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Achieving water security in peri-urban Yangon: exploring the local governance processes

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Abstract

Many cities in the Global South lack the capacity to provide water security to their inhabitants. Peri-urban areas are especially vulnerable to water insecurity. This study concerns the impact of (good) governance on water security among formal and informal settlers residing in Hlaing Thar Yar Industrial Zone (HTIZ), a peri-urban area belonging to Yangon, Myanmar. Through employing mixed methods, we investigate the dynamics of water security by studying the governing processes which shape it on a local level. In HTIZ, various challenges related to water security come together. Our findings reveal that water security in HTIZ was achieved for the majority of the formal settlers, whereas this was not the case for the majority of the informal (riverbank) settlers. Although a well-organized needs-driven system of local water vendors supplied water to the local population there was a high risk of contamination by domestic pollution (e.g., *Escherichia coli*) and industrial effluent, in addition to the relatively high price of the water. The identified water insecurities were driven on an institutional level by the lack of capacity and priority given to supplying and protecting informal settlers. Absence of environmental monitoring and enforcement, and the perceptions of government officials further exacerbated water insecurity.

Keywords: Asia; Informal and formal settlers; Myanmar; Peri-urban development; Water governance; Water security; Yangon

Introduction

Providing access to safe water supply for all and assuring sustainable management of water resources is essential to achieve sustainable development, as articulated in Sustainable Development Goal 6 and the WHO/UNICEF Joint Monitoring Programme (JMP) Water Supply, Sanitation and Hygiene (WASH) targets. Although progress has been made in previous decades, over 1.1 billion people still lack access to safe water resources (UN, 2017) and 844 million people lack even a basic drinking water service (WHO/UNICEF JMP, 2017). Because of rapid population growth, poor regulation, and

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lack of basic infrastructure, water insecurity is increasingly becoming an urban problem in the Global South (UN-Habitat, 2012).

By 2050 between 50 and 70% of the population in Asia and Africa will be urban (UN DESA, 2015). Rapid urbanization and urban expansion in the Global South often occur on cities' peripheries and/or peri-urban areas (Narain *et al.*, 2013; Mehta *et al.*, 2014). Many studies argue that peri-urban areas are especially vulnerable to water insecurity (Allen *et al.*, 2006; Bakker *et al.*, 2008; Narain *et al.*, 2013; Peloso & Morinville, 2014). There are multiple reasons for this. Many peri-urban areas are either insufficiently connected or not connected at all to official water supply and sanitation systems, water-intensive industries located in peri-urban areas contribute to pollution, and peri-urban residents often lack the means of making their households water secure (Allen, 2003; Binns *et al.*, 2003; Allen *et al.*, 2006; Narain *et al.*, 2013; Adams & Zulu, 2015). At the same time, peri-urban areas attract many poor city dwellers and rural migrants – due to new employment opportunities and relatively low living costs – as well as (polluting) industries (Binns *et al.*, 2003; Narain *et al.*, 2013; Mehta *et al.*, 2014). These new stakeholders often have to compete with local residents and private stakeholders for already scarce water resources (Parkinson & Tayler, 2003; Allen *et al.*, 2006).

The key challenge in this study is to determine what factors shape water insecurity, so to what extent water insecurity is caused by a lack of capacity or whether there is *also* a lack of political will or priority to improve the water security in peri-urban areas of a city. What is the impact of good water governance (or the lack of) on water security in peri-urban areas in the Global South? We investigate this in Hlaing Thar Yar Industrial Zone (HTIZ), a peri-urban area belonging to Myanmar's former capital Yangon.

HTIZ, our study area, is located in north-western Yangon and bound by the Pan Hlaing River in the south. As the largest industrial zone of Yangon, it covers over 1,000 acres and different industries operate in this area, including garment, plastics, and food and beverages (MIA, 2012). In addition to the industrial use, HTIZ, at the time of research, was inhabited by an estimated 60,000 formal and informal settlers, living in apartment blocks or huts along the roads and the Pan Hlaing riverbank. HTIZ faced various challenges related to water security. This included a lack of official water supply, limited infrastructure, flooding, and high levels of pollution due to the discharge of untreated industrial wastewater (ALARM, 2016). Hence, water insecurity posed a serious risk for both human health and ecosystems in this peri-urban area.

This study aims to gain more knowledge on the dynamics of water security in a peri-urban context by studying the local governing processes through which water security is shaped. To do this, we adopted a holistic water security approach by focusing both on processes (water governance) and outcomes (water supply and water-related risks). In this study, we address three research questions (RQs): what are the characteristics and responsibilities of the different stakeholders involved in the use and governance of water in HTIZ? (RQ1); how does the local population in HTIZ experience water insecurity? (RQ2); and what are the institutional drivers and barriers of water security in HTIZ? (RQ3).

Literature review

Defining the 'peri-urban'

There is currently no universal definition of peri-urban areas or localities (Simon, 2008). Regardless, we identify peri-urban areas in the Global South as spaces at the periphery of (large) cities where urban

expansion takes place (Narain *et al.*, 2013). These areas are predominantly unplanned settlements, which are characterized by low incomes, marginalized or disenfranchised communities, overcrowding, and lack of basic services such as safe water supply and sanitation (Musa *et al.*, 1999; Peloso & Morinville, 2014; Adams & Zulu, 2015). Peri-urban areas are further characterized by their mixed land use (industrial, residential, landfill, and agricultural) by a wide range of stakeholders (formal and informal settlers, (transnational) companies, farmers, migrants, government agencies, etc.) (Binns *et al.*, 2003; Simon, 2008; Narain *et al.*, 2013). Achieving access to improved water sources, as defined by the WHO/UNICEF JMP (2017). in peri-urban areas in the Global South is far from realized (Simon, 2008; Narain *et al.*, 2013; Starkl *et al.*, 2013; Peloso & Morinville, 2014; Adams & Zulu, 2015). Mehta *et al.* (2014) state that urbanization and peri-urbanism in the Global South have even challenged the model of universal water and sanitation provision. There are multiple factors which hamper water security in peri-urban areas. Before we discuss these factors, we first elucidate the concepts of water governance and security.

Water governance and security: process and outcome

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 (Rogers & Hall, 2003; Franks & Cleaver, 2007; OECD, 2015). For the water sector this meant a global shift from addressing water shortages solely with technical and large-scale solutions to more decentralized water governance, focusing on small-scale and context-specific solutions (Allen, 2003; Marston, 2014). In this study, water governance is 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: p. 7). Building upon this definition, water governance is thus the process through which water resources are governed. Nonetheless, within the water governance literature the outcome of this process is analyzed 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 (Rogers & Hall, 2003; Cook & Bakker, 2011; Bakker, 2012; Bakker & Morinville, 2013). However, relatively little attention is given to how these outcomes can be achieved and which barriers prevent the desired water governance outcome (Lall *et al.*, 2017). As this study concerns the governance dimensions shaping water security on the local level, we will now turn our focus to the concept of water security.

Exploring the dimensions of water security in a peri-urban context

Within the water governance literature, the concept of water security has gained more momentum over the past decade (Srinivasan *et al.*, 2017). This concept concerns the access to and risks of water for both humans as well as ecosystems (Grey & Sadoff, 2007; Cook & Bakker, 2011; Bakker, 2012; Norman *et al.*, 2013). Within this study, we adopt the definition of Bakker (2012; p. 914) 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'. This definition is most holistic in the sense that it recognizes both the risks induced by water (i.e., pollution and flooding) as well as the needs for water of different actors and

systems (i.e., water supply). We apply this definition on the community level, herewith mainly focusing on the human system.

Whereas access to a safe water supply is sometimes framed as a human right, other scholars argue for water as a marketable good (see also Mehta *et al.*, 2014). This distinction also forms the basis of the public versus private water provision debate, in which the relative advantages of providing water through public means or market mechanisms are discussed (Galiani *et al.*, 2005). Some scholars argue that the public–private distinction is too narrow and highlight the wide range of formal and informal water supply arrangements (Allen *et al.*, 2006; Bakker *et al.*, 2008; Marston, 2014). Allen *et al.* (2006) identified a wide spectrum of different water supply systems, divided into 'policy' (formal) and 'needs' (informal) driven water supply. Ideally, policy-driven systems should meet all the needs of its residents, but in the Global South this is often not the case (WHO/UNICEF JMP, 2017). Especially in peri-urban areas, the policy-driven water supply system fails to meet local water needs, resulting in a mix of policy and needs-driven water supply systems (Allen *et al.*, 2006; Bakker *et al.*, 2008; Peloso & Morinville, 2014). These alternative systems are the result of various institutional and household barriers that prevent peri-urban residents from accessing policy-driven water supply (Satterthwaite, 2003; Bakker *et al.*, 2008; Orgill *et al.*, 2013). Institutional barriers include: poor or lack of piped-water infrastructure; lack of financial incentives to supply safe water to peri-urban areas; lack of clear responsibilities among stakeholders; inadequate financial resources; jurisdictional overlaps and ambiguities; and lack of political will to improve the water security situation due to the perceived 'illegality' or 'temporality' of peri-urban residents (Starkl *et al.*, 2013; Mehta *et al.*, 2014; Adams & Zulu, 2015).

Water pollution is also considered a major water governance challenge. This is especially the case in highly populated and industrial (peri-)urban areas. Water pollution is caused by rapid urbanization and industrialization, as well as a lack of effective governance to control these potential sources of pollution (Satterthwaite, 2003). Various studies have shown that both domestic and industrial water pollution severely threaten coupled human–environmental systems in peri-urban areas (Musa *et al.*, 1999; Binns *et al.*, 2003; Simon, 2008). First of all, many peri-urban areas are used as dumping grounds for urban waste, and they attract polluting industries (Narain *et al.*, 2013). Additionally, poor regulation and the discharge of untreated industrial waste, containing various hazardous chemicals and heavy metals, increase the risk of industrial water pollution (Starkl *et al.*, 2013). Second, increased population numbers 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 (Simon, 2008). The provision of sanitary services and the resulting degree of water pollution in (peri-)urban areas are outcomes of the governance process and the different development priorities, perceptions, and values of actors involved in this process (Binns *et al.*, 2003; Allen *et al.*, 2006). As policy-driven sanitary facilities and sewage systems are still absent in many peri-urban areas in the Global South, alternative needs-driven systems are often used instead (Allen *et al.*, 2006).

Lastly, urban flooding is a major water security 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 types of urban flooding can be attributed to a variety of factors, including: climate change, high population density, expansive informal settlements (such as peri-urban areas), living in flood-prone areas, poor housing structures, and a lack of adequate infrastructure (Satterthwaite, 2003; Tanner *et al.*, 2009). Flood risk is also an outcome of governance and institutional factors. Very

often, marginalized (peri-urban) communities in a city face a higher flood risk than other urban residents due to a lack of inclusion in the flood control infrastructure (Liao *et al.*, 2019).

Methods and research area

Methods and data analysis

The data for this study were collected through a mixed-method approach, combining qualitative, participatory, and quantitative research methods, which include: household surveys ($n = 65$), a focus group discussion ($n = 40$), in-depth stakeholder and expert interviews ($n = 17$), and the analysis of secondary documents. The research was conducted from March to May 2017 with the help of local graduate students.

First, a quota sampling strategy has been applied for the surveys in order to be able to compare different groups of settlers in HTIZ. The three groups that we selected were: formal settlers living in apartments in Yay Oakkan village ($n = 20$); informal settlers living along the roadside in HTIZ ($n = 20$); and informal settlers living on the Pan Hlaing riverbank in HTIZ ($n = 25$). Within a certain geographical area, the households were randomly selected by approaching people living in every fifth house. The quantitative data were analyzed with SPSS by using descriptive statistics, frequency tests, Pearson's R, and ANOVA tests.

Second, a two hour-long focus group discussion (FGD) was organized in HTIZ among 40 household representatives. The FGD 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 by water insecurity. The selection of participants in the FGD was based on the participants' socioeconomic status (poor and less poor households) and gender (women and men), this to ensure that a variety of opinions was represented. The participants were selected with the help of the informal village head. The FGD was carried out together with three local graduate students, and it consisted of multiple rounds. Participants were first subdivided in groups to discuss water security issues in their respective village, before they presented their findings to the whole group.

Third, we interviewed 17 stakeholders and experts, ranging from relevant government agencies to non-governmental organizations (NGOs), and industries in HTIZ to village heads. The topic lists mainly dealt with measuring perceptions and attitudes towards water security, and insights on water governance structures and processes. Lastly, we analyzed secondary documents, such as NGO reports, policy documents and data sources from the national and regional government (national policies, Yangon City Development Committee regulations/reports, etc.). The NGO reports (e.g., ALARM, 2016; WaterAid, 2016) were used to supplement our findings with data on pollution in HTIZ. The secondary document analysis was also conducted to understand the relevant laws, water policies, and regulations in Myanmar (HTIZ in particular), and to achieve data triangulation.

RQ1 and RQ3 of this study primarily concern stakeholders and responsibilities, policies and regulations, capacity of institutions, development priorities, perceptions, land-use, and socioeconomic indicators to identify HTIZ's water governance structure as well as institutional drivers and barriers. RQ2 focuses on access to safe water supply (sources, quality, quantity, and affordability of water), water pollution (experienced water pollution, water pollution parameters, and solid and liquid waste collection systems), and flooding (incidences and height of flooding events, and impacts). The effects of

water security on local households are described qualitatively as it is beyond the scope of this study to investigate the extent and livelihood outcomes of water insecurity among local households in more detail.

Research context and area

Yangon was the capital city of Myanmar until 2006 and is still considered the socioeconomic hub of Myanmar. 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). In 2015, around 91.9% and 77.3% of the households in Yangon had access to improved sanitation facilities and improved sources of drinking water, respectively (Department of Population Myanmar, 2015). Despite the relative wealth in Yangon compared to other areas, the former capital faces various challenges related to rapid urbanization rates and increased economic and industrial activities (Forbes, 2016; World Bank, 2017). One of these challenges is the rapid growth of informal settlement pockets in Yangon, which are often places where the urban poor settle and where infrastructure is lacking. A majority of these informal settlements in Yangon are peri-urban (Forbes, 2016). UN-Habitat (2017) identified a total of 423 informal settlements in Yangon city. These settlements in total, cover 1.23% of the land area and are estimated to house 6–8% of the population of Yangon. Although many of these settlements face severe water insecurity, WASH interventions in Myanmar continue to primarily focus on rural areas (Meehan, 2010).

HTIZ is a peri-urban area located in Hlaing Thar Yar township, which is the most highly populated township located in north-west Yangon (16.8819° N, 96.0573° E). 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 reality. UN-Habitat (2017) estimated that 124,325 people lived in informal settlements in Hlaing Thar Yar, which makes it one of the townships with the highest degree of informal settlers in Yangon. HTIZ was chosen as the study area based on criteria that are generally considered to be challenging environments for peri-urban areas to ensure water security: a high population density; the existence of different 'settlement' types (including informal and unplanned settlements); different types of land use by a wide range of stakeholders; a high degree of industrialization; and low infrastructure coverage.

Results

Stakeholders and water governance in HTIZ

Government agencies. In Myanmar different institutions are responsible for governing water resources on both national, regional, and city level. Figure 1 highlights the different government agencies influencing the governance of water resources in Yangon and specifically HTIZ. The figure shows that next to the union government agencies and the region government ministries, the Yangon City Development Committee (YCDC) can be considered the direct service provider for Yangon city, although responsibilities are not always clearly divided (UNDP Myanmar, 2015).

At city level, the YCDC Water and Sanitation Department (W&S) and the YCDC Pollution Control and Cleansing Department (PCCD) both perform key functions related to delivering water security. YCDC W&S is responsible for water supply and installed 13 tube wells in Hlaing Thar Yar township,

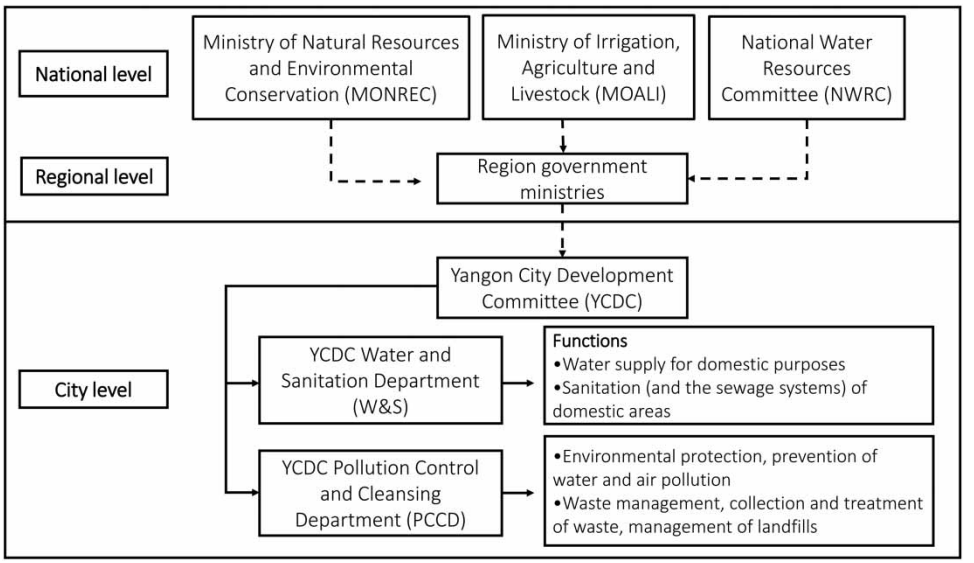

Fig. 1. Government agencies and responsibilities.

of which, two are located in Yak Oakkan in HTIZ (Figure 2). Due to the low quality and quantity of the groundwater from the official YCDC tube wells, this water resource was not the main source used by residents of HTIZ. Next to the tube wells an official water pipeline network was connected to the different factories in HTIZ (Figure 2). The water supplied through these pipelines originated from the Hlawga reservoir and the Thaephyu water treatment plant. However, due to decreasing pressure of water supply over time as a result of the extension of the pipeline network, the large majority of factories in HTIZ did not use the official water supply network for their production processes (interview with YCDC W&S official).

YCDC PCCD is responsible for monitoring (water) pollution control, following the National Environmental Guidelines of 2015 (YCDC, 2014). In Hlaing Thar Yar township, the YCDC PCCD had one local office responsible for the implementation of regulations. In order to control water pollution in HTIZ the YCDC PCCD was responsible for giving out and renewing the licenses of the factories in this area, which had to be done on a yearly basis. Also, waste collection in HTIZ came under the responsibility of YCDC PCCD; solid waste was collected from factories twice a week (Tuesday and Friday), and hazardous waste was collected on an ad hoc basis (interview with YCDC PCCD).

Industry. At the time of research, HTIZ consisted of 695 factories from a wide variety of sectors. Garment, food and beverages, paper and pulp, and plastics are among the largest sectors operating in HTIZ. Around 60 factories were a result of foreign direct investment (FDI), mainly from Asian countries such as Japan, China, and Korea. The industry, being organized and represented as the HTIZ Management Committee (HTIZ MC), is another key stakeholder in the governance and use of water resources in HTIZ.

The HTIZ MC was established by the YCDC in 1997 and consisted of land and factory owners operating in the peri-urban area. It can thus be characterized as a group of industry representatives that have

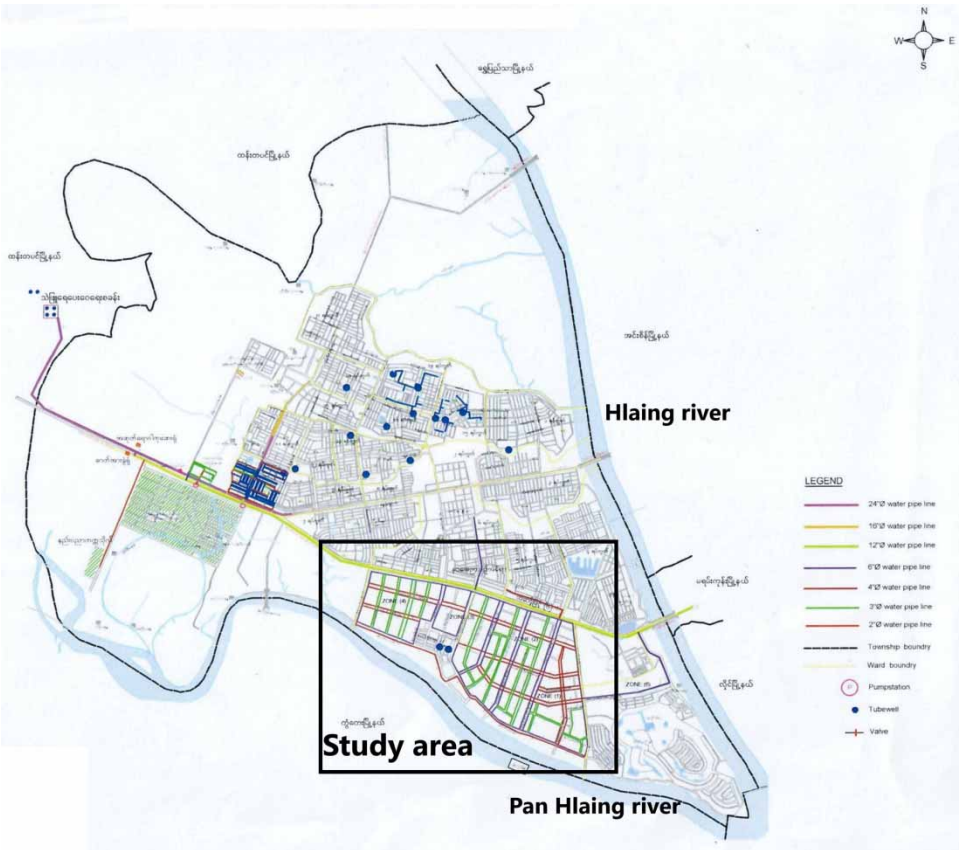

Fig. 2. Water pipe line map of Hlaing Thar Yar township (*Source*: YCDC W&S, 2017; adjusted by authors). *Note:* The dots are tube wells, and the lines show the water pipeline network.

been appointed to perform some of the governance tasks in HTIZ. The Committee was responsible for the maintenance of the infrastructure of the industrial zone, which included the roads, the drainage system, and industrial water supply. Furthermore, the HTIZ MC formed a 'bridge between the government and the industry' (interview with HTIZ MC member), as it created the possibility to communicate and mediate between these two stakeholders. Although YCDC and the HTIZ MC represented different interests, they also collaborated in terms of governing and maintaining HTIZ. Whereas YCDC was responsible for drafting policy and regulations, the HTIZ MC could only implement them and articulate their concerns and perceived challenges.

Water supply to factories in HTIZ officially fell under the responsibility of the HTIZ MC. However, as the official water supply was not able to cope with the demands from industry, the main source of water used by the factories was groundwater. In the absence of a central industrial wastewater plant in HTIZ, factories were individually responsible for wastewater treatment and the maintenance of the drain next to their respective properties. Lastly, factories were required to provide effluent samples to the office of the YCDC PCCD instead of being audited in the factories (interview with HTIZ MC member). Consequently, this made pollution control in HTIZ highly susceptible to fraud.

Local communities. Although HTIZ was 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. Before the establishment of HTIZ, the area was mainly used for agricultural purposes. With the formation of the industrial zone three formal settlements were established in 1995 as designated domestic areas: Yay Oakkan, Nyaung U, and Daing Zu. Farmers residing in the area were resettled to the three villages and were offered compensation in the form of land and money. During the past decade, most of the houses in Yay Oakkan have been transformed into concrete apartment blocks. Within Yay Oakkan a distinction can be made between hostels, in which workers of factories are housed with no or minimal payment for rent, and apartments, which are rented out or privately owned by families.

HTIZ saw a growth in migrants since 2008 due to cyclone Nargis, rural-to-urban migration, and migration within Yangon due to higher rent and living costs. According to our survey findings, the main motivation for people to move to HTIZ was work opportunities (80.3%). A majority of the migrants started to settle along the roadside or in close proximity to the factories. As these settlers were never officially granted permission to occupy these lands they were categorized as informal settlers or squatters. Next to the informal roadside settlements a new pocket of informal settlements developed along the Pan Hlaing riverbank in HTIZ. Satellite images from previous years show that due to sedimentation of the Pan Hlaing river, the riverbank gradually grew and therefore became a more attractive 'empty' land for people to settle. As a result of this, there has been a sudden influx of people moving into these riverbank lands since 2013. Currently, these informal settlements on the Pan Hlaing riverbank can be divided into four villages. The majority of the informal riverbank survey respondents lived in houses made out of bamboo (76%) and had a palm leaf roof (68%); only the wealthier settlers were able to afford a wooden floor (24%) or a roof made out of corrugated sheets (32%).

Informal settlers in HTIZ were generally poorer than formal settlers and lived in a precarious situation. Households of formal settlers averagely earned 12.42 USD a day, whereas informal roadside and riverbank settlers earned 8.26 USD and 7.97 USD, respectively. The City of Yangon Development Law (article 7e; SLORC, 1990) considers informal settlements as places which eventually need to be demolished and in which inhabitants (often defined as 'professional' squatters) need to be resettled. Hence, the YCDC did not seem to consider the informal settlements in HTIZ as a priority area for development (e.g., water security or infrastructural improvement).

Formal settlers have different ways of asserting influencing power. One obvious way is through voting for regional or national elections, which has become possible in recent years due to the democratization process. Furthermore, the formal settlers in Yay Oakkan village were represented through a village head and on a higher level by the township officer of Hlaing Thar Yar. Informal settlers had less influence due to the fact that they could not always vote (50% of the households in our FGD claimed that they could not vote due to not having an identity card) and there was not always a village head in their respective villages. Only a few riverbank villages had an informal village head, who, in turn, lacked recognition from the government (FGD with informal residents). Next to power that citizens can assert in terms of the governance process, there was also a group of citizens who made a living as local water vendors. These vendors constituted an important needs-driven institution influencing water security and governance in HTIZ.

Access to safe water in HTIZ

Current situation of water supply in HTIZ. 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, and cleaning). Within HTIZ, a distinction can be made between the six water resources that were used by the local population (Table 1). Bottled water came in two forms, sealed and not sealed. The former type was premium bottled water sold by outside water vendors, whereas the latter was sourced from local factory boreholes or YCDC pipelines being sold by local water vendors. Local water vendors also sold tank water which came from similar sources as unsealed bottled water but also from private tube wells. Households extracted ground, rain, and river/pond water (primarily from Pan Hlaing river) mostly by themselves.

Table 1. Water supply indicators of survey respondents in HTIZ.

Dimensions		Description
Ranking of water resources used by all households (%)	*Cold and dry season*	Drinking: • Tank water (61.5) • Bottled water (seal) (24.6) • Bottled water (no seal) (13.9) Cooking: • Tank water (67.7) • Groundwater (24.6) • Bottled water (no seal) (6.2) Washing and sanitation: • Groundwater (90.8) • Tank water (4.6) • River/pond water (4.6)
	Rainy season	Drinking: • Same sources as above (55.4) • Rainwater (44.6) Cooking: • Rainwater (63.1) • Same sources as above (26.9) Washing and sanitation: • Rainwater (67.7) • Same sources as above (32.3)
Sources of drinking water used during dry season (%)	*Formal*	Bottled water (seal) (75) Bottled water (no seal) (15) Tank water (10)
	Informal (roadside)	Bottled water (seal) (5) Bottled water (no seal) (10) Tank water (85)
	Informal (riverbank)	Bottled water (no seal) (16) Tank water (84)
Affordability of water in USD (% of total household expenditure)	*Formal*	0.31 USD (2.30)
	Informal (roadside)	0.17 USD (5.79)
	Informal (riverbank)	0.18 USD (6.01)

Note: Conversion rate of 1 USD = 1359.75 MMK (as on 07/06/2017).

The results in Table 1 show that within the cold and dry season (October to June), tank water was the main source used for both drinking as well as cooking. Furthermore, the large majority of the population used groundwater extracted through tube wells as the main source for washing and sanitation. During the rainy season (June to October), it was striking to note that the majority of people used rainwater for cooking and washing, however less than half used it for drinking. The main reasons provided for not using rainwater were: lack of demand (mainly among formal settlers); lack of rainwater collection devices; and perceived lower quality of rainwater. Differentiating among formal and informal settlers, informal settlers mainly used drinking water from unsafe sources such as tank water and unsealed bottled water, whereas formal settlers largely used sealed bottled drinking water. While formal settlers significantly paid more for their drinking water (one-way ANOVA, $p = 0.00$) than informal settlers, their expenditure for drinking water relative to their total household expenditure was much lower (Table 1). Riverbank informal settlers' relative expenditure for drinking water was highest (6.01%). One reason was that local water vendors charged these settlers more due to their geographic remoteness and distance from the main roads.

In terms of water quantity, households used an average of 6.3 liters of water per person a day and it was considered sufficient by most households. The respondents indicated that water shortage could occur during both dry and rainy seasons. During the latter, flooding made it impossible for water vendors to reach some houses in the informal riverbank settlements. Assessing the quality of different water resources in Hlaing Thar Yar in 2016, the NGO WaterAid (2016) reported that 61.2% of the samples contained Escherichia coli (*E. coli*) bacteria, of which 4.8% were considered unsafe and 38.1% as high risk/probably unsafe. Only sealed bottled water contained a safe level of *E. coli* for all samples. All tank water samples contained unsafe levels of *E. coli*. Lastly, 20% of rainwater was found to be unsafe, 60% high risk, and 20% as intermediate risk (WaterAid, 2016).

Impacts and institutional drivers/barriers. The lack of access to safe water causes serious health implications, both short and long term. According to WaterAid (2016: p. 19), drinking unsafe water is 'likely to result in significant and chronic illness with sustained use of the source and no 'point of use' treatment'. The survey respondents acknowledged that they only treated their tank and unsealed water using a simple cloth. Only one household boiled the water before drinking. Hence, most informal settlers, and especially their children, faced serious health risks in HTIZ due to the use of contaminated water and lack of effective treatment methods. In terms of coping with water shortage, households in our survey relied on their social networks, bought water in other areas of the city, or obtained interest-free credit from local water vendors.

The lack of capacity within the YCDC made it difficult to supply Yangon city, and especially its peri-urban areas, with water. The old and limited pipeline infrastructure, the low number of water reservoirs, and the lack of financial resources to improve these systems were 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 was also attributed to low water pricing:

> '*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*'.

The limited extension of the network to peri-urban areas such as HTIZ was furthermore related to the lack of priority given to these areas. When new water reservoirs are constructed, most of the water is planned to go to the more central townships of Yangon or is designated to serve new towns that still need to be developed. One of the reasons for not prioritizing areas like HTIZ was that it was not considered a 'domestic' area; the area was designated for industrial purposes. On the other hand, the influx of settlers over the years has dramatically changed the character of HTIZ from a solely industrial to mixed industrial–residential area. The second argument for not addressing local water needs in HTIZ was that its informal settlers did not legally reside in the area. They were considered to be 'illegal' settlers and hence considered a temporary 'issue' that had to be dealt with at a later stage. Therefore, there was no priority or need by government agencies, such as YCDC, to actually extend infrastructure and services to these people.

Lastly, there was little awareness about the possible risks of utilizing water that may be contaminated. Both households as well as government agencies, like YCDC, did not consider the current quality as a serious 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 from a government official of YCDC W&S:

> '*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.* […] *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*'.

Although the government thus knew that some water resources were contaminated, it was not considered a high risk for health as people were presumed to be 'used' to these bacteria. Furthermore, it showcases the incorrect perception that most people were able to buy bottled water. Contrarily, our findings show that many informal settlers did use unsafe resources for drinking as they would often buy unsealed bottled or tank water, which contained (contaminated) YCDC tap water.

As outlined in this section, an alternative system of local water vendors took over the role of formal (or policy-driven) service supply systems. Although this needs-driven system was working relatively well in terms of serving the urban poor, there was no quality control of the water resources sold (as shown by WaterAid, 2016). This lack of regulation therefore substantially increased the risk of unsafe water supply to customers, who mainly consisted of informal settlers.

Water-related risks in HTIZ

Industrial and domestic water pollution in HTIZ. Due to intensive industrial activity in HTIZ, water pollution induced by the discharge of insufficiently treated industrial wastewater was a major risk in this area. According to the 2015 Environmental Guidelines, all factories in HTIZ are required to have a wastewater treatment plant on their plots in order to treat the wastewater produced. However, as shown in Table 2, the majority of factories discharged their insufficiently treated effluent water in the drainage system, which then runs through seven outlets into the Pan Hlaing river. Evidence of this industrial water pollution can already be found within HTIZ. Many households stated to have witnessed signs of industrial pollution, as the water in the drainages or next to their house had a strange

Table 2. Exposure to water pollution and indicators in HTIZ.

Dimensions	Exposure	Indicators/Parameters
Industrial water pollution	Discharge of toxic wastewater due to only an estimated 10–20% of all factories having a properly working treatment plant.	Surface water of Pan Hlaing and Hlaing river (4 sampling points): • Parameters above limit: BOD; chloride; iron; lead; cadmium; and copper (sometimes) Groundwater from local tube wells (6 sampling points): • Parameters above limit: pH (in acid range); BOD; chloride; iron; lead; cadmium; copper (sometimes) and arsenic (sometimes) Water in the drainage canals in HTIZ (7 sampling points): • Parameters above limit: BOD (except point 7), chloride (except during rainy season); lead and iron (sometimes). (Source: ALARM, 2016)
Domestic water pollution	Large amounts of garbage throughout HTIZ, often piled up on dumping sites but also scattered throughout Yay Oakkan, along the roads and in the drainage system. Only 9.2% of the garbage is collected either by the army or private collector. Disposal of domestic liquid waste.	Formal settlers: • Disposal of solid waste on dumping site (65%) • Use of flush/pour flush toilet (85%) Informal settlers (roadside): • Disposal of solid waste on dumping site (80%) • Use of pit latrine (hole in ground) (70%) Informal settlers (riverbank): • Disposal of solid waste in water next to house (88%) • Use of pit latrine (hanging, disposal in the river) (88%)

Source: ALARM, 2016 and survey data.

color (blue, purple, black) or a chemical smell (e.g., paint or shampoo). A village head of an informal riverbank village proclaimed: '*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 color comes from the factory next to the wall, which is doing printing of paper and plastics*'.

A study of ALARM (conducted from 2013 to 2016) furthermore confirmed households' observations that most of the water sources in HTIZ were polluted (Table 2). Notable were the high levels of biochemical oxygen demand (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, were directly related to industrial pollution.

Another source of pollution of the water resources in HTIZ was domestic waste, both solid and liquid. Whereas there was a waste collection system in place to collect solid waste of the factories, the YCDC PCCD did not systematically collect waste from the 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 national army, incidentally, cleaned up dumping sites in Yay Oakkan. Among some informal pockets in Yay Oakkan, a needs-driven institution, in the form of private collectors, collected household waste for 0.14 USD per bag. However, Table 2 shows that, especially informal riverbank settlers discharge their solid waste in the river, causing waste in the drainages every year. As a

consequence, the HTIZ MC had to spend around 10,000 USD a year to clear all the waste in the drainages. Concerning liquid waste, lack of improved sanitation facilities further added to pollution in HTIZ (hence the high levels of *E. coli* contamination). Due to the fact that a majority of the informal riverbank settlers lacked access to (improved) sanitation facilities, most of their liquid waste would be simply disposed of in the river (Table 2).

Flooding in HTIZ. Households in HTIZ experienced flooding in varying degrees (Figure 3) and due to various reasons. Formal and roadside settlers were mainly exposed to low level flooding as a result of drainage blockage due to solid waste, a lack of drainage, and heavy rainfall. The informal riverbank settlers, on the other hand, were exposed to high levels of flooding as a result of tidal flooding and rainfall (Figure 3). Even during the dry season, many of the roads in the informal settlements were flooded twice a day, resulting in very muddy and slippery roads as they were rarely paved. During the rainy season, flooding was an even bigger challenge; the highest level of flooding ranged from 20 cm to 210 cm. These high flood levels resulted in inundation of roads and sometimes also houses.

Regular exposure to flooding had severe health (i.e., malaria, dengue, diarrhea, fever, and poisonous snakes) and financial (property or infrastructure damage) implications. It also restricted households' mobility and exacerbated water insecurity. Many households in riverbank villages indicated that local water vendors were not able to reach their household at times of serious flooding. Informal settlers living on the riverbank were most exposed to flooding in terms of the level and incidences (Figure 3). They mainly lived in flood-prone locations along the riverbank and they occupied relatively poor housing structures. Additionally, people living further away from the paved road experienced significant higher levels of flooding ($r = -0.885$, $p = 0.00$, $n = 47$) as a result of tidal flooding of the Pan Hlaing river. There was also a non-causal relationship between the households that bought lower quality water (reflected in the price per bottle) and the level of flooding ($r = -0.285$, $p = 0.06$, $n = 45$). This

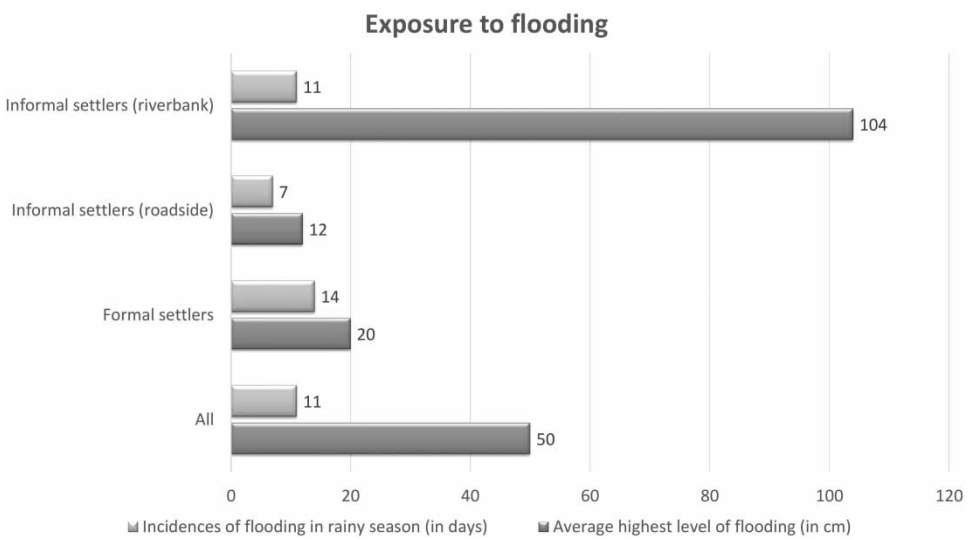

Fig. 3. Exposure to flooding in HTIZ.

indicates that households that were unable to access safe water resources were also more exposed to water-related risks such as flooding.

Institutional drivers and barriers. Water pollution and flooding constituted a significant governance challenge to HTIZ. The heavy metals, chemicals, and organic waste found in the different water resources in HTIZ as well as flooding posed a serious health concern to households in HTIZ, and informal settlers in particular. A direct cause of industrial pollution was the discharge of insufficiently treated effluent of factories. According to the industry, these practices were the result of various (institutional) barriers. First, most of the (local) factories did not have the resources (i.e., financial and land) to install a wastewater treatment plant on their own plot. Second, the industry claimed that they lacked the technical know-how to actually operate and maintain these wastewater treatment plants effectively. Lastly, there were few incentives for the industry to adhere to the 2015 Environmental Guidelines, as enforcement by the YCDC PCCD was lacking. All factories were asked to bring a sample of their 'treated' wastewater to the YCDC PCCD; however, it was not possible for the YCDC PCCD to trace the actual source of water that was brought in for testing. The YCDC PCCD stated that they did not have the capacity to conduct thorough monitoring due to lack of human, financial, and technical resources within the department. In the past, households in HTIZ did complain to the factories and relevant authorities about pollution, but this did not lead to any evident improvements.

Domestic pollution in HTIZ was driven by two factors: the absence of a domestic solid waste collection system and improper sanitation infrastructure, mainly among informal settlements. Although YCDC PCCD was in charge of solid waste collection in Yangon city, they did not extend their services to the population of HTIZ. A needs-driven institution, in the form of informal waste collectors, did appear, but these collectors mainly disposed of household waste on nearby dumping sites. The inadequate state of the solid waste collection system and sanitary infrastructure in informal settlements was the result of the low priority given to provide services to informal settlers, as discussed in previous sections. They were not considered to come under the responsibility and jurisdiction of the YCDC. Hence, they were expected to depend on their own ability to construct waste disposal and sanitation facilities.

The above-mentioned institutional drivers of water pollution largely applied to urban flooding in HTIZ. In addition, the YCDC PCCD transferred the responsibility of constructing and maintaining the drainage system to the HTIZ MC, who mainly focused on the industrial needs. Hence, domestic infrastructure needs have been largely neglected in HTIZ by both the government and industry.

Discussion and conclusion

In this study we highlighted that HTIZ, and other informal and peri-urban areas in Hlaing Thar Yar township and elsewhere in Myanmar were considered to be a temporary problem by the government and therefore a no priority area for improving water security. Currently, informal settlers in Hlaing Thar Yar are being forcibly relocated on a large scale without receiving fair compensation or housing (Chandran, 2019). According to Chandran (2019), the Yangon city government pledged to solve the 'squatter problem' by 2020. Human rights organizations and other NGOs fear that these forced displacement policies could undermine basic human rights and further impoverish informal settlers. Other studies on informal settlements and peri-urban development highlight similar trends

(Binns *et al.*, 2003; Allen *et al.*, 2006; Narain *et al.*, 2013; Mehta *et al.*, 2014; Adams & Zulu, 2015). This study confirmed that peri-urban areas in the Global South are contested sites which are inhabited by marginalized and disenfranchised communities, and characterized by their mixed industrial–residential land use and lack of basic services.

HTIZ faced various challenges related to water security, such as a lack of official water supply, limited infrastructure, flooding, and high levels of pollution due to the discharge of untreated industrial effluent and domestic waste. This study revealed that significant attention should be paid to formal and informal systems in peri-urban areas. First of all, formal settlers faced fewer water security-related challenges than informal settlers. Informal settlers lacked basic water and sanitation services because they were considered "illegal" by relevant government authorities. The YCDC and the industry, which was organized and represented in the HTIZ MC, wrongfully perceived HTIZ as a solely industrial area. Hence, the water governance process was essentially about the control and power over the distribution and use of water resources (Marston, 2014). This political nature is reflected in the lack of priority given to supply water and water-related services to the local population of HTIZ and the informal settlers in particular. Second, water insecurity was further exacerbated by inaccurate perceptions from YCDC officials on local residents' water security, basing them mainly on experiences of formal residents. Furthermore, the absence of environmental monitoring and the enforcement of a system highly susceptible to fraud further exacerbated water insecurities in HTIZ. Lastly, this study shows that in a context in which the formal water governance systems do not supply basic water-related services, these gaps are filled by informal and needs-driven systems (Allen *et al.*, 2006; Simon, 2008). These systems take over the supply and distribution of water resources (albeit contaminated in our study) to the local population. In HTIZ, local water vendors took on this role and herewith the local population became part of the water governance process, even though not formally recognized as such.

In term of policy recommendations, we realize that as peri-urban areas are highly dynamic, fast and adequate government responses to water insecurity are not always achievable. In the short term, however, government agencies could cooperate with needs-based institutions, such as informal water vendors and waste collectors, to ensure an acceptable level of water security and sanitation. In the longer run, government agencies could allow a policy-driven system to gradually take over, or achieve an inclusive and hybrid policy and needs-based system. Additionally, WASH interventions in Myanmar should extend their focus to peri-urban areas (Meehan, 2010). However, if the government adopts a forced displacement and resettlement approach (Chandran, 2019), the question should then be redirected to how households can receive a fair and just compensation and whether or not they will be relocated to areas where they are no longer 'illegal' and have access to basic water-related services.

In this study, we acknowledge that each aspect of water governance (the process) and water security (the outcome) could be a study on its own. However, we argue that adopting a holistic approach provides a more comprehensive picture of identifying the institutional barriers and drivers, as well as the governing processes which shape water security at local level. Peri-urban areas, and cities in the Global South more generally, will need to take up the enormous task to provide its residents basic provisioning services such as clean water. This is not only to achieve Sustainable Development Goal (SDG) 6 and associated WASH targets, but also to create healthy (SDG 3), inclusive (SDG 10), and livable cities and peri-urban areas (SDG 11), and realize robust coupled human–environmental systems (SDG 14 and 15).

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