one of the factories.

Table 6: Land tenure arrangements per group in HTIZ

	Formal settlers (N=20)	Informal settlers (roadside) (N=20)	Informal settlers (riverbank) (N=25)
Bought land / house	10%	25%	28%
Rent land / house	70%	15%	48%
Moved in without buying / renting	5%	60%	24%
Other	15%	-	-

The price of buying land or a house varied from 8 to 16,915 USD, depending on the location and the type of house (apartment or wooden / bamboo structure), with an average of 1652 USD. 7.9% of the people who bought land build the house themselves, whereas only 23.1% bought both the land as well as the house (mainly apartment blocks). The height of the rent ranged from 4 to 74 USD per month, with an average of 26 USD. A majority of 82.8% of the renters indicated not to have built the house themselves, so they rent the land including the house.

Although there is thus a wide range of land tenure arrangements, not having official land rights is a major concern for people living in informal settlements, causing a feeling of insecurity and fear for resettlement. In one the informal riverbank villages, the threat of eviction was very real in 2015 when the villagers were told to move by the ‘local committee’. As a response, the villagers said to have sent a complaint letter to a ‘national committee’, which eventually granted them permission to stay there by means of a letter. Furthermore, these same villagers recently (May 2017) have been granted a ‘permission’ card, which officially recognises the fact that they live there (see Figure 24). The front of the card states ‘Yangon Development Research Project’ and indicates that this is an ‘evidence of household’

card. Furthermore, the card specifies the name, number of people in the household, the 'illegal' address, the card number and the distribution date. On the back of the card, some 'warnings' are listed:

1. The card cannot be hold or given / sold to another person
2. A fine of 1.47 USD needs to be paid to the Township Administrative Office in case of losing or destroying the card
3. When the illegal issues have been finished, the card must be returned to the authorities
4. One needs to take action in case the data on the card is incorrect

The card thus recognizes the informal settlers as inhabitants of this area, as their name and address is registered. However, it is not clear to what extent this actually grants them the right to land or compensation and what the purpose is of giving out these cards. Despite these questions, the villagers indicated to be relieved to have some proof of inhabiting this village, as the majority indicated not to want to in the future.



Figure 24: Permission card for informal riverbank settlers in HTIZ

7.4 Education

The level of education achieved for households in HTIZ ranges from no education to graduate school. For 90.8% of the households, all members completed primary school. Middle school was only completed by all members of the household for 21.5% of the cases, and high school completion of all household members was only achieved for 7.7% of the households. The differences in education level between the three groups is depicted in Table 7; there is a clear difference in education level between formal and informal settlers, and especially the riverbank settlers have a low education level as in only 4% of the cases all household members completed middle school.

Table 7: Completion of different education levels of all members of the household

Group	% of households with all primary school completion	% of households with all middle school completion	% of households with all high school completion
Formal settlers	95%	45%	25%
Informal settlers (road)	85%	20%	0%
Informal settlers (river bank)	92%	4%	0%

7.5 Economic situation

The economic situation of the local population of HTIZ is assessed by looking at the income and expenditures. Figure 25 indicates the average income and expenditures in total per month, per capita per month and per capita per day. When looking at the income per capita per day, the mean is 2.35 USD. When using the international poverty line of 1.90 USD per capita per day, 46.2% of the households fall below this poverty line. This indicates the high level of poverty among the population of HTIZ.

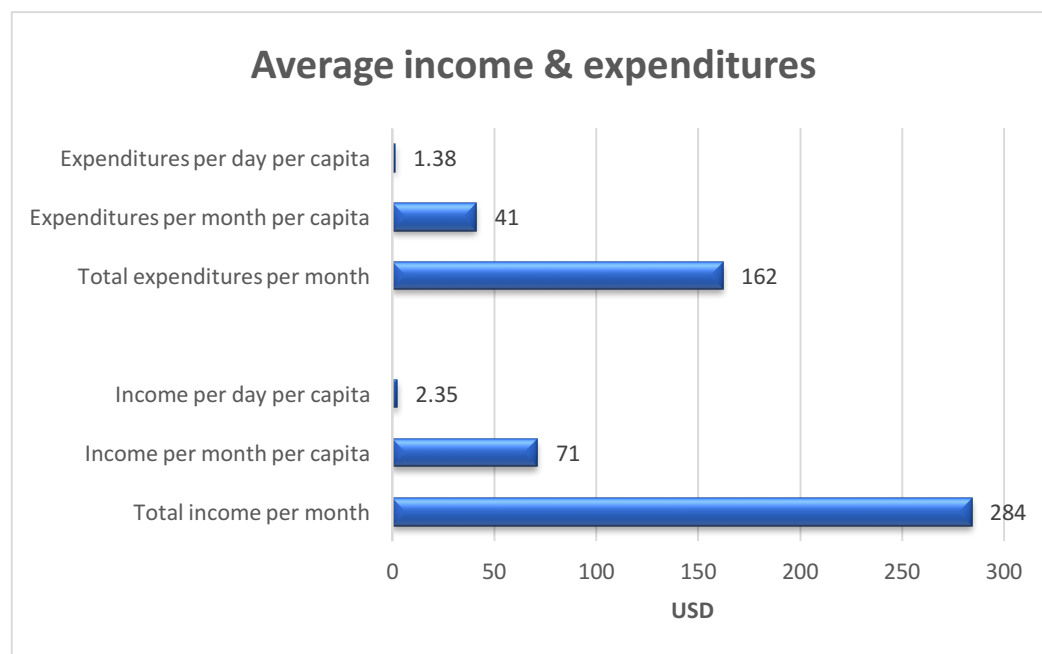


Figure 25: Average income & expenditures (in USD) for the local population of HTIZ

Common sources of income are found in construction jobs (30 respondents) and factory work (28 respondents), mainly in the garment industry. Other jobs were found as carriers, taxi or trishaw drivers, food sellers or shopkeepers. The households indicated to find it hard to get jobs during rainy season; for example construction work was significantly less available during this period, decreasing opportunities for especially low-wage jobs.

With regards to sources of expenditure, the largest share of income was generally spent on food, with an average expenditure of 105 USD per month per household. The second source of expenditure was health (average of 18 USD per month) and water (average of 11 USD per month).

When looking at the average income and expenditures per group, a difference can be observed; Figure 26 indicates the average income and expenditures per day for the different groups in HTIZ, both in total as well as per capita. The findings show that there is a difference between the income and expenditures per day of formal and informal settlers.

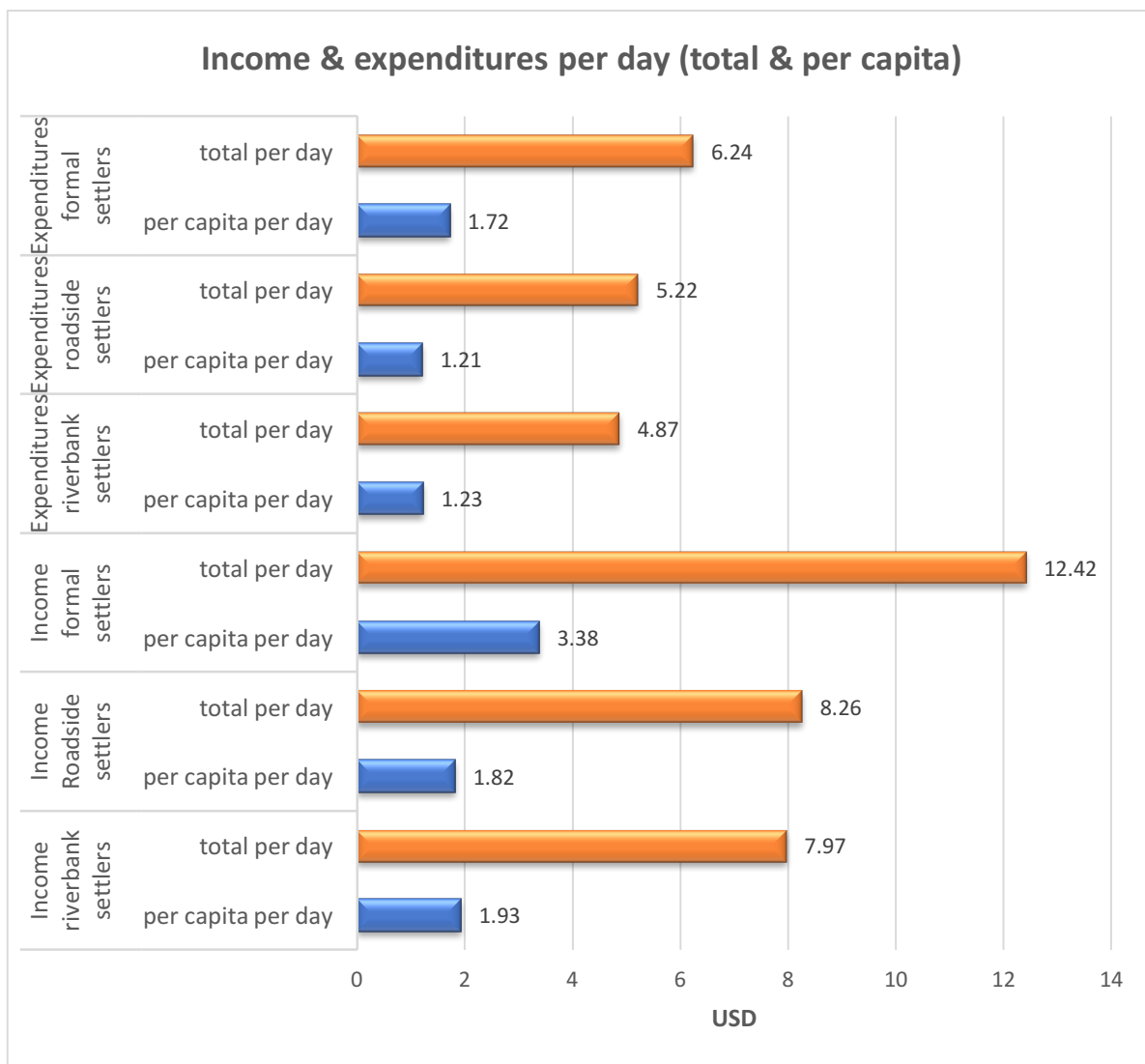


Figure 26: Average income & expenditures, total per day and per capita per day (in USD)

Having debt was also very common, especially among informal settlers in HTIZ. The height of the debt in one of the informal riverbank villages was said to range from 150 to 735 USD per household. The interest rates could be as high as 30%, sometimes paid per month but also per day. Paying off their debts was one of the priorities mentioned among the households when asked what they would do in case of having some extra money.

7.6 Decision making power

Although the local population is a main stakeholder as water consumers, it is also interesting to see to what extent they can actually influence the water governance process and if they have any decision making power in the governance process. A distinction can be made between the three different groups as they are found to influence the governance process differently.

Formal settlers have different ways of asserting influencing power. One obvious way is through voting for regional or national elections, which has become possible over the last year in the democratization process. Furthermore, the formal settlers in Yay Oakkan village are represented through a village head and on a higher level by the township officer of Hlaing Tharyar township.

For informal settlers, the degree of influencing power seems less due to the fact that there is not always a village head (only in a few riverbank villages) and if there is one, it is questionable to what extent this village head is formally recognized as they represent an 'informal' village. These village heads are often elected by the village population however not formally linked to any higher levels of governmental bodies. In informal roadside settlements, signs of collective organization or the existence of village head was not found, which could be explained by the fact that these settlement pockets are often relatively small (sometimes only 5 huts next to a factory). Only the informal roadside settlement pockets next to Yay Oakkan seemed more organized and even partly recognized as an extension of the formal village itself.

Another difference is the fact that not everybody in the informal settlement villages is able to vote due to a lack of identity cards. During the focus group discussion, about 50% indicated not to have identity cards (in one of the riverbank settlement villages). This is also the case for children born in informal settlements as they are not formally registered and hence lack identity cards. The lack of identity cards prevents people to vote and also affects other dimensions of the informal settlers livelihoods (e.g. possibility to access public education). However, the informal settlers with identity cards are able to vote as even within the informal riverbank settlements voting stations are installed during elections. This indicates again the hybrid boundaries between formal and informal in HTIZ.

Next to power that citizens can assert in terms of the governance process, there is also a group of citizens that make a living as local water vendors and hence can be considered an 'informal' institution influencing water governance in HTIZ. This informal system was borne out of need and demand for water within HTIZ as official water supply from YCDC was lacking, this group of local water vendors is now the main 'institution' supplying water and hence have some form of influencing power into how water is used and distributed within HTIZ. This informal system is herewith able to shape and reshape the water governance process, although this might not be acknowledged as such. They are an essential actor in water supply, a hybrid institution filling the gap created by the lack of formal water supply. However, collaboration and organization within this group is limited, which could be the result of competition and the geographical dispersion of the water vendors. The activities and characteristics of the local water vendors are further discussed in Chapter 8.

7.7 Conclusion

Since the establishment of the industrial zone in 1995, the local population was resettled to three villages in the area. The influx of migrants into HTIZ accelerated after Cyclone Nargis in 2008 and continued to grow; next to natural disaster, this in-migration can be attributed to the lack of economic opportunities in rural areas and rising land prices within the central townships of Yangon. Most of the migrants settled around the factories and the roadside, creating 'informal' settlement pockets. Since 2013, people also started to settle down on the Pan Hlaing riverbank, a process that evolved into 4 informal riverbank villages

The living conditions of the local population in HTIZ are challenging, especially so for informal settlers; limited access to infrastructural services, poor housing conditions, low education levels, poor wages and high debts highlight the urban poverty prevalent in HTIZ. The decision making power of especially informal settlers is limited due to their 'informal' status, however they are able to influence the water governance process to some extent through the existence of local water vendors.

Part III: Water security in HTIZ



8. Access to safe water

Within this chapter, the results on access to safe water supply for the local population of HTIZ will be discussed as an essential part of achieving water security. The system through which water is supplied in HTIZ will be described and the quantity and the quality of the water acquired will be discussed. Furthermore, the main barriers for different groups to actually achieve safe water supply will be explored as well as the livelihood implications of the current state of water supply.

8.1 Water resources

The lack of official water supply coverage of the YCDC to both formal as well as informal settlers in HTIZ implies the use of alternative sources for drinking and domestic purposes (cooking, washing, cleaning). Within HTIZ, a distinction can be made between the following six water resources that are used by the local population (see Figure 27):

- a) **Bottled water (sealed)** – premium bottled water sourced from private water factories, supplied by water vendors
- b) **Bottled water (no seal)** – bottles refilled with water, sourced from local factory boreholes/ YCDC pipeline, supplied by local water vendors
- c) **Tank water** – water in plastic ‘tanks’, sourced from local factory boreholes / YCDC pipeline / private tube wells, supplied by local water vendors
- d) **Groundwater** – collected from private tube wells by households
- e) **Rainwater** – collected in barrels, buckets and other devices by households
- f) **River / pond water** – the water from the Pan Hlaing river or local (river) water ponds, collected by households



Figure 27: Different water resources used in HTIZ

The use of these water resources in different seasons is depicted in Table 8, which indicates the ranking of the most commonly used resources. The results indicate that within the cold & dry season (October to June), tank water is the main source used for both drinking as well as cooking. Furthermore, the large majority of the population uses groundwater sourced through tube wells as main source for washing and sanitation. Within the rainy season (June to October), it is striking to note that the majority of the people use rainwater for cooking and washing, however less than half uses it for drinking. The main reasons provided for not using rainwater was that there was no need (mainly among people using sealed bottled water), a lack of collection devices and the 'bad quality' of the rainwater, which will be discussed in more detail in paragraph 8.4.

Table 8: *Ranking of water resources used by households in HTIZ*

	Drinking water	% used as main source	Cooking water	% used as main source	Washing & sanitation water	% used as main source
<i>Cold & dry season</i>	1. Tank water	61.5%	1. Tank water	67.7%	1. Groundwater tube well	90.8%
	2. Bottled water (sealed)	24.6%	2. Groundwater tube well	24.6%	2. Tank water	4.6%
	3. Bottled water (not sealed)	13.9%	3. Bottled water (not sealed)	6.2%	3. River / pond water	4.6%
<i>Rainy season</i>	1. Sources used in dry & cold season	55.4%	1. Rainwater	63.1%	1. Rainwater	67.7%
	2. Rainwater	44.6%	2. Sources used in dry & cold season	36.9%	2. Sources used in dry & cold season	32.3%

When looking at the difference between the three groups, especially the use of drinking water resources is distinct; whereas formal settlers mainly used sealed bottled water for drinking, the main source for informal settlers is tank water. The differences in water resources used for drinking in cold & dry season for the three groups is depicted in Figure 28.

Although there is a clear difference in quality between sealed bottled water and tank water, there is still a large variety within the quality of tank water and unsealed bottled water. The quality is best reflected in the price per bottle, which is discussed in more detail in paragraph 8.3.

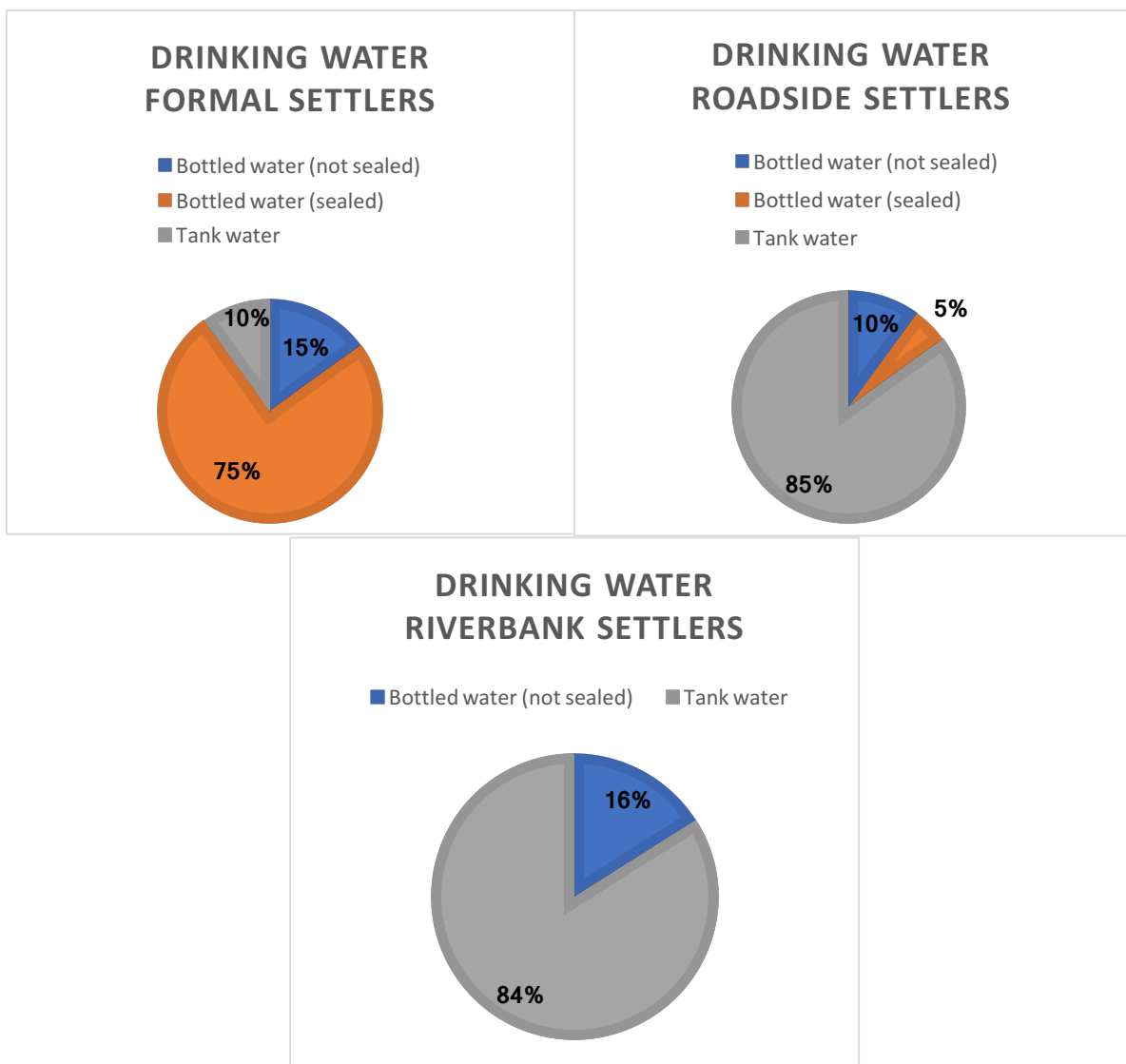


Figure 28: Drinking water resources for formal, roadside & riverbank settlers

8.2 Water supply

The different water resources used by the local population in HTIZ are mainly supplied through an informal system of local water vendors operating in HTIZ. Most of the water vendors in HTIZ sell two different kinds of water: water for drinking and water for domestic purposes (e.g. cooking and washing). This water is acquired from different sources; most water vendors acquire drinking water from the boreholes of local factories in HTIZ (about 0.07 USD per bottle), whereas some others acquire it from the deeper private tube wells (price differs per owner / operator of the tube well) or (illegally) tap it from the official water supply pipelines from YCDC. The lower quality water designated for other purposes is often also acquired from the borehole of local factories in HTIZ (about 0.04 USD/ cart of 20-30 bottles) or from some local electric tube wells able to pump up groundwater at a high speed (price differs). Furthermore, there are some water vendors (often not local residents) who sell 'premium' or sealed drinking water, often acquired from private drinking water companies in other parts of Yangon.

Most of the water sellers store the water in plastic tanks and sometimes bottles with a tap, containing about 20 litres per tank / bottle (see Figure 29). Transportation is mainly done by hand carts; there are some water sellers who transport water by motorized carts (motorbike or small truck), but they are low in number and mainly found in Yay Oakkan village. According to various local water sellers, there are agreements on which water seller can serve what area, although it is possible for 3 or 4 to operate in the same area as most of the sellers do



have their regular customers. On average, a water seller serves about 10 families per day, which are about 7 to 10 carts per day (one cart has 20 – 30 bottles). Although physically hard, the water sellers indicated to have chosen this job as it is ‘easy’ money; it is easy to start doing this job as there is always a need for water.

Figure 29: Local water sellers in HTIZ filling ‘tank water’

8.3 Water prices

The price for a bottle of drinking water in HTIZ ranges from 0.12 to 0.44 USD. According to the local water sellers, the price is mainly determined based on the quality of the water sold. Additionally, the distance of the house from the paved road partly determines the price as the water vendors include extra transportation costs, about 0.04 to 0.07 USD per bottle depending on the remoteness of the location. These extra costs mainly apply to citizens living in the informal riverbank settlements, as they live up to 25 minutes away from the paved road. The water for other purposes, such as cooking and washing, is generally sold at 0.37 USD per 3 bottles.

Table 9 gives an overview of the difference in average price spend per bottle of water among the three different groups. The findings indicate that on average, the informal roadside and riverbank settlers acquire much cheaper water than formal settlers, as it is almost half the price. This difference can be explained by the ability to pay a certain type of drinking water. The slightly higher price paid by riverbank settlers could stem from the extra transportation costs.

Table 9: Price paid per bottle water in HTIZ

	Average price per bottle (20L) of drinking water
<i>Formal settlers</i>	0,31 USD
<i>Informal settlers (road)</i>	0,17 USD
<i>Informal settlers (river bank)</i>	0,18 USD
<i>All</i>	0,22 USD

8.4 Quality of water

The quality of the water resources available in HTIZ differs. As mentioned in the previous paragraphs, the price per bottle is generally the best indicator of the quality. However, some general distinction can be made per water resource as well. The perceived quality of the different resources was measured by asking the local population to assess these sources based on smell, taste and colour. Table 10 gives an overview of the most common perceptions of water quality per source.

Table 10: Perceived water quality per source

Source of water	Description of quality
<i>Bottled water (sealed)</i>	<ul style="list-style-type: none"> - Good - Premium quality
<i>Bottled water (not sealed)</i>	<ul style="list-style-type: none"> - Good / acceptable / fair - Little salty / ionic
<i>Tank water</i>	<ul style="list-style-type: none"> - Good / ok / fair - Yellow / salty / ionic / clay smell
<i>Groundwater</i>	<ul style="list-style-type: none"> - Ok / fair / bad - Yellow / salty / ionic / clay smell - Rice turned blue after cooking
<i>Rainwater</i>	<ul style="list-style-type: none"> - Good / ok / bad - First batch is bad due to dust / dirt on the roof, but from the second batch onwards it is good - Lots of insects / ash in rainwater
<i>River / pond water</i>	<ul style="list-style-type: none"> - Ok - Little salty

Especially the perceived quality of groundwater differed a lot among the households, probably due to a difference in tube wells; whereas most of the informal settlers along the riverbank installed a tube well themselves (hence relatively shallow, about 20 metres), others in and around Yay Oakkan village had access to deeper tube wells and sometimes even electric pumps.

The perceived rainwater quality also varied; whereas most of the respondents thought the quality of the rainwater was good, some others were very convinced that it was clearly dirty and not usable as drinking water due to the ash and dirt in it. This difference could be explained by the fact that the methods of collecting rainwater also varied; many of the households living in informal settlements collected the water that runs off the palm leaves or corrugated sheet roofs, which can affect the quality of the water. The people living in apartment blocks that did collect rainwater (often not the case if they were able to buy sealed bottled water) collected the rainwater through a pipe connected to the roof gutter.

8.4.1 Treatment of water

With regards to treatment of the water sources, most of the respondents using sealed bottled water indicated not to treat it in any way, as there was no need due to the high quality. The not sealed bottled water and tank water was almost always filtered using a cloth, which was often brought to the house by the water vendor who 'filtered' the water before pouring it into the water storage device of the household. However, this 'cloth' is generally only useful to filter out large particles as the filter is wide textured (see Figure 30). Boiling is not a common method to treat the drinking water; only one of the households indicated to boil the water before drinking. With regards to rainwater and sometimes groundwater, most of the respondents indicated to use sedimentation to make sure the larger particles and the dust would settle.



Figure 30: Filtering cloth of water vendor



Figure 31: Storage barrels in roadside settlement

Most of the water sources were stored in plastic bottles, tanks or buckets in or in front of the house, sometimes closed off with a plastic or wooden lid (see Figure 31). In a few cases, people stored their water in ceramic pots closed off by a ceramic lid. The way of storing water varies greatly per settlement; whereas the informal riverbank villages mainly used open buckets, most of the informal settlers along the road had some closed off water collection and storage device.

8.4.2 Measuring water quality

Although most of the households were relatively content with the quality of the water source they used, this assessment is of course also a matter of perception and depends on the options available for the household's specific situation. Hence, it is essential to assess the water quality also on a more objective level by measuring some basic water quality parameters.

The assessment of the quality of different water resources was done by the NGO WaterAid in 2016, as part of a report on the living conditions of garment factory workers in Hlaing Tharyar township. Within this study, both 'local bottled water' (unsealed bottled water), tank water and rainwater were tested for the E. Coli bacteria, which can cause various water-borne diseases. The WHO Guidelines for Drinking Water Quality indicate an E. Coli scale ranging from 0 to 100 MPN/100ml, where 0 is considered safe and E. Coli >100 MPN/100ml is unsafe.

In between, the phases go from low risk, intermediate risk to high risk/probably unsafe. When testing the 'local bottled' water (unsealed bottled water), WaterAid found that only 28.6% of the samples contained a safe level of E. Coli, meaning that the other 61.2% did contain the E. Coli bacteria, of which 4.8% were considered unsafe and 38.1% high risk/probably unsafe. The premium bottled water (sealed bottled water) was also tested and was found to contain a safe level of E. Coli for all samples. All tank water samples were found to contain 'unsafe' levels of E. Coli. Finally, the rainwater was also tested; 20% was found to be unsafe, 60% high risk and 20% intermediate risk. The contamination of the rainwater can be explained by the informal way of rainwater collection and storage.

This high incidence of E. coli contamination found in the drinking water can be partly explained by the lack of sanitation in this area, especially among the informal settlers in Hlaing Tharyar. As described in more detail in Chapter 9, the lack of sanitary disposal of faeces poses a serious risk for water contamination and hence public health.

8.5 Quantity of water

The amount of water acquired by households for drinking and for domestic purposes differs widely, mainly depending on the amount of water resources available near the house (e.g. tube well for washing / cooking). The average amount of water acquired per week was 9.6 bottles per household; with an average content of 20 litres, the average quantity of water per week is 190 litres. As the average household size is 4.3, the average amount of water acquired per week per capita is 44.2 litres. This number is under the standard of the WHO with a minimum of 7.5 litres of domestic water available per person per day (WHO, 2017). However, as indicated before this is only the quantity of water acquired, and not the amount of water used from private sources such as a tube well next to the house. Hence, it is difficult to estimate to what extent the quantity of water used is actually high enough according to the WHO standards. The availability of the water resources in general was indicated to be problematic in some seasons; water shortage sometimes happened during dry season and also during rainy season, when flooding made it impossible for water vendors to reach some houses in the informal riverbank settlements.

8.6 Drivers of limited access to safe water

Despite the alternative water supply system in place in HTIZ, accessing water of sufficient quality and quantity remains a challenge for many households in this area. These challenges are the result of various barriers, both on the household but also on the institutional level.

8.6.1 Household barriers to access water

As already visible in the results, the land tenure arrangement and resulting living location of households is a barrier to access safe water supply; informal settlers living in huts on the riverbank or roadside are less able to access safe water than formal settlers living in apartments. This is evident from the cheaper water acquired among informal settlers, which reflects also reflects the quality of the water. Table 11 shows the differences in means between price paid per bottled, which is found to be significant as indicated by the results of the One-way ANOVA in Table 12. A post-hoc Least Significant Difference (LSD) test shows that the difference between the two informal settler groups is not significant ($p= 0.53$), only the difference between the informal settler groups and the formal settlers living in apartments ($p=0.00$). This indicates the fact that living in informal settlements, whether on the roadside or riverside, limits the possibility for choosing better quality and higher priced water.

Table 11: Mean and standard deviation of 'price per bottle' by 'living arrangement'

Living arrangement	Mean	Std. Deviation	N
Formal settlers	418	55	20
Informal settlers (road)	231	70	19
Informal settlers (river bank)	246	107	24
All	296	114	63

Note: 'price spend per bottle drinking water' is in MMK

Table 12: One-Way Analysis of Variance of 'price per bottle' by 'living arrangement'

Source	df	SS	MS	F	p
Between groups	2	436829,18	218414,59	35,14	0,00
Within groups	60	372942,75	6215,71		
Total	62	809771,94			

These differences between formal and informal settlers are directly related to the level of poverty of the households, which is one of the main drivers for people to live in informal settlements. The lack of financial resources further limits the ability to buy qualitatively better water resources and hence poverty is considered a household barrier to access safe water supply. Although the prices of water are relatively low in HTIZ, income levels are also low; many informal settlers indicated that not having enough money to buy water happened regularly, especially towards the end of the month. These findings are confirmed by the positive relation between 'total income per month' and 'price per bottle' of drinking water ($r=0.341$, $n=62$, $p=0.004$). This indicates that when income rises, people also choose a different quality of drinking water.

Another household barrier is found to be the lack of education; this can limit the employment opportunities and hence the financial resources of a household, but also influences the awareness and knowledge about safe water resources. The fact that many of the informal settler households were relatively content with the water they used for drinking and did not apply much treatment to it could be an indication of this lack of knowledge. The results of the Pearson's R correlation test between 'households where all adults completed middle school' and 'price per bottle' shows that there is a positive correlation of moderate strength ($r=0.559$, $n=63$, $p=0.00$), which confirms that education level influences the choice for a specific water resource.

8.6.2 Institutional barriers to supply safe water

The identified household barriers are also driven by dynamics on the institutional level. As mentioned before, the lack of capacity within the YCDC makes it difficult to supply Yangon city with water; the old and limited pipeline infrastructure, the low number of water reservoirs and the lack of financial resources to improve these systems are the main obstacles for YCDC to supply the rapidly growing urban hub of Yangon. As articulated by an YCDC government official, the lack of financial resources can also be attributed to the low price:

'In comparison to other countries all over the world but also in other Southeast Asian countries, our water price is so low. Because our organization is not like other organizations; our organization is like a governmental organization, so our objective is to supply water to our people, not like a business but as a service. So, the main objective is to supply water to our people. But the problem is that our water price is so

low that it is difficult to handle our operations and maintenance and our future development also. So that it is why in our future we also try to increase the water price a little bit to balance the costs. But it will not be too much, just a small increase. Because we face the problem that our people will not accept to pay a lot more money like in other cities.’ (Interview with government official of YCDC W&S, 2017).

The limited extension of the network to peri-urban areas such as HTIZ can also be attributed to the lack of priority given to these areas; when new water reservoirs are planned, most of the water is planned to go to the more central townships of Yangon or are designated to serve new towns that still need to be developed. One of the reasons for not prioritizing areas like HTIZ is the fact that it is not considered a ‘domestic’ area; the area was designated for industrial purposes. However, over the years the influx of settlers changed the character of HTIZ and hence it cannot be considered solely and industrial area. However, the second argument for not giving priority is the fact that these ‘informal’ settlers do not legally inhabit this area; they are ‘illegal’ settlers and hence considered a temporary ‘issue’ that needs to be dealt with. Therefore, there is no priority or need to actually extend infrastructure and services to these people.

As outlined in this chapter, an alternative system of local water vendors took the place of these formal service supply systems. Although this ‘informal’ system is working relatively well in terms of serving the urban poor, there is no quality control of the water resources they sell. This lack of regulation increases the risk of unsafe water supply.

Finally, there is a lack of awareness on the possible risks of utilizing water that may be contaminated. Both households as well as government agencies like YCDC do not consider the current quality as a big risk, which may also be the result of the lack of capacity and resources to change it. This lack of awareness is highlighted by the following quote:

‘Until now we did not have any problem with water-borne diseases. But actually our sanitation system is not good and maybe it can affect our water supply also. Probably our immune system is also used to it, they have a high immune system. We have a lab and we tested for E. Coli and total coliform and we found that nearly every tap water has it, but only just a small amount. But we don’t have any problem. And then the next point is that most of the people especially in the city area are using the tap water only for cooking, washing, not for drinking. For drinking they use bottled water.’ (Interview with government official of YCDC W&S, 2017).

Although the government thus knows that some water resources are contaminated, it is not considered a high risk for health as people are ‘used’ to these bacteria. Furthermore, it highlights the perception that most people are able to buy ‘bottled water’; however, the findings of this study show that many informal settlers do use these unsafe resources for drinking as they often buy unsealed or tank water, which can also contain the YCDC ‘tap water’.

8.7 Outcomes of limited access to safe water

8.7.1 Health

The lack of access to safe water supply can have serious health implications, both short- and long term. Although the scope of this research did not allow for a thorough assessment of the health impacts on the local population, some findings highlight the implications of water-related challenges in this area. The households were asked to indicate common health problems they experienced during past rainy season and this cold/dry season, both for the adults as well as for the children. Table 13 indicates the incidences of fever and/or diarrhea per season per group in percentages. The results highlight that in rainy season, both children as well as adults in all groups experience fever and / or diarrhea at least once, but often multiple times. For adults, diarrhea was less common than among children. In dry season, there is a clear difference between the formal and informal settlers; among the formal settlers there is a very low degree of fever and / or diarrhea, whereas among informal settlers this is still common. Although this could be the result of the use of contaminated water, it is not possible to establish this causal link. Furthermore, it needs to be noted that these results present 'subjective' evaluations of peoples own health.

Table 13: % fever and / or diarrhea among citizens in HTIZ

	Children (rainy season)	Children (dry season)	Sample size households with children	Adults (rainy season)	Adults (dry season)	Sample size households with adults
Formal settlers	50.0%	6%	N=18	30.0%	0.0%	N=20
Informal settlers (roadside)	55.6%	22.2%	N=18	25.0%	10.0 %	N=20
Informal settlers (riverside)	44.4%	27.8%	N=18	24.0%	24.0%	N=25
All	48.2%	16.7%	N=54	27.7%	12.3%	N=65

The local population does not consider fever or diarrhea a major risk; during the focus group, villagers indicated that they and their children grew very 'strong' and that there is no 'major' problem, herewith almost normalizing the incidences of diarrhea. Although it is thus not recognized as a major issue, the report of WaterAid highlights the risks of the consumption of contaminated water, in this case with the E. Coli bacteria. According to Water Aid, drinking the 'unsafe' water is 'likely to result in significant and chronic illness with sustained use of the source and no 'point of use' treatment' (WaterAid, 2016: 19).

8.7.1 Poverty

The lack of access to a formal water supply system and safe water supply in general also has implications for poverty. As a result of a lack of official water supply to HTIZ, people in HTIZ are dependent on the local water vendors selling different quality of water. The results highlighted the fact that informal settlers generally buy lower priced water in order to minimize the costs of water. However, when looking at the % spend on drinking water of the total expenditures, the results show that the relatively burden of water costs is still much higher for the poorest groups, namely the informal settlers. Table 14 indicates the average

price paid per bottled and the % of total expenditures spend on water, which shows that for the informal settlers drinking water takes up almost double the share of expenditures than it does for formal settlers. Hence, the poorest groups spend a much larger share of their total financial resources on drinking water.

Table 14: *Price per bottle and % spend on drinking water in HTIZ*

	Average price per bottle (20L) of drinking water	% of expenditures spend on drinking water
<i>Formal settlers</i>	0,31 USD	2,30%
<i>Informal settlers (road)</i>	0,17 USD	5,79%
<i>Informal settlers (river bank)</i>	0,18 USD	6,01%
<i>All</i>	0,22 USD	4,76%

Table 14 also indicates that informal settlers on the riverbank spend relatively more per bottle of water than settlers near the roadside. This can be explained by the fact that remote informal river bank settlements pay a higher price for water than for example the roadside settlers, as these areas can only be accessed by foot. Even within the informal riverbank villages, the price of water varies according to the distance from the main road; according to inhabitants, the price of the same bottle varies between 0.22 USD and 0.44 USD. Herewith, water becomes a relatively large share of expenditure for this group that on average has the lowest income, increasing the risk of further impoverishment.

8.8 Ways of coping with limited water supply

The identified challenges to access safe water, especially for informal settlers, are coped with in various ways. In times of shortage of water in dry season, the villagers of one of the informal settlement villages indicated to go to the other side of Hlaing Tharyar township (above the Yangon – Patheingyi highway) in order to try to buy water in this area. However, villagers also indicated that this comes with high transportation costs and hence was only done in times of pressing shortages.

Another coping strategy was found in the social network of the villagers; in case of water shortage or the inability to buy water due to a lack of money, they indicated to support each other where possible:

‘Everybody in this village is very close to each other as they all depend on each other. If somebody has a lack of money, other people will support them.’ (Interview with village head of informal riverbank village, 2017).

However, it is not clear to what extent this is also the case in larger riverbank villages or the roadside settlements, as the social network might be less close-knit than in this particular riverbank village. A final way of coping with limited financial resource to buy water was by asking for payment at a later point in time, hence building up debt with the water vendor. However, as the water vendors often came from the same village, they did not ask for interest rates. This was a common practice among the villagers of the informal riverbank settlement where the focus group discussion was conducted.

8.9 Conclusion

In HTIZ there is a lack of official water supply to the local population. This lack of 'policy-driven' supply resulted in a system of 'needs-driven supply' (Allen et. al., 2006); a system of informal water vendor supplies the local population with different water resources for drinking and domestic purposes. The prices of the different water resources vary according to quality as well as transportation costs. Furthermore, households in HTIZ acquire some water resources themselves through rainwater harvesting or the use of private tube wells.

There is a clear difference in water resources used between formal and informal settlers; whereas formal settlers are able to acquire premium bottled water for drinking, tank water is the main resource used by informal settlers. The quality of the water resources used is in general considered acceptable according to the local population, despite the bad smell or colour. However, water quality measurements show a high and often unsafe level of E. Coli contamination in all water resources except for premium bottled water (WaterAid, 2016), posing serious health risks especially for informal settlers who use these resources for drinking. Hence, these findings confirm the fact that the urban poor are often unable to access safe water supply (Satterthwaite, 2003). The quantity of water available was in general described as being sufficient, except for shortages in dry season or difficulties of accessing it during flooding events in rainy season.

The challenges to access safe water supply can be explained by various barriers; on the household level, the living arrangement, income level and education level are found to be correlated with the ability to choose a certain type and quality of water. On the institutional level, the lack of capacity, awareness and priority for these areas and the lack of regulation of local water vendors are found to be major causes for the identified water insecurities. The identified water insecurities can have serious implications for health as well as for further impoverishment of the already poor groups in HTIZ, herewith confirming the relation between access to water and poverty found in different studies (Kingsbury, 2012; Harvey, 2008). However, the existence of social networks and the ability have debt with water vendors are found to be coping strategies for inhabitants to deal with the lack of access to water supply.

9. Water-related risks

Next to access to safe water supply, the extent to which humans are exposed to water-related risks is also an essential part of the overall water security. In HTIZ, water pollution is found to be one of the major risks, induced by both domestic as well as industrial waste. Whereas the domestic water pollution can be attributed to the lack of sanitation infrastructure and solid waste management, the industrial pollution is the result of the discharge of untreated wastewater from factories in HTIZ. Next to water pollution, water poses a risk for the population in HTIZ in the form of flooding, one of the main challenges especially for informal settlers living on the Pan Hlaing riverbank.

9.1 Water pollution

9.1.1 Industrial water pollution

Due to intensive industrial activity in HTIZ, water pollution induced by the discharge of insufficiently treated industrial wastewater is a major risk in this area. As described in paragraph 4.2.2, the 2015 Environmental Guidelines aim to reduce this risk by specifying the effluent standards that need to be adhered to by the industry in Myanmar. Nevertheless, as enforcement and monitoring are often lacking, the discharge of toxic wastewater is still said to be common throughout Myanmar and also in HTIZ specifically.

According to the regulations, all factories in HTIZ are required to have a wastewater treatment plant on their plots in order to treat the wastewater produced. However, according to the YCDC PCCD only 10% of all factories do have a properly working treatment plant, whereas the HTIZ management committee estimates the number of factories with a well working treatment plant at 20%. This indicates the severity of the risk of industrial pollution in HTIZ; an estimated 80 to 90% discharges their insufficiently treated effluent water in the drainage system, which then runs through 7 outlets into the Pan Hlaing river.

Evidence of this industrial water pollution can already be found within HTIZ. Many of the respondents indicated to have witnessed signs of industrial pollution, as the water in the drainages or next to their house had a strange colour (blue, purple, black) or a chemical smell (e.g. paint or shampoo). Observations within the research area confirm these experiences; Figure 32 shows the purple coloured stream water found within an informal riverbank settlement in HTIZ. The severity and suspected source of pollution according to the local population of one of the riverbank villagers was the following:



Figure 32: Purple stream water in HTIZ

‘There is purple water near and along the factory wall. Some animals have been drinking from it some time ago and they died afterwards. We suspect the colour comes from the factory next to the wall, which is doing printing of paper and plastics.’ (Interview with village head of informal riverbank village, 2017).

Although these experiences indicate water pollution in this area, more sound evidence is needed to actually prove the extent and severity of industrial pollution. In order to actually measure the suspected pollution, the local NGO ALARM initiated a study to measure the water quality of various water resources in HTIZ. The aim of this study was to raise awareness and ‘shake’ policymakers to address this growing problem of pollution in Yangon.

In the light of this study, systematic testing of water samples from HTIZ has been done from 2013 onwards. The water resources tested for are the surface water of Pan Hlaing and Hlaing river (4 sampling points), the groundwater from local tube wells (6 sampling points) and the water in the drainage canals in HTIZ (7 sampling points). The samples were tested 6 times per year, namely once a month ranging from February 2016 to July 2016. All 17 water samples were tested on the following 10 parameters: pH, Lead, Cadmium, Turbidity, Arsenic, Iron, hardness, Chloride, BOD and Copper. The differences in international and national standards for these 10 parameters are depicted in Table 15

Table 15: *International and national water quality standards (Source: ALARM, 2016)*

	Drinking Water Standards	Surface Water Standards	Effluent Water Standards	
	WHO & EU	USEPA	EQS, India, FAO	Myanmar Environmental Guidelines (2015)
<i>pH</i>	6.5 – 8.5	5.5 – 8.5	5.5 – 9.0	6.0 – 9.0
<i>Lead</i>	<0.01 mg/L	< 0.05 mg/L	< 0.1 mg/L	< 0.1 mg/L
<i>Cadmium</i>	< 0.005 mg/L	< 0.005 mg/L	< 0.04 mg/L	<0.1 mg/L
<i>Turbidity</i>	<10 NTU	< 30 NTU	-	-
<i>Arsenic</i>	<0.01 mg/L	<0.2 mg/L	< 0.2 mg/L	<0.1 mg/L
<i>Iron</i>	<0.2 mg/L	<2 mg/L	<3 mg/L	< 3.5 mg/L
<i>Hardness</i>	<300	-	-	-
<i>Chloride</i>	<250 mg/L	-	-	-
<i>BOD</i>	-	<4 mg/L	<350 mg/L	< 50 mg/L
<i>Copper</i>	< 0.05 mg/L	< 0.1 mg/L	-	< 0.5 mg/L

The results of the ALARM study in HTIZ are depicted in Table 16, including the standard used to determine if the results are within or the limits. According to these findings, most of the water sources are ‘polluted’ as 3 to 6 parameters are above limits at all time. Notable are the high levels of BOD, lead and cadmium in the water resources tested; whereas the BOD level points towards more general pollution of water resources, the heavy metals lead and cadmium can be directly related to industrial pollution and form a high risk to human- and ecological systems. Both toxic chemicals are often used in the battery industry as well as paint, dying and fertilizer industries. As these types of factories are found within HTIZ as well, it is necessary to further assess to what extent these industries treat their wastewater properly. In Appendix VI, a map of HTIZ on which these ‘high risk’ factories are highlighted is provided.

Table 16: Results of water quality tests HTIZ (Source: ALARM, 2016)

Parameters	Drainage cannels (Myanmar Environmental Guidelines 2015)	Rivers (Surface Water Standards USEPA)	Groundwater wells (Drinking Water Standards WHO)
<i>pH</i>	All Normal to Limit	All Normal to Limits	In Acid Range (usually)
<i>BOD</i>	All above Limit except Points 7	All Point above the Limit (usually)	All points above the Limit (usually)
<i>Copper</i>	All Normal to Limit	Above Limit Sometimes	Above Limit sometime
<i>Chloride</i>	Above Limit except rainy season	Above Limits except rainy season	All Above Limit (all time)
<i>Iron</i>	Above Limit sometimes (5,6,7,8,9)	All Above Limit (Usually)	All Above Limit (all time)
<i>Lead</i>	All Above Limit (usually)	All Above Limit (Usually)	All Above Limit (all time)
<i>Arsenic</i>	All Normal to Limit	All Normal to Limit	W1 & 6 Above Limit sometimes
<i>Cadmium</i>	All Normal to Limit	All Above Limit (All time)	All Above Limit (all time)

9.1.2 Domestic water pollution

Another source of pollution of the water resources in HTIZ is domestic waste, both solid as well as liquid. Whereas there is a waste collection system in place to collect solid waste of the factories, the YCDC PCCD does not systematically collect waste from the local population of HTIZ. No garbage bins were found in the area and households only reported to have seen the YCDC trucks collecting domestic waste once or twice a year. The only waste collection that was said to take place was by the national army, who incidentally cleaned up dumping sites in Yay Oakkan village. Furthermore, in some of the streets in Yay Oakkan village (mainly informal settlements), informal waste collection takes place; a private collector comes to collect the household waste for 0.14 USD per bag. However, it is not clear where the private collector dumps this waste, which could be on a larger dumping site or in one of the landfills closest to HTIZ. Finally, the management committee of HTIZ tries to clear all the waste in the drainages every year, as the blockages are highly problematic. These operations cost about 10,000 dollar a year. However, due to on-going disposal of waste throughout the year it does not take long before blockage of the drainages occurs again.

This lack of systematic domestic waste collection results in large amounts of garbage throughout HTIZ, often piled up on dumping sites but also scattered throughout Yay Oakkan village, along the roads and in the drainage system (see Figure 13). Due to the lack of official solid waste collection, the majority of the population in HTIZ dumps their waste nearby their house. Figure 33 depicts the most common solid waste disposal methods of the local population; the majority dumps their waste on a nearby dumping site, followed by a large group the disposes their waste in the water, often next to their house. There is a clear difference between the three groups; whereas the majority of the formal settlers (65%) and the informal roadside settlers (80%) dispose their solid waste on a dumping site, 88% of the informal riverbank settlers dumps their waste in the water next to their house.

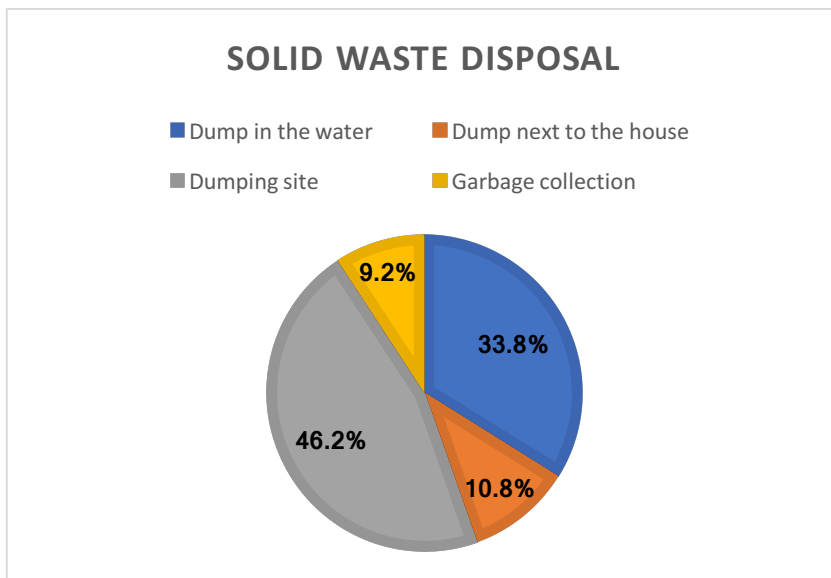


Figure 33: Solid waste disposal of the local population in HTIZ

Next to solid waste disposal, disposal of domestic liquid waste also contributes to water pollution in HTIZ. As depicted in Figure 34, only 29.2% of the population in HTIZ has access to improved sanitation facilities. There is also a clear difference between the groups; whereas 85% of the formal settlers have access to a flush or pour flush toilet connect to a septic tank, among the informal settlers a pit latrine is the most commonly used toilet facility. Among the informal roadside settlers, a pit latrine with a whole into the earth is the most commonly used system (70%), whereas a hanging pit latrine is most common among informal riverbank settlers (88%). Most of the pit latrines are located next to the house, increasing the risks of bacterial pollution of water resources used by the households. Finally, 9.2% of the households in HTIZ do not have any toilet facilities, which are only informal settlers.

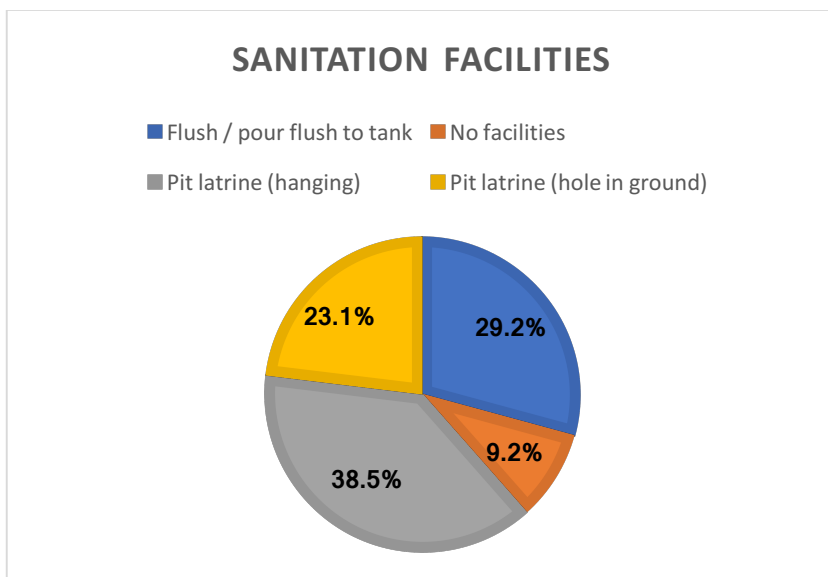


Figure 34: Sanitation facilities for the local population in HTIZ

9.1.3 Drivers of industrial & domestic water pollution

The apparent water pollution in HTIZ is driven by a variety of factors, summarized in Table 17. A direct cause of the industrial pollution is the discharge of insufficiently treated effluent of factories. According to the industry, these practices are the result of various barriers. First, most of the (local) factories lack the resources to actually install a wastewater treatment plant on their own plot; a lack of land and financial resources make this a highly challenging requirement. Second, the industry is said to lack the technical know-how to actually operate and maintain these wastewater treatment plants effectively. Finally, there is no incentive for the industry to adhere to the 2015 Environmental Guidelines, as enforcement by the YCDC PCCD is lacking as already discussed in Chapter 5; all factories are asked to bring a sample of their ‘treated’ wastewater to the YCDC PCCD, however it is not possible for the YCDC PCCD to trace the actual source of water that is brought in for testing. According to the YCDC PCCD, the lack of thorough monitoring is a result of the lack of human, financial and technical resources within the department.

Domestic pollution is in the first place driven by two factors: the lack of a domestic solid waste collection system in HTIZ and the lack of sanitation infrastructure, mainly among informal settlements. Although YCDC PCCD is in charge of solid waste collection in Yangon city, they do not extend their services to the population of HTIZ as the overall capacity of this department is said to be low and this area is foremost considered an industrial area. The lack of sanitary infrastructure in informal settlements is the result of the low priority given to provide services to ‘informal’ settlers; they are not considered the responsibility of the YCDC as they are not officially citizens of this area and live in ‘illegal’ houses, hence depending on their own ability to construct sanitation facilities.

Table 17: Drivers and causes of water pollution in HTIZ

Drivers	Direct cause	Status quo
Industry <ul style="list-style-type: none"> • Lack of financial resources • Lack of land • Lack of technical know-how • Lack of incentive Government <ul style="list-style-type: none"> • Lack of effective monitoring & control measures to enforce regulations 	Discharge of untreated effluent	Contamination of water resources
<ul style="list-style-type: none"> • Lack of domestic solid waste collection • Lack of improved sanitation facilities for informal settlers 	Discharge of domestic (liquid & solid) waste	

9.1.4 Outcomes of water pollution in HTIZ

The current level of water pollution, due to both industrial as well as domestic waste discharge, has various implications for the stakeholders in HTIZ. The contamination of the fresh water resources in HTIZ does not seem to have direct implications for the industry on the short term, but it does affect them on the longer term. As articulated by Coca-Cola company, the sustainability of the water resources in HTIZ is essential for the factories in the area that are highly dependent on groundwater for production purposes. Although the boreholes are still deep enough to be able to source relatively uncontaminated water, a water vulnerability assessment conducted by the Coca-Cola factory indicated that in the future (in approximately 20 years), the risk of groundwater pollution is considerable.

For the local population, the implications of water pollution are more direct. The heavy metals and chemicals present in the different water resources in HTIZ, as indicated by the study of ALARM, pose a serious health risk for households using this water for drinking and domestic purposes. Especially due to the fact that water supply is not monitored in any way, there is a high risk of people actually using contaminated water. Furthermore, the lack of improved sanitation facilities in informal settlements increases the risk of bacterial contamination, which was also highlighted in the study of WaterAid (2016); the high level of E. Coli found in most of the water resources can further increase the health risks for the local population in HTIZ. The health risks are relatively higher among informal settlers as they are often more dependent on local water resources than formal settlers, who are able to acquire premium bottled water.

Finally, the lack of a domestic solid waste collection system also contributes to the pollution of water resources in HTIZ as the dark coloured and badly smelling water ends up in the drainages, streams and the Pan Hlaing river. Next to pollution, solid waste is also one of the causes of flooding in HTIZ; drainages are regularly blocked, causing flooding throughout the streets of Yay Oakkan village and in front of many roadside settlements. Next to the inconvenience caused by this regular flooding, it also poses a health risk as people are forced to come in contact with highly polluted drainage water on a regular basis.

9.1.5 Coping strategies

Besides the evidently polluted water in the drainages and the purple coloured ponds, the awareness on the pollution of the water resources in HTIZ is limited; people were relatively content with the sources they used for drinking and domestic purposes, however this can also be the result of the lack of alternatives and hence the acceptance of using this resource. The local population does not apply thorough coping strategies to deal with the pollution except for not using the visibly polluted water and some form of treatment (as described in paragraph 8.4.1). Furthermore, some respondents indicated that in the past, a few residents of HTIZ have complained at the factories about the evident pollution, however without any success.

9.2 Flooding

Based on the research findings, flooding can be considered another major water-related risk for the local population in HTIZ. Tidal flooding, heavy rainfall and blocked drainages all result in a high occurrence of flooding in the area, which impacts the different population groups in HTIZ to various degrees.

9.2.1 Exposure to flooding

The households in HTIZ are all exposed to flooding, however to varying degrees and from various sources; whereas the formal and roadside settlers are mainly exposed to low level flooding as a result of drainage blockage, a lack of drainages and heavy rainfall, the informal settlers living on the Pan Hlaing riverbank are exposed to high levels of flooding as a result of tidal flooding and rainfall. Figure 35 presents the differences between the three groups regarding the exposure to flooding; both the average number of days of flooding as well as the average highest level of flooding reached in rainy season are indicated. These results show that although the number of days does not differ highly among the groups, the highest level of flooding is much higher for informal riverbank settlers.

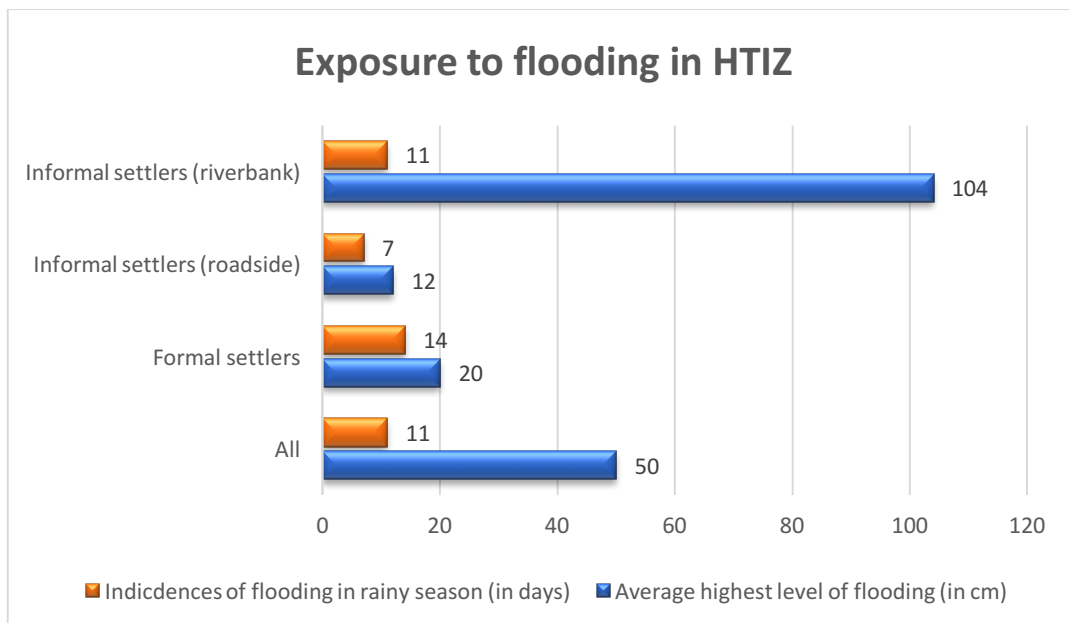


Figure 35: Exposure to flooding in HTIZ

This high level of flooding for the informal riverbank settlers can be explained by the tidal pattern of the Pan Hlaing river. Even during the dry season, many of the roads in the informal settlements are said to be flooded twice a day, resulting in very muddy and slippery roads as they are rarely paved. During rainy season, flooding is an even bigger challenge; the highest level of flooding ranged from 20cm to 210cm, depending on the location of the house. These high flood levels result in inundation of roads and sometimes also houses.

The informal and formal settlers living near paved roads in and around Yay Oakkan also perceive flooding as a challenge, especially during rainy season. However, this type of flooding comes from drainage blockages combined with heavy rainfall or due to the fact that in some areas (especially near informal houses) there are no drains, leading to low levels of flooding due to the discharge of domestic wastewater on the road. The highest level of flooding near and in Yay Oakkan was said to range from 10cm to 30cm, which is thus significantly lower than in the riverbank villages.

9.2.2 Driving factors of exposure to flooding

The direct drivers of flooding in HTIZ are the tidal pattern of the Pan Hlaing river, the rainfall pattern and the blockages or lack of drainages. However, these factors do not explain the degree of exposure to flooding, which is mainly the result of the living location and housing conditions of households. The results indicate that the informal settlers living on the riverbank are the group most exposed to flooding in terms of the level and incidences of flooding, mainly due to the flood-prone location and the relatively poor housing structures. Furthermore, people living further away from the paved road experience significant higher levels of flooding ($r=-0.885$, $p=0.00$, $n=47$) as a result of tidal flooding of the Pan Hlaing river. Finally, it is noticeable that there is a link between the households that buy lower quality water (reflected in the price per bottle) and the level of flooding ($r= -0.285$, $p= 0.06$, $n= 45$), indicating that the lower the quality of water achieved, the higher the level of flooding a household is exposed to. Although this does not represent a causal link, it does indicate that many households that are unable to access safe water resources are also more exposed to water-related risks such as flooding.

Flooding as a result of the lack of drainages in many settlements in HTIZ and the blockage of existing drainages can be attributed to the lack of priority given to improve or maintain the infrastructure in this area. The responsibility of these issues has been transferred to the HTIZ management committee, who mainly focus on the industrial needs. Hence, the domestic infrastructure needs and challenges are largely neglected.

9.2.3 Outcomes of exposure to flooding

The different forms of flooding occurring in HTIZ have various implications. Regular exposure to (polluted) flood water can have serious health implications. This was highlighted by the experiences of villagers in one of the informal riverbank settlements. In the first months of the establishment of the Pan Hlaing riverbank villages, it rained heavily and flooding was common. During this period, many children and women got sick and suffered from severe diarrhea and fever. After this experience, they grew 'stronger' and hence fever and diarrhea were not considered a major problem in their village anymore. Nevertheless, women stated that the water used for washing regularly caused skin rash amongst their children. With regards to malaria, the villagers indicated that 2 children (out of approximately 2400 people in the whole village) suffered from malaria or dengue fever in the past 3 years. Another concern to the villagers was the snakes that live in the waters around their houses, especially during flooding.

Although these health risks might be less present for the other groups of citizens in HTIZ, the exposure to highly polluted and stagnant water brings health risks. Furthermore, many formal and roadside settlers mentioned that transportation was hindered due to the flooding. This was again even more the case for the informal riverbank settlers; due to the high levels of flooding and the fact that most of the people cannot swim, mobility was a major concern during rainy season even preventing people from going to work or children from going to school.

Herewith, flooding also has monetary implications; the lack of mobility prevents people from doing business or going to work, which directly affects their financial resources. Furthermore, riverbank villagers indicated that they need to rebuild their house yearly, as they are exposed to heavy rain and flood on a regular basis.

9.2.4 Coping strategies

Citizens of HTIZ applied various coping strategies in order to decrease the negative impacts of flooding. In order to cope with the flooding within and around Yay Oakkan village, households used bricks or bags of sand to increase the possibilities for walking without needing to go through the dirty domestic wastewater. Furthermore, some households tried to remove the wastewater manually by shoving it to another area away from their home.

Informal riverbank settlers also applied measures to cope with the severity of flooding in this area. In order to keep the house from flooding, many households indicated to have built another higher floor in their house or even moved to another house. Another preventive measure was the upgrading of roads in the riverbank villages; during dry season, many of the dirt roads were heightened with bags of sand, gravel or mud to prevent them from getting muddy during (tidal) flooding. Another method applied was the construction of bamboo walking bridges, used to reach the most remote houses on the riverbank. In some rare cases, a group of households managed to collect a fund and build a paved road in front of their street of houses. Despite these strategies to decrease the impact of flooding, especially during rainy season the majority of the area was still heavily flooded. Hence, most of the households indicated to have a 'boat' in order to increase their mobility. However, as these boats are often made out of Styrofoam sheets or boxes they are often not strong enough to carry many people or last for more than a few weeks.

9.3 Conclusion

The local population of HTIZ is exposed to various water-related risk. One of the main risks is the high level of industrial pollution; due to a lack of proper treatment of industrial wastewater, different water resources (cannels, surface water, groundwater) are found to be highly polluted (ALARM, 2016). Another major source of pollution of HTIZ is domestic waste; although there is a waste collection system in place for the industry, domestic waste of the local population is barely collected. Hence, most of the solid waste is dumped in the water, next to the house or on dumping sites found throughout HITZ. The domestic waste often ends up in drainages, resulting in highly polluted drainage water and drainage blockages. Next to pollution due to solid waste, the lack of sanitation infrastructure among informal settlers results in 'needs-driven' sanitation facilities as pit latrines and open-air defecation (Allen et. al., 2006), increasing the risk of faecal contamination.

Major drivers for water pollution are the lack of resources and incentive for the industry to improve their wastewater treatment practices and the lack of priority given to improving domestic solid waste collection and sanitation facilities in HTIZ. As a result, water pollution threatens the sustainability of fresh water resources, affecting both industry in terms of production and the local population in terms of health. These findings correspond with other studies that identify water pollution as a major urban governance challenge for highly populated and industrial areas (Satterthwaite, 2003).

Another major water-related risk identified is flooding, especially the following two types found in many urban hubs: localized flooding due to inadequate drainage systems and flooding of major rivers (Douglas et. al., 2008). The formal and informal settlers near paved roads in HTIZ are mainly exposed to flooding due to drainage blockages combined with heavy rainfall or due to the lack of drainages, especially near informal settlements. For informal settlers along the riverbank, flooding is one of the main challenges; during both dry and rainy season, (tidal) flooding results in the inundation of roads and houses, negatively impacting mobility and health. Main drivers for flooding are the lack of drainages, the blockage of drainages, the flood-prone living location of informal settlers and the relatively vulnerable housing structures, as also found in other studies (Winsemius et. al., 2015; Douglas et. al., 2008; Satterthwaite, 2003). Coping strategies to decrease the impact of flooding are the heightening of roads and the use of Styrofoam 'boats'.

Part IV: Conclusion & discussion



10. Discussion

Within this chapter, both limitations as well as the relevance and implications of this study are discussed, allowing for a right use and interpretation of the findings.

10.1 Limitations of the study

This study was explorative and qualitative in nature; the relatively small sample size and the lack of existing data did not allow for thorough quantitative analysis. Herewith, reliability of the results can be problematic as they are always subject to the interpretation of the researcher (Bryman, 2008). However, the use and triangulation of different data sources such as surveys, interviews and a focus group discussion increases the reliability of the results as it helps in recognizing patterns and having sufficient contextual knowledge for interpretation. Furthermore, the relatively small sample size and the focus on a relatively specific area within Yangon can pose a risk to the external validity and hence generalizability of the results. However, as many other townships in Yangon city and other South-East Asian hubs resemble the challenges found within his specific area, the findings can still be of added value within other localities. Finally, the internal validity is not considered problematic as these findings are the result of the in-depth qualitative study of a relatively small group of subjects, which allows the 'researcher to ensure a high level of congruence between concepts and observations' (Bryman, 2008: 376).

10.2 Theoretical contribution

Despite these limitations, the findings of this study are relevant for both theory and practice. It contributes to the water governance framework by exploring the dynamics and outcomes of water governance in a peri-urban locality. Water governance is generally defined as the different systems in place that manage water resources and the delivery of water services (Roger & Hall, 2003). These governance processes result in a certain degree of water security for a community, area or even a nation. This study shows that in a context in which the formal water governance systems in place do not supply basic water-related services, these gaps are filled by informal and so-called 'needs-driven' systems (Allen et. al., 2006) taking over the distribution and supply of water resources to the local population. In HTIZ, local water vendors take on this role and herewith the local population becomes part of the water governance process, even though not formally recognized as such. This research also highlights the political character of water governance, as the process that is essentially about the control and power over the distribution and use of water resources. This political nature is reflected in the lack of priority given to supply water and water-related services to the local population of HTIZ, as the majority of the residents are considered 'illegal' and hence not entitled to these basic urban services.

The level of water security can be considered the outcome of the water governance process as well as the result of certain household characteristics; whereas a lack of formal water supply prevents informal settlers to access safe water, it does not have the same effect on formal settlers able to buy premium bottled water. Hence, both institutional as well as household barriers can be the cause of water insecurities for a certain individual, household or group. This distinction between different 'levels' of barriers was also applied by Bakker et. al., 2008, however more specifically on the access safe water supply for urban poor. Within this study, this format was also applied to the water-related risks of water pollution as well as flooding in order to explore all dimension of water security. When looking at the water-

related risks, the degree of water security is also the result of certain contextual factors on both the institutional and household level, which eventually shape the degree to which a household is exposed to these risks. Herewith, this study confirms the findings of earlier studies on the relative greater exposure of urban poor to environmental pollution and hazards (Winsemius et. al., 2015; Satterthwaite, 2003).

The implications of water insecurity have also been assessed in this study. Whereas scholars have previously linked access to safe water to poverty (Kingsbury, 2012; Harvey, 2008), this study takes on a broader approach by looking at the livelihood outcomes of water insecurities, including the water-related risks of pollution and flooding. The findings confirm the risk for health hazards in the light of limited water security, which eventually increases the risk of further impoverishment through high costs and limited productivity (Harvey, 2008; Karn & Harada, 2002). However, the identified water insecurities also increase the risk of further impoverishment due to the relative high costs (of buying from local vendors and from the damage due to flooding events) and limited mobility (during flooding events), which can also decrease productivity.

10.3 Implications for policy & practice

This study has also implications for policy and practice. The risks of the current water insecurities stress the importance of better infrastructure and the supply of services towards the local population in HTIZ, and also to the industry. Both of these groups are now highly dependent on groundwater, which can pose a risk to the sustainability of the ecosystem in the future due to land subsidence, saline intrusion and depletion. Furthermore, the lack of effective regulation of water supply, sanitation but also water pollution in HTIZ can result in highly contaminated water resources, which can be pose a risk to both the human as well as the natural system.

However, the lack of capacity but also priority given to this area makes it unlikely that, on the short term, the YCDC is able to supply these services and improve infrastructure in such a way that more water security is achieved. Hence, it can be beneficial to first work through these informal systems of water governance to improve the current situation, e.g. working with local water vendors to improve the knowledge on water quality and treatment, or increasing the capacity of households to collect and store rainwater. However, on the long term it is essential that especially these informal settlers are recognized as actual residents of HTIZ and Yangon city, who have the right to access certain services and should be enabled to achieve basic needs.

The acknowledgement of the informal settlers and their challenges and needs also brings the question of land tenure security to the forth; as long as these citizens are labelled as 'informal' or even 'illegal' squatters, this will form an obstacle for different institutions to actually supply or service them, even for NGOs or private actors as the categorization as 'illegal' has political implications. It is thus essential that solutions are found that strengthen the land tenure security of these settlers. Whereas upgrading of informal settlements is often perceived as the most sustainable and desirable way, future plans of the government indicate that resettlement will be the main strategy. This makes it even more essential to understand the livelihoods and challenges of these urban poor, as only then sustainable solutions can be found. For example the importance of social networks and informal income generation activities is essential to acknowledge, as these are all part of the coping strategies of urban poor. Hence, choosing for upgrading or resettlement, it is always necessary to involve the

local population as a main stakeholder, already in an early stage. Instead of seeing the upgrading or relocation of these settlements as a technical fix, the complexity of the social, economic and political factors at play needs to be recognized. This study can help to understand these complex processes and the challenging livelihoods of the urban poor in Yangon; however, specific and more extensive research and the piloting of intended solution is necessary in order to find suitable solutions that can help to build a more sustainable and inclusive Yangon city.

10.4 Recommendations

More specific recommendations can also be drawn from this study, both for the governance of industrial wastewater within HTIZ as well as the improvement of water security for the local population in HTIZ, especially the informal settlers.

10.4.1 Governance of industrial wastewater

Based on the findings of this study, the following recommendations regarding the governance of industrial wastewater are provided:

- The private sector needs to be made aware of the necessity and long-term benefits of preserving water resources in HTIZ assuring proper wastewater treatment.
- Raising awareness alone is not enough; there is an urgent need to increase the level of monitoring and enforcement of the 2015 Environmental Guidelines. The results of this study indicate that without effective enforcement, the majority of the industries in HTIZ not adhere to the national wastewater standards and hence contribute to the pollution of Myanmar's water resources.
- Enforcement should be increased equally among industrial zones, as it is undesirable and ineffective to increase the level of enforcement only in one area. Furthermore, although the penalties should be clear and strict, there should be a window of change for the factories to apply the necessary measures.
- Providing the possibility of technical and financial support for factories is essential in order to prevent further pollution, as the lack of experience and resources to correctly deal with wastewater is found to be a bottleneck for the private sector. The establishment of an (national) environmental fund and training facilities is hence an essential step towards more sustainable production.
- The waste collection system in HTIZ should be expanded towards the domestic areas as well. Currently, the lack of domestic waste collection causes public health risks and drainage blockages, resulting in regular flooding of the drainages. These issues could easily be resolved by creating a few central dumping sites or garbage bins near the informal settlements and implementing a structural system of waste collection.

10.4.2 Water security for local population

Furthermore, some policy changes are recommended to enhance water security among the local population in HTIZ:

- Although HTIZ is an industrial zone, it needs to be recognized that it is also the living and working area of about 60,000 people. Hence, it is essential to address the domestic needs and challenges as well in order to achieve sustainable development of HTIZ.
- Connecting the local population of HTIZ to basic infrastructure should be incorporated in policy and urban planning strategies. This is a necessary step to reduce the current public health and ecosystem risk induced by domestic pollution.
- The specific needs and challenges of the informal settlers in HTIZ and in Yangon in general should be addressed by drafting policy and projects specifically aimed at this group of urban poor. As an important workforce and as citizens of Yangon city, it is necessary to acknowledge and address their basic needs. Furthermore, actions need to be taken in order to prepare for or prevent the further growth of informal settlements in Yangon, for example by drafting pro-poor housing schemes.
- In order to increase the access to safe water supply among informal settlers in HTIZ, there is a need to construct deep tube wells and / or supply more rainwater collection devices. Currently, the capacity to use rainwater as a drinking water source is only limitedly used due to the lack of good collection and storage devices.
- Within the informal river bank villages, there is a high need of improving the roads; the high occurrence of flooding combined with the dirt roads challenges the mobility of the villagers and can form a risk for health, as water-borne diseases and infections can spread easily. Improving the road network is thus highly essential for the improvement of the informal settler's livelihoods.
- WASH training should be provided among informal settlers in HTIZ to increase knowledge on safe and hygienic water use. This could help to mitigate some basic health risks.
- The low education level of many of the informal settlers influences their current income, and often prevents them from achieving a more stable economic situation. This problem could be addressed by providing vocational training to increase economic mobility and financial security. An increase in financial security can in turn increase the water security of people.
- Addressing the lack of financial resources by offering low-cost loans or by facilitating the establishment of lending-groups could be highly effective in reducing vulnerability of the informal settlers.

11. Conclusion

‘Access to a secure, safe and sufficient source of fresh water is a fundamental requirement for the survival, well being and socio-economic development of all humanity. Yet, we continue to act as if fresh water were a perpetually abundant resource. It is not.’

- *Kofi Annan*

Providing access to safe and sufficient water for all is still considered a major development challenge, as reflected in the formulation of SDG6 (UN, 2017b). Although a lot of attention has been given to this issue in science as well as practice, an estimated 663 million people are still depend on unimproved water sources for drinking (UN, 2017a). Also in growing urban hubs in the global South, ensuring sustainable and inclusive water governance is challenging; rapid population growth, a lack of infrastructure, industrialization and poor regulation result in a high risk for water pollution and limit access to safe water resources (UN-Habitat, 2012). Another major risk for cities in developing countries is flooding; both localized flooding as a result of poor waste management as well as coastal or tidal flooding, exacerbated by climate change and rising sea levels, can pose a threat to life in cities (Douglas et. al., 2008). These water-related challenges can be considered major obstacles for increasing well being and development in urban hubs, especially so for the urban poor. This group is found to be disproportionally affected by water-related risk, such as a lack of access to safe water, environmental pollution and flooding, mainly as a result of poor living conditions and living in hazard prone (peri-urban) areas (Winsemius et. al., 2015; Satterthwaite, 2003).

11.1 Theoretical debate

Within the water governance literature, these various water-related challenges have been studied from various disciplines. Whereas water governance is generally considered the process and systems in place to manage water resources and water services (Rogers & Hall, 2003), the relatively new concept of water security is considered a desirable outcome of this process. Water security can be defined as both the access to safe water supply as well as the exposure to water-related risks (Bakker, 2012). This concept has been applied on different levels, from global to the community level and with a different thematic focus, sometimes focussing more on natural systems or human systems. However, only a few scholars have paid attention to the actual drivers of water insecurities faced by many households over the world; what governance barriers prevent people to access water? What are the household barriers to be able to move to less flood-prone areas? On the institutional level, the lack of effective governance and the lack of service provision, especially to areas inhabited by the urban poor, are found to be main barriers (Bakker et. al., 2008). On the household level, low income and the lack of property rights are considered main barriers (Bakker et. al., 2008; Satterthwaite, 2003). Next to these drivers, the implications of the inability to achieve water security have been studied and is often linked to increased impoverishment for already vulnerable groups (Kingsbury, 2012; Harvey, 2008).

11.2 Research aim

This study aimed to explore these dynamics of water security on a local level by using this concept to find water-related challenges as well as drivers and outcomes of these challenges. The socio-economic hub of Myanmar, Yangon city, has been chosen as the research site, and more specifically a peri-urban industrial zone within this city: Hlaing Tharyar Industrial Zone (HTIZ). The research area has been chosen in the context of rapid urbanization and industrialization and the many water-related challenges found within peri-urban Yangon, especially highly populated and industrial areas such as HTIZ. The lack of infrastructure, poor (industrial) wastewater management and the location just above the Pan Hlaing river created difficulties for accessing safe water supply and a high risk of water pollution and flooding. This poses an even bigger risk for the many informal settlers who settled themselves along the roadside or riverbank in this area; pushed to this area by poverty and attracted by the economic opportunities it offers, this group was expected to be most vulnerable for the water insecurities in HTIZ as living conditions are poor.

In order to explore the dynamics and different dimensions of water security within this locality, this study aimed to answer the following research question:

To what extent is water security achieved for the local population in HTIZ and what are the drivers and livelihood outcomes of identified water insecurities?

11.3 Stakeholders in HTIZ

Within HTIZ, different stakeholders are involved in the use and governance of water resources. Whereas the governmental institutions, YCDC W&S and YCDC PCCD are considered responsible for water supply and waste management, the HTIZ management committee is concerned with the maintenance of the infrastructure. However, whereas all these institutions do provide some services to the industry in this area, no priority is given to provide or improve infrastructure for the local population living in HTIZ. Furthermore, there is a lack of useable water supply due to the low pressure of the official pipeline network and enforcement of the 2015 Environmental Guidelines by the YCDC PCCD is low. These different governance gaps are said to be the result of a lack of capacity, priority and (financial) resources among the YCDC departments. The main water users in this area are the industry as well as the local population. The industry consists of 695 factories from many different sectors and represented in the HTIZ management committee. The local population can be roughly divided into three groups: formal settlers, informal roadside settlers and informal riverbank settlers. Whereas the first group is represented by an official village head, the informal settlers have less influencing power as a result of their informal status. However, the informal system of local water vendors can be considered part of the water governance process as an essential informal institution responsible of water supply in the area in the context of lacking formal water supply. The living conditions of the local population in HTIZ are challenging, especially for informal settlers; the lack of land rights and sometimes also identity cards, limited access to infrastructural services, poor housing conditions, low education levels, poor wages and high debts highlight the urban poverty prevalent in HTIZ.

11.4 The level of water security in HTIZ

Whereas the industry is able to access sufficient water through private bore holes or by buying premium water, the local population became dependent on a need-driven system of informal water vendors supplying different types and qualities of water, reflected in the price. Whereas the majority of formal settlers are found to be able to acquire safe water supply by buying premium bottled water, the majority of roadside and riverbank informal settlers use tank water for drinking. The quality of tank water is at risk due to E. coli contamination (WaterAid, 2016) and industrial pollution; the quantity supplied is sometimes problematic, during dry season or flooding events.

When looking at water pollution, there is a high risk of both industrial as well as domestic water pollution; the first is the result of illegal discharge of industrial effluent, leading to high levels of heavy metals in canals, the river and the groundwater (ALARM, 2016). Domestic pollution can be attributed to the lack of domestic waste collection and the lack of improved sanitary facilities in the informal settlements. Water-pollution results in health hazards, especially for informal settlers who use groundwater (bottled in tanks) and in a few cases river water for drinking or domestic purposes.

Flooding was identified as the second water-related risk. For formal and informal roadside settlers, flooding is mainly the result of the blockage or the lack of drainages leading to regular however low-level flooding. However, informal riverbank settlers are exposed to much higher levels of flooding due to the tidal pattern of the adjacent Pan Hlaing river, resulting in a high impact on the livelihoods of this group.

These results indicate that water security in HTIZ is achieved for the majority of the formal settlers in HTIZ, whereas this is not the case for the majority of the informal settlers, especially the informal riverbank settlers.

11.5 Synthesis

The results indicate that water security in HTIZ is achieved for the majority of the formal settlers in HTIZ, whereas this is not the case for the majority of the informal settlers, especially the informal riverbank settlers. The identified water insecurities and the drivers and livelihood outcomes are summarized in Table 18. This synthesis table shows that whereas the identified water insecurities are mainly driven by the lack of capacity and priority given to supply and protect informal settlers on the institutional level, on the household level the lack of financial resources and the living conditions and location are found to be the main drivers. The identified water insecurities for informal settlers can result in further impoverishment due to the associated health hazards, costs and limitation of mobility. These findings provide a useful framework for assessing local water security in peri-urban contexts. Further research can help to test, complement or adjust this framework in order to increase the understanding of factors that influence the water governance process and hence the level of water security.

Table 18: Summary of the drivers & outcomes of identified water insecurities in HTIZ

Water insecurities	Drivers	Outcomes
Lack of official water supply & access to safe water	<p><i>Institutional barriers</i></p> <ul style="list-style-type: none"> • Lack of capacity and (financial) resources to extend capacity of water supply • Lack of priority to supply industrial zone & informal settlers <p><i>Household barriers</i></p> <ul style="list-style-type: none"> • Living location & conditions • Lack of resources • Limited awareness 	<p><i>General</i></p> <ul style="list-style-type: none"> • High dependency on groundwater (risk of land subsidence / saline intrusion) • Informal water vendor network <p><i>Formal settlers</i></p> <ul style="list-style-type: none"> • Dependency premium-bottled water <p><i>Informal settlers</i></p> <ul style="list-style-type: none"> • Dependency on tank water • Relatively high costs for water • Health-hazards due to (industrial & domestic) contamination
Industrial and domestic water pollution	<p><i>Institutional barriers</i></p> <ul style="list-style-type: none"> • Lack of monitoring & effective control measures to enforce environmental guidelines • Lack of domestic waste collection system • Lack of basic sanitary & WWTP infrastructure <p><i>Industrial barriers</i></p> <ul style="list-style-type: none"> • Lack of resources for own WWTP • Lack of incentive to adhere to environmental guidelines <p><i>Household barriers</i></p> <ul style="list-style-type: none"> • Lack of waste disposal opportunities • Lack of sanitary facilities • Limited awareness 	<p><i>General</i></p> <ul style="list-style-type: none"> • Pollution of fresh water resources <p><i>Formal settlers</i></p> <ul style="list-style-type: none"> • Health-hazards due pollution of water resources used for domestic purposes <p><i>Informal settlers</i></p> <ul style="list-style-type: none"> • Health-hazards due pollution of water resources used for drinking & domestic purposes
Tidal and localized flooding	<p><i>Institutional barriers</i></p> <ul style="list-style-type: none"> • Lack of domestic waste collection system → blockage of drainages • Lack of drainages in informal settlements <p><i>Household barriers</i></p> <ul style="list-style-type: none"> • Flood-prone living location • Lack of resources → poor/ vulnerable housing structures 	<p><i>Formal settlers & roadside settlers</i></p> <ul style="list-style-type: none"> • Exposure to polluted drainage water <p><i>Informal riverbank settlers</i></p> <ul style="list-style-type: none"> • Limited mobility • High costs • Health hazards due to water-borne diseases <p>→ further impoverishment</p>

11.6 Take-home message

The case of water security in HTIZ shows that especially the most vulnerable group of urban poor, informal settlers, face many water insecurities as a result of drivers on both the institutional as well as the household level, creating the risk of further impoverishment. Addressing these barriers is essential in order to achieve more sustainable and inclusive water governance, essential for achieving development as articulated in SDG6 (UN, 2017b).

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Appendices

Appendix I: Household survey

<i>Questionnaire Nr.</i>		<i>Gender respondent</i>	M / F
<i>Questionnaire Date</i>		<i>Name of village</i>	

Introduction

This interview is conducted for a study by Ms. Rebecca Groot, a master student Sustainable Development from Utrecht University in the Netherlands. Her study will focus on the water supply and use in Hlaing Thar Yar Industrial Zone, with the aim to find ways forward in sustainable water governance in this area.

The results of this study will be written down in a report, which will be made publically available. This report will not mention your name or exact location; the information provided through this survey will be handled confidentially.

The interview will take about 30 minutes. If you agree to be interviewed, please sign the consent form below.

Consent Form

- I confirm that I consent to be interviewed by Ms. Rebecca Groot and here colleague.
- I agree that the information I will provide her with will anonymized and used for her report, which will be made available for anybody interested in its content.
- I confirm that I have read this document, understand it and sign it willingly.

Signature /

name:

General information

1. What is your **household composition** (of people living under the same roof)?

Household member	Household position	M / F	Age	Enrolled in school?	Highest education
1. Respondent				Yes / No / NA	
2.				Yes / No / NA	
3.				Yes / No / NA	
4.				Yes / No / NA	
5.				Yes / No / NA	
6.				Yes / No / NA	
7.				Yes / No / NA	
8.				Yes / No / NA	
9.				Yes / No / NA	
10.				Yes / No / NA	

Education levels: 3 = High school
 0 = No education 4 = Ungraduated school
 1 = Primary school 5 = Graduate school
 2 = Middle school 6 = Postgraduate school

2. What is your ethnicity (e.g. Bamar)?

3. What is your religion?

4. For how long do you live in Hlaing Thar Yar Industrial Zone (HTIZ)?

Since _____ in HTIZ, since _____ in this house

5. Where did you originally move from and why?

Place of origin: _____

Why moved to HTIZ? _____

6. What is applicable to you land tenure status?

Δ Bought the land from: _____ for _____ Kyat – Rights? Yes / No

Δ Rent the land from: _____ for _____ Kyat / Month – Rights? Yes / No

Δ Received land use rights from government for _____ years

Δ Moved on land without buying / renting - Rights? Yes / No

Δ Other: _____

7. What are your main sources of income per month?

Source of income (e.g. job, support)	Kyat	Hours / days of work
1.		
2.		
3.		
4.		
5.		
Total income per month		

8. What do you spend per month on:

Source of expenditure	Costs (in Kyat)
<i>Water</i>	
<i>Food</i>	
<i>Housing (rent land/ house)</i>	
<i>Health</i>	
<i>Electricity</i>	
<i>Telephone costs</i>	
<i>Transportation</i>	
<i>Education</i>	
<i>Other:</i>	
Total expenditures per month	

9. What are the main health problems that members of your households experienced last year (e.g. diarrhea, fever)?

	<i>Children</i>	<i>Adults</i>
Past rainy season		
This dry season		

10. What is the main source of drinking-water for members of your household?

<i>Water source DRY SEASON</i>	<i>Description of quality</i>

<i>Water source RAINY SEASON</i>	<i>Description of quality</i>

<i>Water source COLD SEASON</i>	<i>Description of quality</i>

11. If NO use of rainwater, why not?

12. If YES bottled water: How much bottled water do you buy per week and at what price?

Amount of units: _____

Price per unit: _____

From whom?: _____

13. How much time to you spend collecting water per week?

- Δ No. of minutes: _____ x _____ (times) per week
- Δ None, water is brought to my home by the seller
- Δ None, water supply in the house

14. If YES collecting water: who goes to fetch drinking water for your household (max. 2)?

- Δ Adult woman
- Δ Adult men
- Δ Female child (under 15)
- Δ Male child (under 15)

15. Do you treat your drinking water in any way to make it safer to drink?

- Δ No
- Δ Yes, namely (circle all options mentioned)
 - i. Boil
 - ii. Bleach/chlorine
 - iii. Filter, using: _____
 - iv. Sedimentation
 - v. Other: _____

16. What water source do you use for cooking?

<i>Water source DRY SEASON</i>	<i>Description of quality</i>

<i>Water source RAINY SEASON</i>	<i>Description of quality</i>

<i>Water source COLD SEASON</i>	<i>Description of quality</i>

17. What water source do you use for washing yourself?

<i>Water source DRY SEASON</i>	<i>Description of quality</i>

<i>Water source RAINY SEASON</i>	<i>Description of quality</i>

<i>Water source COLD SEASON</i>	<i>Description of quality</i>

18. Do you use the river / stream water for any purpose?

- Δ No, never
- Δ Yes, for:

19. Did the quality of the river / stream water changed over the past 5 years?

- Δ Don't know
- Δ No changes
- Δ Yes:

Changes in quality: _____

Why do you think it changed? _____

20. What kind of toilet facility do members of your household usually use?

- Δ Flush/pour flush (connected to sewer system / septic tank)
- Δ Pit latrine
- Δ Bucket
- Δ No facilities
- Δ Other: _____

21. Where do you dispose your solid waste?

- Δ Dump it next to house / in water / dumping site (circle applicable option)
- Δ Garbage
- Δ Burn
- Δ Other: _____

22. How many days per month are the following areas flooded during rainy season?

- Δ Roads in front of house: _____ days/month in rainy season, up to level of _____
- Δ Entry of the house: _____ days/month in rainy season, up to level of _____
- Δ Living area of house: _____ days/month in rainy season, up to level of _____

23. What are the most important challenges for your household during rainy season?

24. What are the most important challenges for your household during dry season?

Thank you for your participation!

If you are willing to participate in a possible follow-up interview or focus group discussion, please write down your telephone number: _____

Appendix II: Focus group questions

Focus group introduction

- Thank you for your willingness to participate in the focus group discussions.
- The aim of this focus group is to get more understanding of access to water and water-related risks in this village.
- The focus group will take about 60 minutes. As we want to understand your feelings / experiences better, please feel free to share them with us and give additional comments or thoughts whenever you want. Also feel free not to respond to any question.
- All the information gathered today will be anonymized and the results will be used for writing the master thesis of Rebecca Groot, a student for the Netherlands.
- Are there any questions about this research or focus group before we start?

Challenges (interactive)

- What are the main challenges you face in your life, what worries you most?
 - Discuss in pairs of two
 - Write down a list of 5 things, ranging from 1 to 5
 - Share with group

Water supply

- What are your main challenges regarding water supply?
- Would you buy different kind of water if you would have more money?
- Do you sometimes buy less water in order to save money?
- Did it happen during past year that you did not have sufficient drinking water available? What was the reason?
- How did you try to resolve this issue?

Water-related risks

- To what extent did you think the water in HTIZ is polluted and what are the main sources of pollution?
- Do you see any negative impacts / effects of this way of waste disposal?
- How does flooding impact your daily life?
- What do you do in order to cope with flooding during rainy season?

Health

- What are the most common health issues / diseases in this village?
- How often did you visit the health clinic last year and what was the reason?

Housing conditions

- How often do you need to rebuild your house?
- What are the costs of rebuilding a house?

Land

- What are the main problems of not having official land rights as an 'informal settler'?

Identity cards

- What are the problems of not having an identity card?

Security

- To what extent do you feel secure in this village?
- To what extent do you feel secure in HTIZ?

Economic situation

- Income
 - Is the income you get generally high enough to cover costs of living?
 - What are the first things you cut costs on when you have a lack of money?
 - Who do you ask for help when there is a shortage of money?
- Debt
 - Do you currently have any debts and with whom?
 - How high is the loan and how high are the interest rates?
- Saving
 - Who of you has any savings?

Future

- Do you have the intention to move somewhere else?
- Are you afraid of resettlement?

Priorities (interactive)

- If somebody would give you 100,000 MMK, what would you do with it?
 - Brainstorm in pairs of two
 - Share with group what you have chosen and why

Appendix III: Interview topic list

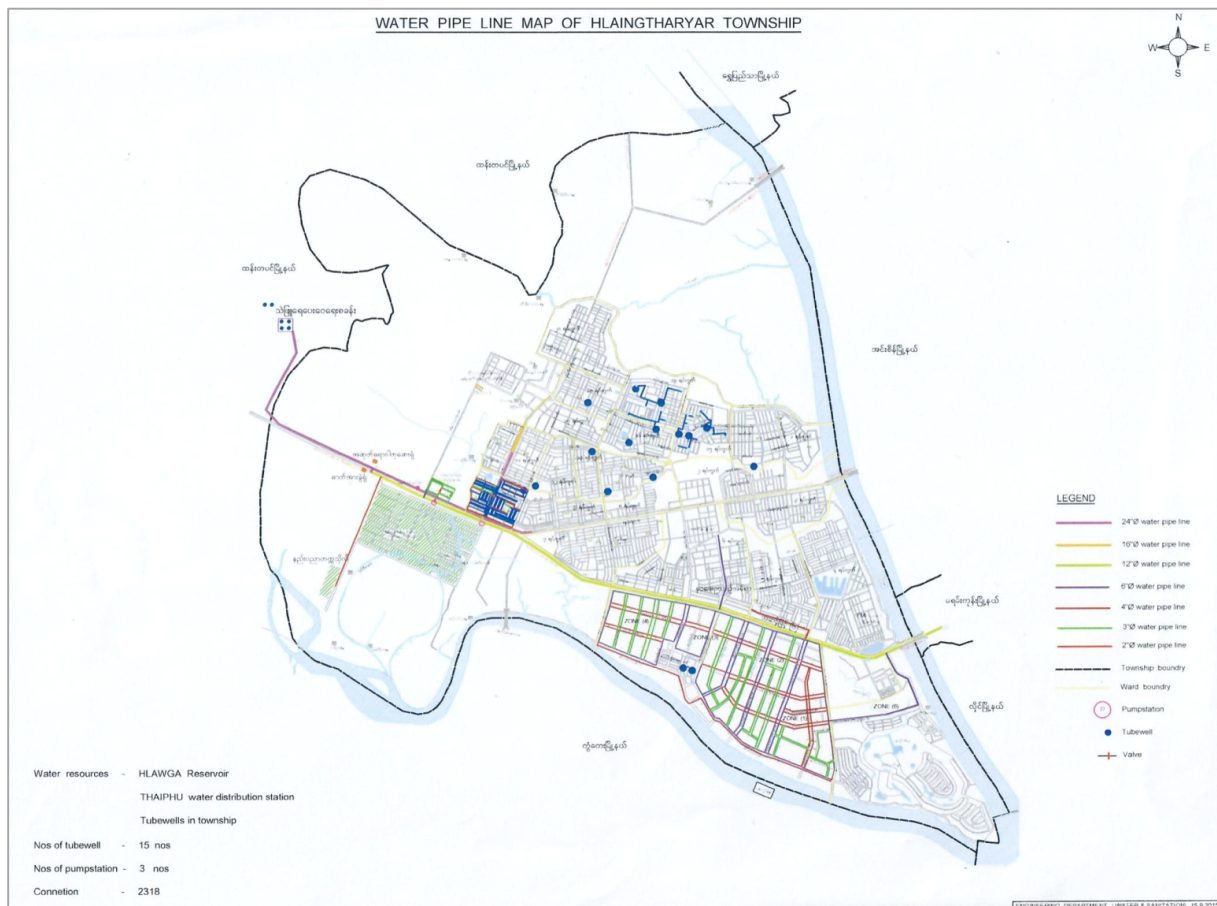
Interview guide local stakeholders

- What are the responsibilities of your department?
- Who do you report to? Who reports to you?
- Mapping water governance structure (starting from own position)
- What policies are in place to regulate water supply / pollution?
- Current situation HTIZ:
 - Water resources / users
 - Main water challenges:
 - Supply
 - Pollution
 - Causes of challenges / outcomes
- Trends / future scenario
- Possible solutions

Interview guide experts / other stakeholders

- Own role in Hlaing Tharyar Industrial Zone (projects, partnerships, etc.)
- Current situation Hlaing Tharyar:
 - Main water challenges:
 - Supply
 - Pollution
 - Causes of challenges / outcomes
- Trends / future scenario
- Possible solutions

Appendix IV: Water pipe line map of Hlaing Tharyar township



Source: YCDC W&S (2017)

Appendix V: List of industrial sectors in HTIZ

The following list indicates the sectors and the number of factories within this sector as found in HTIZ in 2017.

- Logistic & service companies (201)
- Consumer goods factories (101)
- Garment factories (91)
- Food & beverage factories (83)
- Grain, bean & pulses processing factories (56)
- Construction material factories (42)
- Chemical product factories (28)
- Forest product factories (24)
- Paper & packaging factories (22)
- Machinery parts & car assembly factories (22)
- Cold storage factories (20)
- Electrical goods factories (9)

Appendix VI: Map of 'high pollution risk' factories in HTIZ

This map of HTIZ was marked with 'high pollution risk' factories, which are all factories producing battery, paint, fertilizer, leather products or factories that are involved in painting or dying in their production process, for example dying of textiles. The factories were singled out and located by using a list of their self-stated production activities, after which the location of the factory was marked on this map. The map solely aims to give an indication of factories who are suspected to use highly polluting chemicals, however as this was not actually measured it cannot be interpreted as factual evidence.

