# Assessing Cascading Effect of Typhoon on Water and Sanitation Services in Informal Settlements: A case of Barangay Catmon, Malabon City, Philippines.

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April, 2018

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Thesis submitted to the Faculty of Geo-Information Science and Earth Observation of the University of Twente in partial fulfilment of the requirements for the degree of Master of Science in Geo-Information Science and Earth Observation.
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# ABSTRACT

Urban infrastructures are critical and highly interconnected and interdependent systems of services that physically tie together metropolitan areas, communities, and neighbourhoods. When such highly inter-related systems are affected by a disaster, cascading effects may result in infrastructure systems failure. In existing research, the assessment of cascading effects has often been carried out on the web or network of major physical infrastructures present in a region. There is very limited research that assesses the impact of cascading effects on a specific infrastructure and the affected population as well. This thesis presents a method for studying cascading effects which can be applied in situations where the documented information of the hazardous event is limited.

The study presents the case of Barangay Catmon in Malabon City, a densely developed urban area, located on Manila Bay, which is exposed to various hazards. Many of Malabon's low-income households reside in informal settlements that are prone to flooding from the combined effects of land subsidence, pluvial flooding from the Tullahan River and from storm surges. Such hazards are potential causes of basic service delivery disruption. A service chain management framework is used to examine how services for water supply, sanitation, electricity and solid waste in Catmon were subject to cascading effects after typhoon Glenda (2014). Focus group discussions with informal settlers and interviews with key stakeholders were used to gather basic information on the existing status of services, and to collect local accounts of systemic disruption of services triggered by the typhoon. The data analysis shows a breakdown of the basic service system into service chain and service elements which characterise the inter-relatedness of these services. Empirical analysis reveals the temporal spread of the typhoon's cascading effects on basic services and the subsequent impacts on informal settlers that may potentially counteract their hope for sustainable improvement through the upgrading of their settlement. The analysis highlights the existence of critical service elements with substantial effects on the liveability in the informal settlement that endured well beyond the typhoon event itself. Possible strategies and actions to reduce cascading effects are highlighted. The methodology helps to identify cascading effects and to identify possible interventions to improve community resilience residing in informal settlements.

**Keywords**: *Cascading effects, water and sanitation, informal settlements, service chain management framework*

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# LIST OF ACRONYMS

| | Acronym | Full form |
|---|---|---|
| 1 | ACCORD | Assistance and Cooperation for Community Resilience and Development, Inc |
| 2 | BBT | *Bayanihan Bayan Tubig* (Cooperative endeavour for people for water) |
| 3 | CENRO | City Environment and Natural Resource Office |
| 4 | CMP | Community Mortgage Programme |
| 5 | DRRM | Disaster Risk Reduction and Management |
| 6 | EMI | Earthquake Megacities Initiatives |
| 7 | FGD | Focus Group Discussion |
| 8 | HCC | Human Cities Coalition |
| 9 | HOA | Homeowner Association |
| 10 | MWSS | Metropolitan Waterworks and Sewerage System |
| 11 | NDRRMC | National Disaster Risk Reduction and Management Council |
| 12 | STM | *Samahang Tubig Maynilad' (*Community based water management) |
| 13 | Temfacil | Temporary Support Facility |
| 14 | CARE | Cooperative for Assistance and Relief Everywhere |
| 15 | DSWD | Department of Social Welfare and Development |
| 16 | ISFs | Informal Settlers |

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# 1. INTRODUCTION

## 1.1. Background and Justification

Rapid urbanisation is increasing the world's susceptibility to natural disasters (McGee, Frittman, Ahn, & Murray, 2015). Half the world's population now lives in urban areas, and that figure is estimated to rise 70% by 2050. As the urban sprawl of rapid urbanisation expands outwards and upwards, it provides ready opportunities for hazards such as floods, storms, and earthquakes to wreak havoc (UN-HABITAT, 2003). Cities and disaster create a nexus shaping urban fabric with interconnected features, systems and flows, geographical location and natural phenomena. When a massive natural disaster strikes the city, it leaves a cascade of impacts affecting physical, spatial, environmental, socio-economical and institutional features and systems of the region (Deely, Dodman, Hardoy, & Johnson, 2010). Urban infrastructures are highly critical and interconnected system of services that physically tie together metropolitan areas, communities, and neighbourhoods, and facilitate the growth of local, regional, and national economies. These interdependent systems work together to provide the essential services of modern society (Thouret et al., 2014). Infrastructure systems including transportation, energy, water, wastewater, public health system and communication, are interdependent for their material/functional output. This interdependency partly drives the cascading effects of disasters, resulting in infrastructure system failure (Kadri, Birregah, & Chtelet, 2014). A cascading effect occurs when one critical infrastructure affects another, usually negatively, through interdependencies between them (Zimmerman & Restrepo, 2009), for example when a water supply system starts facing difficulties after a failure in the electricity supply system because the pumps are dependent on electricity (Pescaroli & Alexander, 2016). Interdependency, in this research, is defined as "a bi-directional relationship between two infrastructures through which the state of each infrastructure influences or is co-related to the state of the other"(Rinaldi, Peerenboom, & Kelly, 2001). Recent noteworthy disasters such as Hurricane Katrina, the Haiti earthquake, and the Fukushima Daiichi nuclear disaster reinforced the need for the research of how disasters can cause cascading effects, predominantly on critical infrastructures (McGee et al., 2015).

Strong initiatives have been taken up by the international humanitarian community incorporating goals to reduce disaster risk to critical infrastructure. The Sendai framework 2015-2030 emphasizes in one of the targets, "To promote resilience of new and existing critical infrastructure, including water, transportation and telecommunications infrastructure, educational facilities, hospitals and other health facilities, to ensure that they remain safe, effective and operational during and after disasters in order to provide life-saving and essential services" (UNISDR, 2015, p. 21). Global Assessment Report on Disaster Risk Reduction 2015, discusses the need of strengthening disaster preparedness by incorporating a new indicator to address the identification of critical infrastructure interdependencies and prioritisation planning for critical infrastructure recovery operations in Hyogo Framework (McGee et al., 2015, p. 32). The Swedish Civil contingency agency in 2014 developed a strategy and action plan for protecting critical infrastructure and mapping dependencies between them the last few years (Swedish Civil Contingencies Agency, 2014). The European Union also initiated a programme for the protection of critical infrastructure in member states and developed a framework to provide a necessary platform for a coherent and uniform implementation of measures to enhance the protection of critical infrastructure (Commission of the European Communities, 2006). However, disaster risk dynamics in urban settings are poorly understood and, consequently, their root causes are seldom addressed. Hence in-depth knowledge of the interdependent features of critical infrastructure and, the impact of disasters on the infrastructure and the affected community is indispensable for

mainstreaming risk reduction and building disaster resilience into urban sector work (Wamsler & Brink, 2016).

Therefore, this study focus on assessing the cascading effect on water and sanitation infrastructure, which are critical for human survival in the initial stages of a disaster emergency (UNICEF, 2016). Disaster-affected population especially children, women and elderly are more susceptible to illness and death from diseases that are often caused by lack of sanitation, inadequate safe water supplies and poor hygiene (United Nations, 2015). Water and sanitation are a highly interconnected and interdependent infrastructure, not just to each other but being dependent on several other infrastructures such as transportation, electricity, and energy to deliver the output. Hence, it becomes essential to identify the interdependencies of the water and sanitation infrastructure and its impact on the service delivery and the community dependent on these services, when disrupted massively by a natural disaster. The assessment of the cascading effects on the water and sanitation infrastructure and the disaster-affected community will allow recognising the critical points, which trigger public health challenges in a cascade causing a further socio-economic loss in different spatial and demographic extent. The research analysis further led to the identification of strategies and actions to reduce the risk of cascading effects and improve community disaster resilience.

## 1.2. Research Problem

Water and sanitation, being two of the most critical infrastructures, are lifelines for human survival. If massively disrupted, it may lead to an outbreak of public health challenges like water-borne diseases and possibly epidemics which may further lead to a humanitarian crisis. The service provided by the water and sanitation infrastructure is of utmost importance, and hence the impact of loss on this service on society makes it even more valuable. It is extremely important that water supply and sanitation services should be resilient enough to be able to withstand shocks of natural disasters, and stay functional which is essential for a speedy recovery of affected communities (Commission of the European Communities, 2006).

The cascading events caused by natural disaster vary in occurrence in time and nature of impact when compared with immediate or direct impact. Conceptually, the direct impact is easier to identify, understand and to evaluate, arising as they do from the direct impacts of disaster incidence. A direct impact can be referred as quantifiable losses such as the number of people killed and the damage to buildings, infrastructure, and natural resources. Conversely, the indirect loss is less easy to identify and can include losses which may occur at a later stage caused by a primary event of a sudden disruption. The indirect loss may have a different impact on population depending on the nature of impacts such as a decline in output or revenue, impact on the well-being of people, and disruptions of the flow of goods and services as a result of a disaster (Lange, Sjöström, & Honfi, 2015). When it comes to disaster impact on essential services, which are interconnected and interdependent, the impact may or may not appear immediately. In case the impact is not visible immediately, it is difficult to identify the damaged link in the system, which may cause system failure triggering cascading effects. In order to identify the damaged or weak critical points in water and sanitation system triggering cascading impact (Kadri et al., 2014), it has become essential to carry out an assessment of interdependency driven failure of water and sanitation infrastructure, and its impact on affected population in case of mass scale disruption (Pescaroli & Alexander, 2016).

Many growing cities around the globe are located near the coast and are constantly threatened by extreme effects of natural disasters (PAHO, 2006). Majority of such growing cities are in Asia with a high vulnerability to natural disaster especially tropical cyclones, storm surge, annual floods, heavy precipitation, earthquakes and other natural disasters. Therefore, this research study proposes to assess the cascading impact of a tropical cyclone on interdependent water and sanitation infrastructure in an urban context and to identify how cascading effects can be reduced by recommending adaptation and mitigation strategies complimented with local adaptation strategies of the target community. Cascading impact of a tropical cyclone can be reduced when appropriate measures are adopted by the hazard-prone community to mitigate the identified critical points triggering cascades of impacts. The measures will be more effective with long-

term impact if developed based on the local measure adopted by the community, supported by local administration (Anderson-Berry & King, 2005).

The study has chosen a slum community in a coastal city of Philippines to explain the cascading effects on water and sanitation infrastructure. Slum population is socially and economically vulnerable and are exposed to the high risk of impacts from hazards and disasters; they are also often denied access safe water and sanitation facilities (UNICEF, 2016). Also, recurrent disasters in disaster-prone areas have a long-term impact on slum communities, making them even more marginalised and unable to manage the devastations (Romero-Lankao et al., 2014). This research attempt to study cascading effects not only on infrastructure but also its impact on the slum community.

## 1.3. The significance of the study

Interventions to reduce the risk of cascading effects:

The result of the study could provide information on weak links or critical points which lead to aggravating cascading effects that will help the local authorities and other stakeholders to understand the different stages of cascading effects varying with time and nature of the impact. This could also help to answer questions like: Where are the weak links leading to more challenges in Water-Sanitation system? What are their characteristics? Which stage would require minimum effort and easy to apply interventions and yield maximum benefit? Which stage would need intervention from the higher level of authorities or rather policy level intervention? In fact, they need to know the types of interventions that may be needed for the different stages of cascading impact to reduce the disaster risk on water and sanitation infrastructure. It will enable city authorities and other urban actors to improve and adapt their work without negatively influencing the interconnectedness of urban risk. Furthermore, this study can provide an opportunity for future research.

## 1.4. Research objectives and research questions

**General objective**

To identify how to reduce cascading effects of typhoon/flood on water and sanitation services in a slum community.

**Specific Objectives and Research questions**

1. **To assess the existing status of utilisation of water and sanitation services in the slum community (informal settlement).**

a. What is the current availability of water and sanitation infrastructure?
b. What is the current accessibility of water and sanitation infrastructure?
c. What role other infrastructure services play in service delivery of water and sanitation?
d. How different stakeholders maintain a functional water and sanitation services for the slum community

2. **To assess cascading effects on water and sanitation services triggered by typhoon/flood events.**

a. How do cascading effects cause the failure of water and sanitation services?
b. How is the slum community affected by cascading effects?
c. What are the factors and actions exacerbating the impacts of cascading effects?

3. **To identify strategies and actions to reduce the impact of cascading effects and improve community resilience.**

a. What are the slum community's current actions to reduce the impact of typhoon/floods?
b. What are the regulations and practices local and government and non-government organisations to typhoon/floods in the study area?
c. What actions and strategies could be adopted to reduce the impact of cascading effects?

## 1.5. Research Innovation

There are critical or weak points in the interdependent water and sanitation infrastructure which causes more damage by triggering cascading impact. Critical points here can be called as those links or parts in an infrastructure system which when are affected by a sudden shock triggers events causing more damage. If the critical points in water and sanitation infrastructure can be identified about socio-economic dynamics within the urban fabric or the community chosen for the study, the weak links can be strengthened by the authorities or in collaboration with the local community. Possible measures can then be adopted without hampering the interdependency of the concerned system as well associated system providing functional support.

## 1.6. Methodological Outline

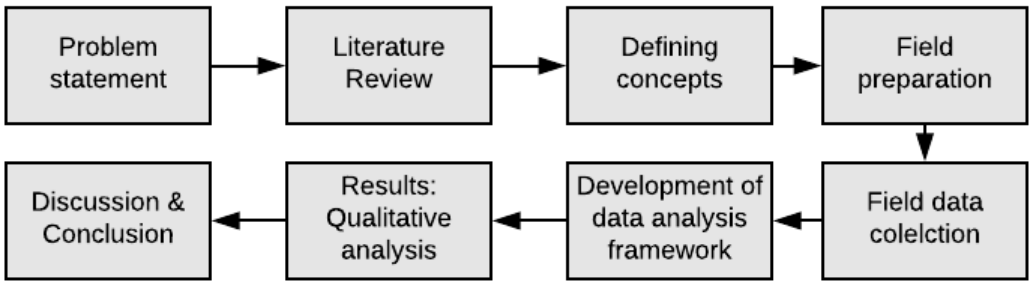



Figure 1: Research outline Source: Own draft

This research thesis is exploratory research as it attempts to study cascading effect on water and sanitation infrastructure triggered by typhoon/flood and its impact on slum community. Concepts of cascading effect, critical infrastructure and interdependency of infrastructure have been studied extensively separately and about each other. This further facilitated in defining concepts significant for the study and helped in developing the conceptual framework, relevant research objectives, and research questions. The appropriate site was selected and prepared for field data collection for primary and secondary data. Data analysis framework was developed to analyse collected data using a qualitative approach to derive results. The obtained results are then discussed, followed by a conclusion drawn by reflecting upon linking once again to the broader context. The process followed throughout the research can be viewed in figure1.

## 1.7. Outline of the thesis

**Chapter 1: Introduction**

This chapter gives a brief introduction to the research problem, its background and justification. Also describes the research objectives and an outline of research questions.

**Chapter 2: Literature Review:** Detailed study of relevant literature which is required to provide a ground for the research problem within the scope of existing theories. Also explores and defines the concepts for this research study.

**Chapter 3: Study Area:** Contextualize the study area, discuss the socio-economic, environmental and hazard profile of study area.

**Chapter 4: Research Methodology:** Provides a detailed overview of the research methodology undertaken and the processes followed during the research.

**Chapter 5: Results:** This chapter presents the results of the gathered primary and secondary data and key findings obtained from the result.

**Chapter 6: Discussion:** Presents a detailed discussion of this research regarding obtained results by critically reviewing them and presenting its relation to literature and the broader context. It also discusses methodological shortcoming and limitation of the study.

**Chapter 7: Conclusion:** Being the last chapter of the study provides conclusion obtained from this research. It also presents recommendations for furthering the research.

# 2. LITERATURE REVIEW

This section briefly reviews some of the existing approaches to investigate cascading effects and also describes the underlined concepts, thoughts, and ideas of the formulated problem. It also relates the concepts with approaches that have addressed the similar problem and the intended methods that will be used for this study.

## 2.1. Review of concepts, thoughts, and ideas

### 2.1.1. Slum population

A slum is a highly populated urban residential area with squalid, crowded or unsanitary conditions under which people live, irrespective of the physical state of the building or area (UN-HABITAT, 2003, p. 9). Under such a set of definitions, slum population is identified as the urban poor, individuals or families residing in urban and peri-urban areas whose income or combined household income fall below the poverty threshold of the region or country (Ragragio, 2003). While slums differ in size and other characteristics, most lack reliable sanitation services, the supply of clean water, reliable electricity, law enforcement and other basic services. Slum residences vary from shanty houses to professionally built dwellings which, because of poor-quality construction or provision of basic maintenance, have deteriorated (UN-HABITAT, 2003, p. 12)

### 2.1.2. Typhoon

A tropical cyclone also referred to as typhoon or hurricane, originated over warm tropical oceans with an intense circular storm characterised by low atmospheric pressure, strong winds and heavy precipitation (Zehnder, 2018). It draws its energy from the sea surface and maintains its strength as long as it remains over warm water, a tropical cyclone generates winds that exceed 119 km/hour. In some severe cases, winds speed exceeds 240km/hour, and gusts may exceed 320 km/hour. Such a combination of strong winds and heavy rainfall makes cyclones a severe hazard to coastal areas in tropical and subtropical regions of the world. Tropical cyclones are referred by different names in different parts of the world. In the North Atlantic Ocean and the eastern North Pacific they are called hurricanes, and in the western North Pacific around the Philippines, Japan, and China the storms are referred to as typhoons. In the west of South Pacific and the Indian Ocean, they are variously referred to as severe tropical cyclones, tropical cyclones, or simply cyclones (Zehnder, 2018).

### 2.1.3. Critical infrastructure: Interdependencies and dependencies

Critical infrastructure systems, often called lifeline systems, do not exist in isolation but are interconnected with other infrastructures (Wang, Hong, & Chen, 2012). With the development of scientific technology and social economy, these infrastructure systems become increasingly complicated and interdependent. Rinaldi et al., (2001) differentiate between interdependencies and dependencies in infrastructure systems and provide a typology for interdependencies including spatial and functional distinctions.

**Dependencies:** A linkage or connection between two infrastructures, through which the state of one infrastructure influences or is correlated to the state of the other. A dependency is a unidirectional

relationship between two assets (e.g., critical infrastructure, firm, organisation, or facility) where the operations of Asset A affect the operations of Asset B (Boaru & Bădiţa, 2008). The author also defined following type of dependencies:
**Upstream dependencies.** The products or services provided to one infrastructure by another external infrastructure that is necessary to support its operations and functions
**Downstream dependencies.** The consequences to a critical infrastructure's consumers or recipients from the degradation of the resources provided by a critical infrastructure.

**Interdependencies:** An interdependency is a "bidirectional relationship between two infrastructures in which the state of each infrastructure influences or is reliant upon the state of the other (Boaru & Bădiţa, 2008). Author has defined following interdependencies relevant for this study:
**Spatial Interdependencies**: One infrastructure can be located near another infrastructure for economic reasons, so a physical failure in one leads to damage and a failure in another nearby facility.
**Functional Interdependencies**: Two infrastructures depend on one another to function. For example, information technology requires electricity to function, and electricity requires information technology to manage control systems, so they are mutually interdependent to support each other's' functions.
**Resource interdependencies**: common resources such as fuel, water, people that are consumed or used by each service.
**Common components interdependencies**: Components that might fail at similar times (types, specific) or have common vulnerabilities that attract coincident attacks.

Interdependent infrastructures are observed as complex adaptive systems with linkages, which strongly influences the operational characteristics of the infrastructure services. These links are key elements within and between infrastructure system performance as well as system vulnerabilities. Some linkages are loose and thus relatively flexible, whereas others are tight, leaving little or no flexibility for the system to respond to changing conditions or failures that can exacerbate problems or cascade from one infrastructure to another (Rinaldi et al., 2001).

#### 2.1.4. Critical services: Water, Sanitation, and Hygiene (WaSH)

*"The United Nations Office of the High Commissioner for Human Rights (OHCHR) declared in 2007 that access to safe water and sanitation is a human right that applies in times of peace as well as in emergencies"(United Nations, 2014)*

WaSH is the combined word for Water, Sanitation, and Hygiene. Due to their interdependent nature, these three core issues are joined together to joined together to denote one sector. Though each of the issues is a separate field of work, each is dependent on the other for the effective outcome. For example, water sources will be contaminated in the absence of toilets; safe hygiene practices are not possible without access to clean water. All three areas of WaSH support and strengthen one another. The progress of one core area is dependent on another (United Nations, 2015).
However, when defined separately, WaSH has a sub-thematic area within the core area, especially for sanitation. WHO defines sanitation as, 'provision of facilities and services for the safe disposal of human urine and faeces. The word 'sanitation' also refers to the maintenance of hygienic conditions, through services such as garbage collection and wastewater disposal'. In some countries, faecal waste and solid waste management are considered as part of sanitation and hygiene management making it a collaborative effort of the collection, transport, treatment, and disposal or reuse of human excreta, domestic wastewater and solid waste, and associated hygiene promotion (Harvey, 2008).
Developing countries are facing rapid growth of population and urbanization, and increased economic activity (UNICEF, 2016). Basic needs are unfulfilled, and the human right to water and sanitation remains unrealised for billions of people globally (United Nations, 2014).

Providing WaSH services to the increasing urban population living in informal settlements or slums is likely to be a major challenge(UN-HABITAT, 2003). An estimated 1 billion people – half of the global urban population - now live in slum areas (Deely et al., 2010). The slum population is not only increasing, but it often faces other complex challenges such as land insecurity, high population density, and violence. Many urban slums have a poor waste collection and no drainage to protect from flooding (Ali, 2017).

### WaSH in Emergencies in Slums

The WaSH situation gets further aggravated in Slums by the recurrent disasters in a geographical disaster susceptible regions such as Asian coastal cities, prone to tropical cyclones and seasonal floods. Population affected by emergencies often suffer from malnutrition, injuries, stress and other ailments. Unhygienic living conditions such as inadequate sanitation, lack of safe drinking water, poor hygiene practices make affected populations even more vulnerable and prone to diseases (Mosello & Matoso, 2017). Having inadequate water and/or sanitation can lead to increased instances of diseases and death, and a lack of hygiene can contribute to diarrhoea, cholera, measles, scurvy, and other hygiene-related disease outbreaks in emergencies (United Nations, 2015).

Although access to sanitation has been improving over the past decades, the World Health Organization estimates that still "2.5 billion people – more than one-third of the global population – live without basic sanitation facilities" (WHO, 2015). The international humanitarian community is active and progressing towards achieving the targets set by the sixth goal of sustainable development goals, i.e., clean water and safe sanitation (UNDP, 2016). However, the work which has progressed so far is lacking behind as development efforts made during the Millennium Development Goal era failed to reach millions of people in poor and urban-rural communities. As a result, massive inequalities exist between those with access to clean water and basic toilets and those without basic services.

It has also emerged that emphasis is being put on the direct impact on the water sanitation infrastructure rather than indirect impact within the disrupted interdependent features of water and sanitation infrastructure (Lange et al., 2015). Such indirect impacts further increasing the vulnerability of urban poor struggling within the vicious circle of recurrent disaster, poverty and inadequate access to water, sanitation and hygiene with a long-term impact on slum dwellers (Baker, 2012).

### Interdependent WaSH services

Water and sanitation is an interdependent system of services, which needs the presence of each other to progress. This interdependency drives the system to run in sync to provide water and sanitation services (Mosello & Matoso, 2017). If one of the services fails for some reason or disrupted for some time, the failure of one service triggers a sequence or cascade of failure of services within the infrastructure. If sanitation units do not receive water supply, people will be forced to opt for open defecation, which may lead to contamination of water sources. If this contaminated water source is used for water supply will result in water-borne diseases and more challenges. Disruption of one service in water and sanitation infrastructure results in such havoc, the impact will be massive in an area where population density is high and is highly vulnerable to socio-economic issues and natural hazards. Also, water and sanitation services being interdependent, safe hygiene practices are recognised as an important part to achieve improved public health reduce poverty (WHO, 2015). Hygiene promotion is an integral part of water and sanitation service provision. Disrupted water and sanitation services can further worsen in the absence of poor hygiene practices (UNICEF, 2016) and may trigger health issues on a massive scale in the wake of a natural disaster. Slums present a perfect example of such situation, where cascading impacts triggered by a natural disaster, will be complex as vulnerability path facilitates the cascading effect of impacts causing more loss (Wisner, Blaikie, Cannon, & Davis, 2003).

#### Cascading effect on water and sanitation infrastructure services

In the urban context, water and sanitation, being interconnected and interdependent critical infrastructure, when disrupted by massive disasters, increases the likelihood of complex disasters and a cascading effect from related impacts (McGee et al., 2015). These cascading effects are the indirect impact on WaSH system caused by the disaster, which may or may not be evidently visible immediately after the occurrence of catastrophe, to be repaired or responded to (Lange et al., 2015). Cascading impact in water and sanitation services are caused by the interconnected features in the infrastructure. Such features when weakened or damaged by the disaster further triggers the failure of the system or feature linked to it. These features are critical points which hold the potential of creating havoc worsening the impact left by the natural disaster (McGee et al., 2015). Failure at the critical points of interdependency will propagate a lag in disaster recovery process (Kotzanikolaou, Theoharidou, & Gritzalis, 2013). Cascading impact spread-out quicker in locations where damage and secondary hazards that are created by the combination of all types of vulnerabilities, i.e., socio-economic, physical and environmental (Wamsler & Brink, 2016).
Blaikie et al. (2004) recommended that different levels of vulnerability have to be considered if one is to identify the root causes of disaster impacts, and they are determined by social systems and power relations, not natural forces. According to these authors, vulnerability is a phenomenon that has multiple layers and different ways in which it progresses as result of interaction between social networks, economic models, and unsafe physical conditions. About cascading impacts, socio-economic and physical vulnerabilities generate a pathway for cascading events leading more damaging impacts on the community. Pescaroli & Alexander (2016), argue that because of high complexity and cross-scale dynamics in interdependent critical infrastructures, cascading disasters cannot be prevented, the latent vulnerability can be understood and addressed before the trigger events occur.

#### The spread of Cascading effect

Cascading effects can be majorly identified in indirect damage caused by a disaster aggravated by direct damage. The cascading effects spread with time, as the time proceed, the impacts will also spread depending upon the intensity of the cause triggering cascade and scale of impact within the affected community utilizing the water and sanitation infrastructure (Pescaroli & Alexander, 2015). As explained by Zimmerman & Restrepo (2009), as the time passes by, the cascading impacts will spread out faster depending upon the vulnerabilities of the community, and the response provided for the disaster emergency. The cascading impact will keep increasing if emergency response is delayed or no response provided. This situation will further increase the vulnerabilities of the affected community to suffer more loss in case of occurrence of a new disaster event (Thouret et al., 2014).

### 2.2. Review of existing approaches to investigate cascading effects

Some of the existing research on cascading effects so far includes the work of Rinaldi et al. (2001) who developed a comprehensive theoretical framework and terminology for cascading effects between critical infrastructures. They also defined types of interdependencies (i.e., physical, cyber, geographic, and logical) - identifying factors that affect analyses of infrastructure interdependencies and identifying types of failures (i.e., cascading, escalating and common cause failures). Their work also found that failure to identify and analyse interdependencies between critical infrastructures will lead to bad or inappropriate policies and decision making during crises or massive infrastructure disruptions. McGee et al. (2015), for example, studied relationships among power infrastructures, telecommunications systems, and emergency services. An assessment methodology was applied to study the relationship between critical infrastructure and cascading effects caused by disasters. A causal loop diagram (CLD) was created to visualize the cascading effects within the interconnected critical infrastructure. The research team recommended identification of

cascading interdependencies across critical infrastructure and risk assessment at a regional and national level that accounts for interrelated disasters.

Gonzva, Barroca, Gautier, & Diab (2016), developed a modelling based methodology offering identification and automatic generation of failure scenarios caused by cascade effect between the components of a rail transport system, facing a flood hazard, as an example of risks.: The Functional Analysis, the Failure Modes and Effects Analysis (FMEA) and the Fault Tree Analysis (FTA). Krimgold et al. (2009), has documented the hurricane season of 2004 in Florida. They studied how intra-dependencies within a critical infrastructure and interdependencies between and among critical infrastructures, affected the operations and serviceability of the infrastructure during and after three hurricanes struck the area. The methodology used was direct interviews with personnel from a total of eighteen lifeline organizations that provide service in the selected impact area in central Florida were interviewed. The interviews were supplemented by a review of relevant after-action, lessons learned, and other reports. They concluded that, if these reviews are integrated into the emergency management organizations, will enhance an understanding of the roles that interdependencies play, and it will bring out a structured outline how changes in emergency plans and procedures can be implemented before, during and after future hurricanes to improve disaster preparedness, response, and recovery. Pescaroli & Alexander (2016), investigated how the progress of a cascading disaster can be guided by the vulnerability of critical infrastructure, rather than being merely an artefact of high-impact, low-probability, and unexpected events.

The research and methodology carried out to so far have a major emphasis on the infrastructure system failure being a web or network of multiple infrastructures which is interdependent for the service delivery (Arvidsson, 2015). A review of accident investigation methods by Sklet (2004), referred to as causalities leading to the humanitarian crisis. Some of the methods reviewed by him to analyze the evidence and facts and development of conclusion: Events and causal factors charting and analysis, Barrier analysis, Change analysis, Root cause analysis, Event tree analysis and Sequential Timed Events Plotting (STEP).

Michaël, Bruno, Pierre-Étienne, & Youssef (2015), developed a model based methodology to analyze disruptions cascade effect within a rail transport system facing a flood hazard. The model adopted dependability methods offering an interesting way to assess the resilience of the complex system. The interdependencies between the sub-system were concluded as the source of cascading effect. Likewise, Rahnamay-Naeini & Hayat (2016), proposed a novel interdependent Markov-chain framework which allows capturing interdependencies between two critical infrastructures with an objective to estimate their resilience to cascading failures and characterizing the effects of interdependencies on electric-cyber infrastructure system reliability.

Some recent research work brought out the conceptual analogy of infrastructure services with supply chain management concerned with the planning and management of activities from raw materials to the delivery of finished goods. Similarly, Service Chain Management is concerned with the planning and management of activities from support functions to the delivery of end-user services (Abbott, 2005). Service Chain Management until recently has been applied studying the operations and systems of large and vertically integrated service organisations such as airlines, utilities, healthcare providers, banks, or the after-sales functions of manufacturers as described by Lee et al. (2005). As part of service delivery, facilities and assets are networked and represent critical and expensive infrastructure. Facilities such as electricity stations, water supply stations play a crucial role in linking of service delivery from one link node to the other link node, offering service across geography (Abbott, 2005). However, the literature reviewed for this study has not come across with the application of service chain management to assess cascading effects triggered by sudden disruption (for, e.g., disaster/accidents). Available literature on the study of service chain management indicates towards upgrading the efficiency of service delivery of the service chain to its users. Assessment of cascading effect in existing research has been carried out on the web or network of major physical infrastructure present in a region. There is very limited research with an emphasis on assessing the impact of cascading effects on a specific infrastructure and the affected population as well. The methodologies applied in assessing cascading effects are useful in explaining the system failure of

interconnected critical infrastructure. A majority of methodologies reviewed here are based on mathematical and statistical models developed forecasting the cause and effect triggered by the systemic interdependencies due to sudden disruption occurred in an infrastructure service system. However, these methods do not go a step ahead to explore the cascading impact on the community hit by a natural disaster in an urban context. Therefore, this research study offers to assess the cascading effect driven by the interdependency or dependency of specific infrastructure (water-sanitation) and its impact on the disaster-affected slum community.

## 2.3. Conceptual Framework

Cascading effects of critical infrastructure are explained in figure 2 using interdependent water and sanitation services affected by the disaster. The interdependency of critical infrastructure drives the cascading effect when services behave like a chain mechanism affecting services which are dependent or interdependent on other services for final service delivery to its user. The emphasis of this research is on assessing the impact of cascading effects caused by typhoon and its impact on society using qualitative data from slum population. The framework explains the overall structure of occurrence of cascading effects on water and sanitation services which are interdependent. The framework also defines water and sanitation as a chain of services which are disrupted post-disaster leading cascading effect which spreads across time and space impacting slum community in a given area

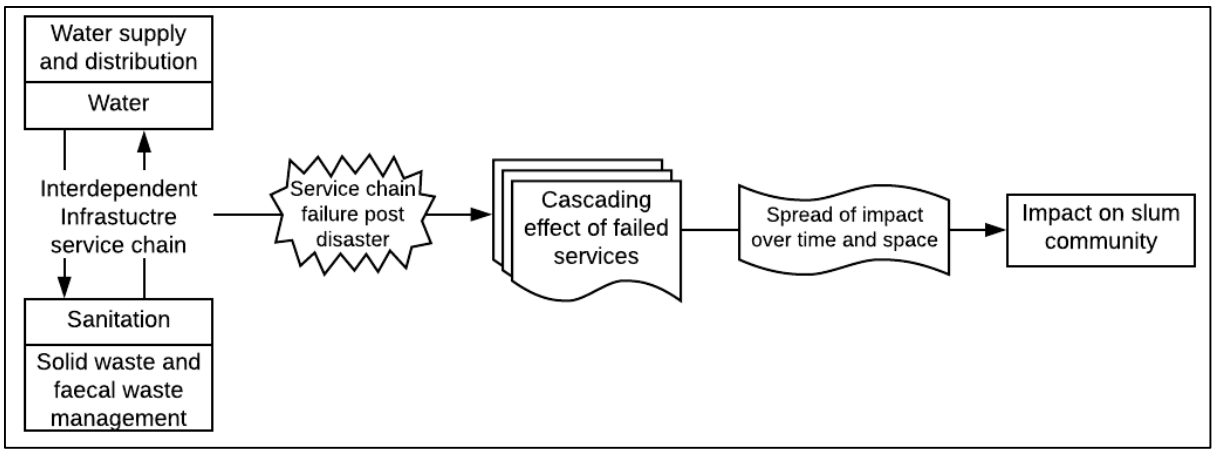


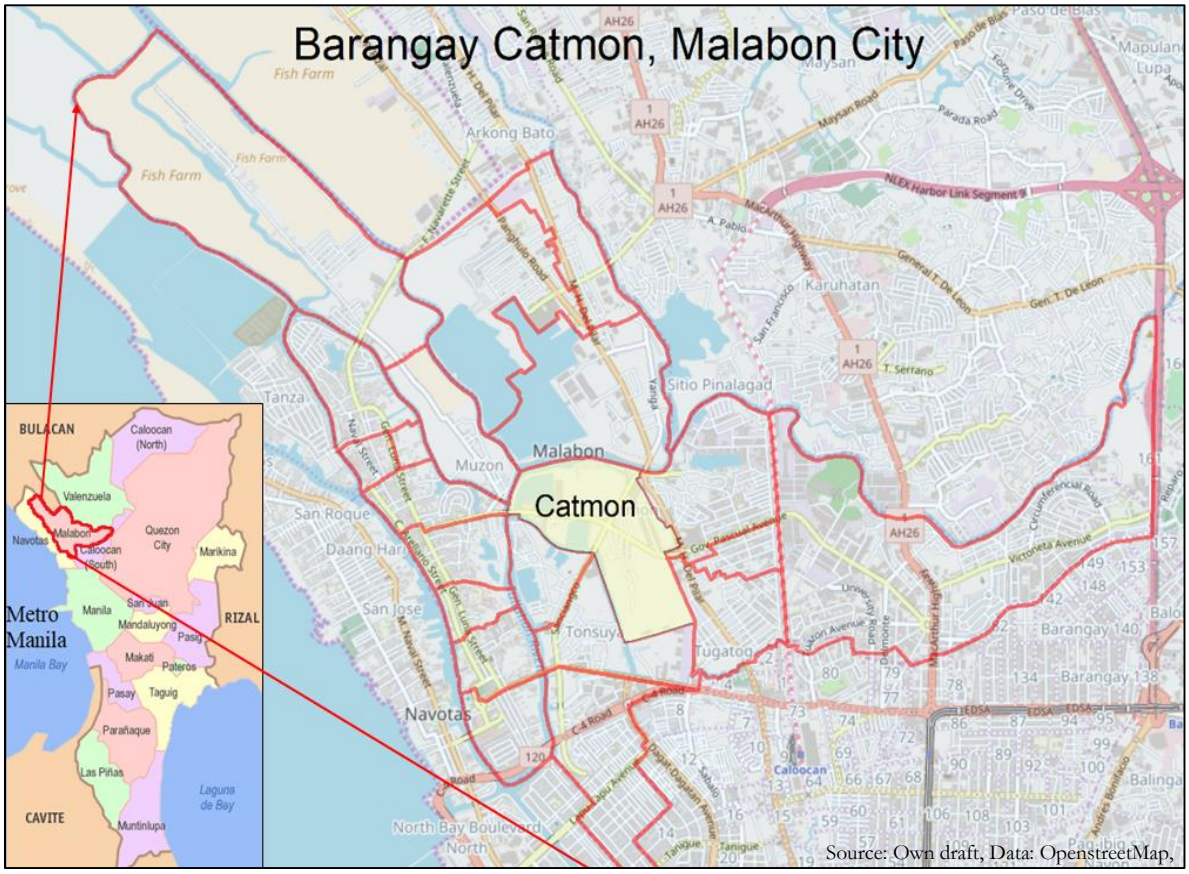

Figure 2: Conceptual framework Source: Own draft

# 3. STUDY AREA

This chapter introduces the general overview of the study area to provide general information about the selected area, water and sanitation service provision in the region. The chapter also covers a brief description of typhoon selected as a case to study cascading effects on water and sanitation service and slum population.

## 3.1. Selection of study area

Malabon City, a densely populated developed urban area which makes up Metro Manila. The city is located at Manila Bay and is exposed to various natural hazards. A large number of low-income household reside in Barangays which are prone to and get exposed to combined effects of land subsidence, monsoon flooding from Tullahan river and storm surges. Such hazards are potential causes of basic service delivery disruption. This research study has selected informal settlements of Barangay Catmon of Malabon City, residing in a hazard-prone area along with high population density, poor housing and limited access to basic infrastructure services. The study has selected flooding caused by Typhoon Glenda 2014, which disrupted basic service delivery of water supply and sanitation.

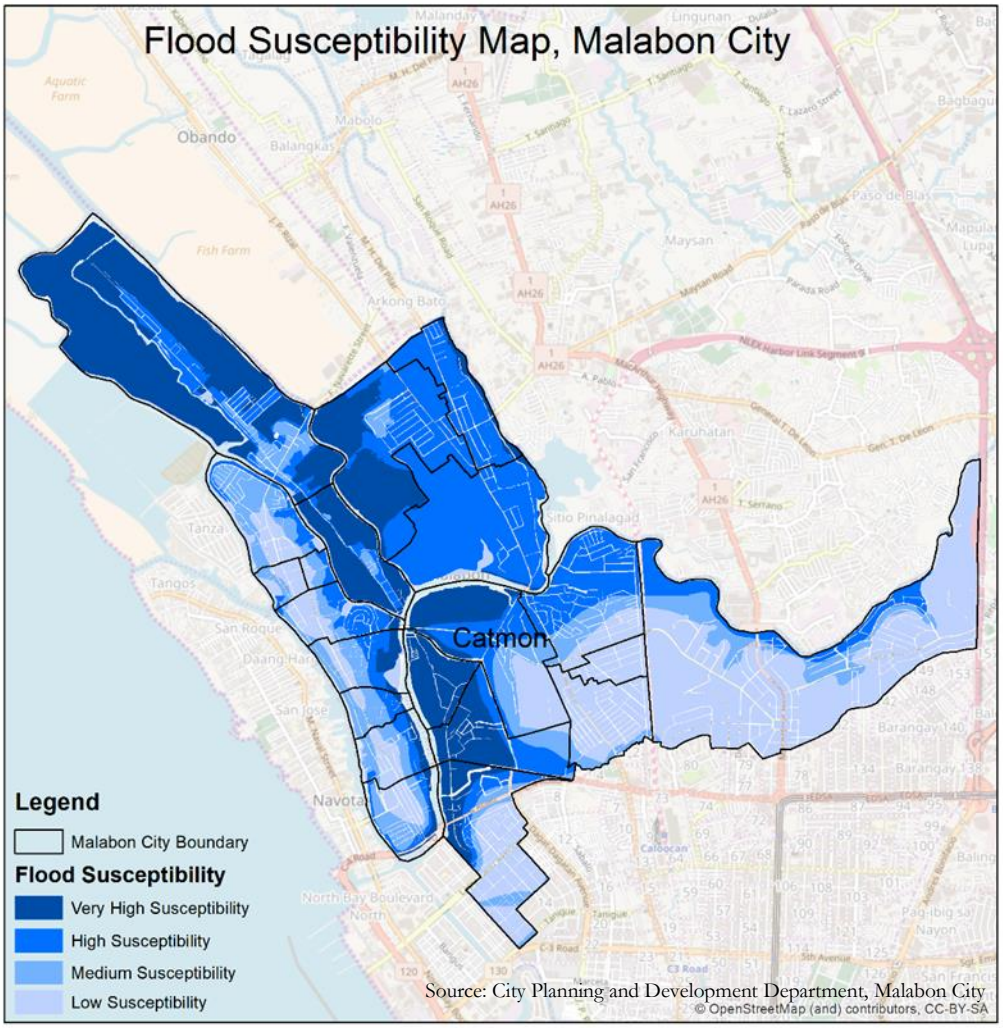



Map 1: Study area

### 3.2. Malabon City

Malabon has a total population of 87,808 with a total land area of 1,571.40 hectares or 2.50% of Metro Manila's total land area[1]. It is primarily an industrial and residential city and the most densely populated city in Metro Manila. Malabon is geographically highly prone to flooding because of its combined topographic and hydrological characteristics, as well as the meteorological conditions due to the frequent occurrence of extreme weather events such as typhoons and monsoon rains[2]. The Annual Mean Number of typhoons that pass across the Philippines is 19.6[3].

Flood conditions worsen (Map 2), as the City is surrounded by a network of four interconnected rivers, Tullahan river being the closest. The water holding capacity of the river has reduced drastically in recent decades due to the encroachment of land by industrial plots and homes of thousands of slum dwellers without legal ownership of the land (Ragragio, 2003). In past few years, floods have become more frequent and worse with several feet deep water. Families of slum dwellers residing in Barangays close to the river or in hazard risk zones are the most affected population of the City.




Map 2: Flood Susceptibility Map, Malabon City

[1] http://malabon.gov.ph/
[2] Habagat
[3] http://www.nababaha.com/

### 3.3. Barangay Catmon, Malabon City

Barangay Catmon is located in the heart of the City of Malabon, with a land area of about 97.77 hectares which represents 6.22% of Malabon's total land area. Barangay Catmon has a total population of 36,450 with approximately 11,500 households[4]. Three rivers surround the barangay namely Tullahan River, Catmon River and Sucul River which makes the barangay prone to flooding. Flood water inundation after heavy precipitation is very common in Catmon attributed to its flat terrain, reclaimed landfills and encroached waterways. In past few years, Catmon has suffered massive damage regarding socio-economic and physical loss by Habagat (2012), Typhoon Haiyan (2013), Rammasun (2014) and Chan-hom (2015). Research has selected slum community of Barangay Catmon to study the impact of cascading effects on water and sanitation services triggered by the typhoon. Slums are referred as informal settlements and slum dwellers as informal settlers (ISFs) in the Philippines.

**Informal settlements (Slums) in Barangay Catmon**

Catmon consists of 27 informal settlements and is currently home to over 5,000 households, which translates to 31,137 total informal settlement population. Out of 27 communities, four communities are located on government-owned lands, covering 21% of the land area[5] (Map 3). These informal settlements consist of households from low-income backgrounds residing illegally on land owned by either private owners or government. Without legal authorisation to own land title, informal settlers cannot construct permanent structures for housing. Therefore, current housing structures are made of light material such as wood, tarpaulin sheet, and corrugated galvanized iron sheets (picture1). Such houses make Barangay Catmon highly vulnerable to accidents. Barangay has faced 3-4 major fire accidents in last two years charred the houses of informal settlers, leaving a devastating impact on people.


Picture 1: Informal settlement, Barangay Catmon

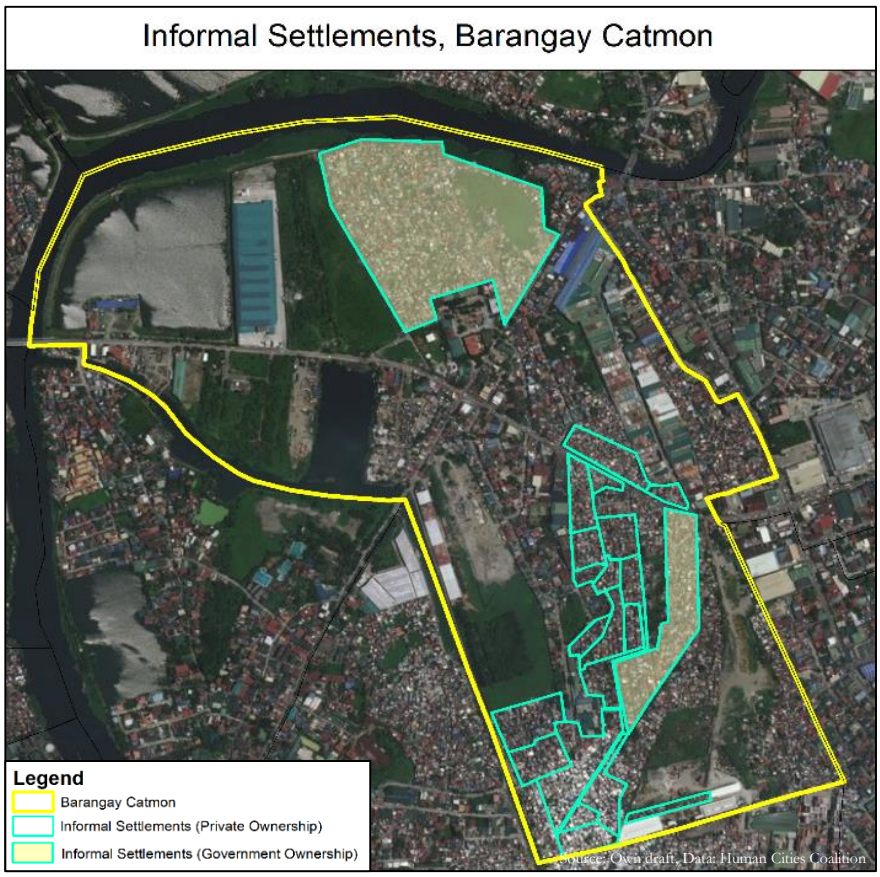
The land currently occupied by informal settlers consisted of wetlands before the development of settlement: fishponds and water-logged swamps. Informal settlers started settling in, from late 1980's to early 1990's, by landfilling the fishponds with layers of garbage (Ragragio, 2003). People who currently occupy the area now mostly the descendants of the first settlers. Some migrated from provinces, and others were relocated to the area after being evicted from other urban areas. In later years, communities came to learn that the land they were occupying is a private property owned by business families and are under constant eviction threat in some of the settlements[5]. Access to basic service infrastructure in an unauthorised setup is a challenge in informal settlements especially due to unofficial residential status.

[4] Malabon City Development Plan 2016-2020
[5] Human Cities Coalition (https://www.humancities.co/)

Authorised service provisioning is of poor quality to informal settlers making it difficult to continue living in an already difficult environment of informal settlements.

**Basic service provisioning in informal settlements, Barangay Catmon**

Access to basic infrastructure services is a challenge for informal settlers in Catmon, in lack of authorised recognition of their residential status. Without registration of the land ownership to get legal recognition of residential status, the government has difficulty in upgrading basic services and improving the living environment. Though, Malabon City Administration supports informal settlers by providing them with an endorsement letter to obtain access to water and septic tank cleaning services from private service providers. As part of safe sanitation, it is mandatory to construct a septic tank for a toilet in areas where construction is feasible. Also, informal settlers do not have legal access to electricity in lack of recognised residential status of informal settlers, resulted in electricity theft and led to frequent fire accidents.
In some informal settlements, access to basic services is illegal in the absence of sufficient documentation not made available by the Government to informal settlers. In such cases, accessibility and availability of basic services have turned into a major challenge for informal settlers.




Map 3: Informal settlements in Barangay Catmon, Malabon City

**Land tenure security for informal settlements in Catmon**

The Philippine constitution bill of rights of 1987 grants right of access to affordable housing to all its citizen. Under the law, different modes of land acquisition are open to the urban poor through various government programmes, among which Community Mortgage Programme (CMP) is one of them. Malabon City Administration is putting in its best efforts for the upgrade of informal settlements by implementing community mortgage programmes through HOAs. Informal settlements are registered as Home Owner

Association[6] (HOA) with 'Housing and Landuse Regulatory Board; in Malabon City. HOAs are managed by its residents of respective informal settlement. Each HOA has an abbreviated name and official names registered with the administration.
CMP is a financing system that enables legally organised informal settlers to own the property they occupy or the land where they opt to relocatee (Ballesteros, Ramos, & Magitbay, 2015). Malabon City is encouraging and accelerating CMP process by mediating between informal settlers and private landowners of the settlements in Malabon. Informal settlers registered in CMP have to register their Home Owner Association as a representation of their community. Government officials then further mediate between informal settlers and owner of the land occupied by informal settlers to negotiate the price of land. Once finalized, the government pays the amount to the landowner and informal settlers further keep paying the amortization amount in instalments over a period of 25 years. Meanwhile, the community can start constructing their houses according to government development plan which also approves of water supply meter, electricity connection, sewage tanks and another basic service.

### 3.4. A brief description of Typhoon Glenda, July 2014

During focus group discussion, participants were asked to share their experiences from a recent most devastating typhoon, and the majority of the experiences were from typhoon Glenda which occurred in 2014. Therefore, to study the impact of cascading effects on water and sanitation services in Barangay Catmon, typhoon Glenda has been chosen as the case of natural disaster. Typhoon Glenda also referred as 'Rammasun' was one of the strongest typhoons which affected the City of Malabon after typhoon Haiyan (Yolanda) in 2013. Typhoon Glenda was active from 13th -17th July 2014, affected National Capital region of Metro Manila and other parts of the Philippines, caused damage of more than 7 billion USD. As reported by National disaster risk reduction and management council (NDRRMC), Typhoon Glenda made three landfalls in total and affected more than one million families in National Capital Region of Metro Manila and other provinces of Philippines. Following are details of progression of effects of typhoon Glenda in Malabon City, based on its characteristics defined in literature:

**14th July 2014:** Strong winds *(Primary stage)* at a speed of 165 km/hr caused heavy damage in the region resulting in the uprooting of trees, electricity poles and damage to houses made of light material. Damage triggered in water supply infrastructure was not massive however strong winds triggered damage which was evident post rainfall and water inundation.

**July 15th, 2014:** Heavy rainfall/precipitation *(Secondary stage)* continuously for more than 24 hours.

**July 16th and 17th, 2014:** Due to flood water inundation *(Tertiary stage)*, more than a thousand individuals from different areas in Malabon City evacuated to nearby schools and gyms on 16th July due to floods caused by rains spawned by typhoon Glenda. Based on News agency, government supported 1,650 individuals (403 families) in Malabon City. At least 90% of the total residents of Metro Manila lost power since 15th July, as poles were toppled and lines downed. However, Power supply was restored totally in Metro Manila by 22nd July 2014 ("GMA News Online," 2014).Water supply was irregular and was affected by flood water inundation. The eye of Glenda passed to the south of Metro Manila at wind speeds of up to 120 kilometres per hour and with gusts of up to 165 km/hr.

[6] Home Owner Associations: These are government recognised associations of community within the smallest administrative unit Purok in Philippines, to provide and/or maintain community facilities and to facilitate the delivery of adequate social services and economic advantages for the association to improve the quality of life and well-being of its members, on a non-profit basis consonant with the provisions set forth

### 3.5. Barangay Rizal, Makati City

The research study also selected Barangay Rizal in Makati City to provide a context for the development of informal settlements in Makati City. Barangay Rizal (map 4) has been chosen to present as an example case of a formal and authorised[7] settlement which was an informal settlement in the past. Rizal also shares geographical similarities with Catmon regarding natural hazard and risks. The area is composed of former tidal flats hence suffers from frequent flooding especially areas close to river Taguig. Though Rizal being part of Makati city enjoys highly developed infrastructure services in comparison to other Cities of Metro Manila, but flood vulnerability is still high and results in socio-economic and physical damage every year after floods/typhoons (Einsiedel, Bendimerad, Rodil, & Deocariza, 2010). Presently, Barangay Rizal does not have informal settler settlements, as the majority of them have been relocated in social housing out of Makati City.

The purpose of inclusion of Barangay Rizal as an example case to discuss the policy programme intervention implemented by the City Administration in development of the area and the community residing in Rizal. However, data collected from Rizal is not part of research data analysis and is mainly discussed in chapter 6.


Map 4: Barangay Rizal, Makati City


Picture 2: Authorized settlement, Barangay Rizal, Makati City

[7] Formal settlements recognised and authorised by government

# 4. RESEARCH METHODOLOGY

The research study is exploratory in nature, using a qualitative research design approach to assess the cascading effects triggered by typhoon/floods on water and sanitation services in informal settlements of Barangay Catmon, Malabon City. In this regard, the study developed a service chain management framework to understand the water and sanitation service chains and to explore consequences of cascading effects on physical infrastructure and communities of informal settlers. Experiences of informal settlers on past flood/typhoon event have been considered as an important source of primary data collection to assess cascading effects. Qualitative research design has been adopted to facilitate the investigation of subjective experiences enabling an in-depth understanding of the occurrence of specific events resulting in cascading effects. Data collection was majorly qualitative; data was gathered using focus group discussion and expert interviews. Following is a description of data collection and research methodology implemented to analyse primary and secondary data to achieve research objectives.

## 4.1. Primary data collection

Primary data was collected through focus group discussions, field observations and expert interviews. Two different sets of questionnaires were developed based on concepts reviewed from the existing literature to conduct a focus group discussion and expert interviews. The target for expert interviews were government officials and local NGOs in Malabon City, and informal settlement community residing in Barangay Catmon were targeted for focus group discussion.

### a. Focus group discussion (FGD)

The purpose of focus group discussions was to collect data on water and sanitation services, its availability and accessibility to informal settlers and challenges for water and sanitation services faced by the community, which emerged after the occurrence of a typhoon/flood. Group discussions consisted of questions (annexe 4, pg.70) based on different stages of the typhoon, e.g. strong winds, heavy precipitation (rainfall) and flood water inundation also defined as characteristics of the typhoon as discussed in the literature. Therefore, focus group discussion questions were kept flexible to modify questions to dig deeper and bring out additional information that provided a good context for the data analysis. A total of nine focus group discussions were conducted, consisting of 5-7 participants each, from different informal settlements, invited by the Barangay head. Each 1-1.5-hour group discussion session took place in the barangay community hall. Participants seemed to be comfortable during the sessions and were sharing their experiences very positively in their local language, Tagalog. To assist in translation, the host organisation EMI[8] provided one staff for the entire data collection duration. An audio recording was made of each session. Each participant in FGD was considered as representative of one household and hence for each household health status after the occurrence of the typhoon was collected to evaluate the impact on people.

**Profile of informal settlements selected for the study**

Following is a brief profile of informal settlements selected for focus group discussion. Selection of settlements was random and was decided by Barangay Head based on the convenience of participants available from different settlements (picture 3). The profile (table1) also describes the status of Community Mortgage programme registration and land ownership to provide more background to collected data.

[8] Earthquake Megacities Initiative, Quezon city: http://emi-megacities.org/

Table 1: Informal settlement profile, Barangay Catmon Source: Human Cities Coalition

| Group No. | Informal Settlement | Name of HOA | No. of participants / Group type | Area sq mtr | Establish ment year | Total Population | No. of HH | HH size | Land Ownership | CMP Status |
|---|---|---|---|---|---|---|---|---|---|---|
| Group1 &2 | Gulyan Pilapil | Gulayan Pilapil HOA | 10/Mixed group | 100727 | Jan 1, 2010 | 2640 | 440 | 6 | Government | Yes |
| Group5 | Gulayan | Gulayan Catmon HOA | 6 /Women only | 97674 | Jan 1, 1989 | 6000 | 1000 | 6 | Government | Yes |
| Group3 | SANAPU | Samahan ng mga Naninirahan sa Purok 4 HOA | 3 /Mixed group | 7707 | Jan 1, 1990 | 2700 | 540 | 5 | Private | No |
| Group4 | S6 | Sitio 6 Barketball Court HOA | 8 / Mixed group | 1583 | Jan 1, 2016 | 496 | 62 | 8 | Private | No |
| Group6 | UPNA | United People Neighborhood Association HOA | 4 / Mixed group | 2009 | Jan 1, 2007 | 552 | 92 | 6 | Private | No |
| Group7 | CVHOA | Catmonville HOA | 3 /Women only | 15748 | Jan 1, 2005 | 1236 | 206 | 6 | Government | Yes |
| Group8 | Samapil | Samahang Masigasig ng Pilapil HOA | 7 / Mixed group | 5556 | Jan 1, 2012 | 1260 | 180 | 7 | Private | Yes |
| Group9 | Solid Bisig | Samahang Kapit Bisig ng Catmon HOA | 4 / Mixed group | 6231.86 | Jan 1, 1994 | 918 | 153 | 6 | Private | Yes |

**Gulayan HOA-Group 1,2 & 5**

FGD groups 1, 2 & 5 are grouped as participants were from the Gulayan Catmon HOA and Gulayan Pilapil HOA. Both the settlements are part of Gulayan HOA.

Gulayan HOA is the largest informal settlement regarding the land area and population size. With a population of 6000 people and 600 households in an area of 9 hectares, was established in 1989. The land is government owned and registered under Community Mortgage Programme (HCC). It is a swampy land located adjacent to river Tullahan connected by a small canal of wastewater. Settlement being at riverbank is protected by a river wall of 12 feet with a river gate used to release excess water during low tide and closed during high tide to prevent excess water entering in the settlement.

Gulayan's swamp was previously used as dumping solid waste, which later was occupied by informal settlers. Hence, has a huge amount of solid waste lying under floating houses of informal settlers. There is no organised drainage and sewage system within the settlement resulted in the release of waste and sewage water in the swamps further channelizing all the water in the canal to the river. Gulayan is also prone to frequent flooding, land subsidence, fire accidents due to its physical features. Annually, the community faces 2-3 events of pluvial flooding and fire accidents due to unsafe electrical wiring from illegal connections.

- **SANAPU (Samahan ng mga Naninirahan sa Purok 4 HOA)- Group3**

SANAPU is located on a privately owned land, close to the major road. The settlement is occupied by 540 households with 2700 people, established in 1990 in an area of 7707 sq.mtr. ISF community is negotiating the land price with the owner to register for CMP scheme soon in future. SANAPU is also prone to frequent flooding caused by heavy rainfall and land subsidence as HOA was as swamp full with solid waste and wastewater.

- **S6BCHOA (Sitio 6 Basketball Court HOA)- Group4**

S6BCHOA also called S6 with private ownership and presently facing eviction threats. With a small land area of 1583 sq.mtr, supports 62 households of 496 people. However, this HOA has been omitted from the study as the data collection has more instances from typhoon Glenda which occurred in 2014 and the establishment year of S6BCHOA is 2016. Therefore, FGD participants could not share their experiences on typhoon Glenda.

- **UPNA (United People Neighbourhood Association HOA)- Group 6**

UPNA has a population of 552 people with 92 households, established in 2007. The settlement was a swampy dump site, which was converted to a landfill settlement by ISF to construct houses. Land ownership for UPNA is private and yet to register for CMP scheme. The community is trying to negotiate the price with the landowner and wish to register for CMP soon. The settlement is facing eviction threats though not as frequent as S6.

- **CVHOA (Catmonville HOA)- Group7**

The settlement was established in 2005, hosting 206 households with a population of 1236 people residing in the area of 1.6 hectares. The land owned by the government and is registered under CMP scheme, but the land price is under negotiation with the government. The settlement is close to a canal and was previously used as dumpsite which is now a landfill, but houses are constructed on the solid ground, unlike Gulayan.

- **SAMAPIL (Samahang Masigasig ng Pilapil HOA)- Group8**

Sampail was established in the year 2012 and has a land area of approx. 5556 sq. meter occupied by 180 households with a population of 1260. The settlement is owned by the private owner, registered under CMP scheme and has received approval on settlement development plan. Re-blocking process of land has already been completed. Housing construction will start soon in 2018. Samapil has already started paying the amortisation of the land to the City Administration.

**SOLID BISIG (Samahang Kapit Bisig ng Catmon HOA- SAKABICA)- Group9**

Solid Bisig is a small part of SAKABICA HOA, occupied by 153 households with, a population size of 918 in a land area of 6232 sq.mtr. It was established in the year 1994 owned by a private owner. The community has registered the settlement under CMP and waiting for the further process to negotiate the price of the land.

### b. Expert interviews

A total of twelve expert interviews were conducted with different government departments and non-government organisation active in programmes and projects on water and sanitation services in Barangay Catmon (table 2 & 3), Malabon City. Duration of each interview varied from 30 minutes to an hour based on the availability of the staff. Data collection focussed majorly on the mandate of the department, disaster response and preparedness plans, inter-dependency of the department (interviewee) on other departments for the service delivery such as electricity and healthcare). Interview questions (see annexe 5, pg.74) also covered events of disrupted basic services triggered by the failure of other supporting services when hit by flood/cyclone. Non-government organisations were interviewed to collect information on project implementation on water and sanitation, and disaster preparedness with informal settlers in Barangay Catmon.

Table 2: Expert interviews in Malabon City

| Code No. | Departments | Designation |
|---|---|---|
| Expert Interview.1 | Dept of City Planning and Development | Head of the dept. |
| Expert Interview.2 | City Environment and Natural Resource Office | Head of the dept. |
| Expert Interview.3 | Engineering (drainage) | Asst. Engineer |
| Expert Interview.4 | Disaster risk reduction and management | Head of the dept. |
| Expert Interview.5 | Dept. of Social welfare and Development | Head of the dept. |
| Expert Interview.6 | Health (sanitation) | Head of the department |
| Expert Interview.7 | Housing | Coordinator |
| Expert Interview.8 | Catmon Barangay | Barangay Captain (Head) |

Table 3: Non-government organisation active in Barangay Catmon

| Code No. | NGOs | Designation | Projects under implementation |
|---|---|---|---|
| Expert Interview.9 | ACCORD, Quezon City | Project Officer | Active in Catmon, Malabon on Urban Resilience |
| Expert Interview.10 | EMI, Quezon City | Technical Director | Active globally on development and training on integrated approaches on urban resilience especially on earthquake |
| Expert Interview.11 | Homeless People's Federation, Quezon city | Programme Coordinator | Partner in HCC project as an affiliate of Slum Dwellers International, focus on organising the community and initiate savings groups in Catmon. |
| Expert Interview.12 | Mother Earth Foundation, Quezon City | Officer-in-Charge | Active in Catmon, Malabon on solid waste management and organising the community to manage waste. Successfully implemented solid waste management in Barangay Potrero, Malabon. |

### c. Field observation and quantitative data

Field observation was recorded for the physical condition of infrastructure services of water & sanitation facilities, solid waste management, hygiene management, maintenance of water and sanitation services in Barangay Catmon. Along with qualitative data collected from FGD, quantitative data on health challenges occurred after typhoon Glenda, was also collected from FGD participants.

## 4.2. Secondary data collection

Secondary data (table 4) was collected from the government offices of Malabon City, local NGOs and websites accessible only in the specific country domain. Secondary data was collected both in hard and soft copies. Spatial data such as maps were in digital form and were processed further on GIS (geographic information system) software to align them with same projection and coordinate system.

Table 4: Secondary data from Malabon City

| Sr.No. | Type of data | Source |
|---|---|---|
| 1. | Annual reports, City development & land use plan and disaster management plans | City Planning and Development Department, CENRO, Barangay Catmon (Malabon City) |
| 2. | Spatial data (Land use, administrative, hazard and risk maps) | City Planning and Development Department (Malabon City) |
| 3. | Project reports | ACCORD, EMI (Quezon City, Philippines) |
| 4. | Situation reports for Typhoon Glenda | Disaster Risk Reduction and Management Department, Malabon City |
| 5. | Demographic data and profile of informal settlements of Barangay Catmon | Human Cities Coalition (The Netherlands) |

## 4.3. Data collection: Makati City

With a limited focus on Barangay Rizal, Makati City, data collection was kept brief. A short focus group discussion was conducted with a community residing in the former informal settlement. Barangay Captain was also interviewed to understand the programme interventions implemented for the development of the area. However, data from Makati City has been used to only to reflect upon the policy and programme intervention for development of informal settlements in Barangay Rizal. Further elaborated in the chapter on the discussion.

## 4.4. Data processing of primary and secondary data

To analyse data, primary and secondary data was processed first by compiling and organising the data. Transcripts were generated for a focus group discussion and expert interviews based on the audio recordings from field data collection. Transcripts of focus group discussion were then divided into two sets: pre and post-disaster condition of target infrastructure further compilation of data based on service provisioning of target infrastructure in pre and post-disaster conditions.

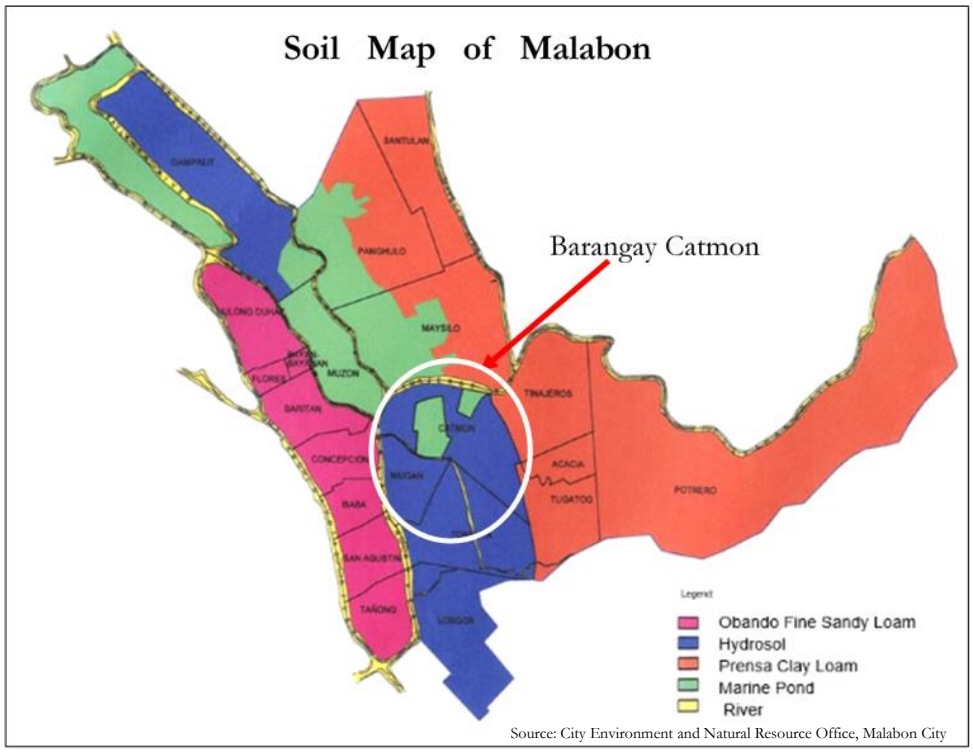
### Clustering of informal settlements based on habitat condition in the study area

While data processing for focus group discussion, it was noticed that a majority of data collected from selected informal settlements of Barangay Catmon are repetitive regarding service provisioning from target infrastructure. To avoid repetition of data for data analysis selected informal settlements aggregated into clusters. For clustering, differences were checked, and a major point of difference evident from the experiences shared by the FGD participants was following settlement habitat conditions.

## Type of habitat condition of informal settlement

**Landfill:** The entire Barangay Catmon is developed on hydrosol soil series (Map5) which influence the basic physical infrastructure provision as well as its social and economic activities (City Government of Malabon, 2017) Hydrosol soil is a conglomeration of clay materials & organic matters originating from the decay of marshy growth. Majority of such land areas are reclaimed and developed, except areas which were used as dumpsites. These dumpsites gradually turned into landfills and occupied by informal settlers (Porio, 2011).

**Waterlogged Swamp:** However, a small part of Catmon is still a marine pond which has now turned into a low lying swamp also occupied by informal settlers with floating houses (CENRO, 2015). Therefore, informal settlements included in this study are aggregated into two clusters based on the habitat conditions (Map 5) which influence the provision of basic infrastructure services.




Map 5: Soil map of Malabon City

Following is an explanation of two types of clusters (Map 6) of selected informal settlements of Barangay Catmon:

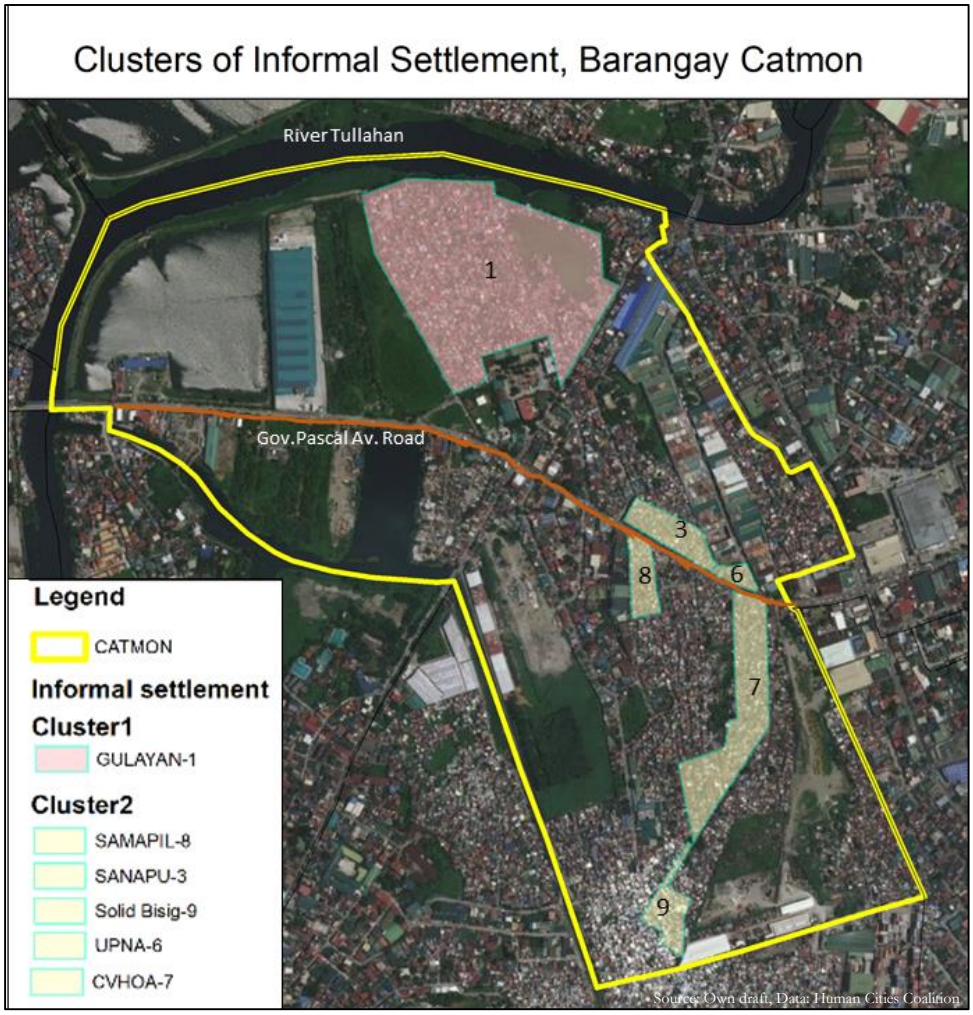
**Cluster 1: Informal settlement on the marine pond (swampy land)**

The informal settlement which is located in waterlogged low lying area which was initially used as fish ponds in Catmon. Houses in such settlements have raised plinth surrounded by dirty sewage water, water lilies and solid waste. Also, this group of settlement is located away from the road network which requires informal settlers to walk a long distance to get access to basic services. Following are the settlements located on swamp: Gulayan Pilapil HOA (Group1), Gulayan Catmon HOA (Group2 & 5).

**Cluster 2: Informal settlement on hydrosol soil type (landfill)**

Fishponds turned dumpsites in Catmon were gradually filled up using garbage and other solid waste material by informal settlers to occupy the land. The landfills are no longer swampy but are exposed to frequent flooding and land subsidence. Settlements are also located very close to major road network with easy access to road transportation. Following are the settlement location on landfill: SANAPU HOA(Group3), UPNA HOA (group6), CVHOA (group7), Samapil (group8), Solid Bisig HOA (group9).

Result section further elaborates on the difference in service provisioning target infrastructure in both Clusters of the selected informal settlement; hereafter will be referred as Custer 1 and Cluster 2 in upcoming sections




Map 6: Cluster of informal settlements, Barangay Catmon


Picture 3: Focus group discussion in Barangay hall, Catmon

## 4.5. Development of the Service Chain Management Framework

The study is targeting highly interconnected and interdependent infrastructure services, with significant value for service delivery to its users. Any impact or disruption of service delivery has a direct or indirect relation to the service delivery process of infrastructure services. These impacts or disruptions when driven by an interdependent component of service delivery process results in cascading effects. Therefore, to assess these cascading effects it essential to understand how infrastructure services are interdependent, what is the service delivery process of the infrastructure services, how each component of service delivery is connected to each other and how they will affect each other in the wake of disruption or failure.

**Infrastructure services in Service Chain Management**

To understand the service delivery process, this study assumed infrastructure services as a chain of services consisting of service elements linked to each other delivering services in a geographical area. As part of research methodology, the study has developed a service chain management framework based on the concepts of the supply chain management framework. Service chain management framework facilitates to understand the details of service delivery process to assess how service is getting transferred from one service element to another, which element of service delivery is getting affected in case of a sudden disruption (for, eg, natural disaster), and because of that disruption which service delivery element is getting affected. It also facilitates to assess, if the disruption is spreading across time and space affecting other service delivery components of the service chain.

Concepts of service chain management as adapted from the existing literature consists of service infrastructure, service support functions and final service delivery to its consumer (Voudouris, 2008). These concepts are explained below and take an example from electricity infrastructure to explain the concepts.:

- **Service support function:** Service support function in this study is defined as the physical facility supporting operationalisation of generation or processing the service as part of service delivery. For example, units/stations generating electricity
- **Service infrastructure:** Transfer of material/service in service chain takes place through service infrastructure linking of service support function. To deliver services in a large geographical area, infrastructure system is planned and installed as a network of service infrastructure linked to each other processing and transferring the service material from one support function to another and finally to its consumer. For example, electricity wires supply power to its users
- **Service delivery**: Delivery of final product of the service chain which may or may not have a tangible shape and size. For example, water can be defined as a tangible material whereas energy is intangible regarding its physical shape and size. Quality and quantity of service delivery can be assessed by the performance of service support functions and service infrastructure.
- **Consumer**: The consumer is the one who pays something to consume goods and services produced The consumer also forms part of the chain of distribution at the end of the chain, and beginning of the chain of collection infrastructure services.

The service chain management framework here serves as a generic model characterising service chain of infrastructure comprising of distribution based service (inflow of material) to its consumers and collection based services (outflow of material) from its consumer (figure3). For example, electricity is distributed to consumer and waste is collected from the consumer. The geographic spread of service chain of infrastructure can be defined based on the extent of the study area or specific requirement of the study. Following is an explanation of distribution and collection based services in the service chain management framework. Figure 3 presents service chain of distribution and collection based services.

1. **Distribution based services**: Infrastructure service which caters distribution or inflow of services to its consumers with distribution based service support function and service infrastructure (fig.2)

a. **Service support function:** Service support function which is used to further transfer service (material) to service infrastructure for distribution or processing at next service support function.
b. **Distribution infrastructure**: The distribution infrastructure which is used for carrying the service from one service support function to another.
c. **Service support function/distribution infrastructure:** Service support function/distribution infrastructure which is located within a specific geographic extent and used to further transfer service (material) to next service infrastructure for distribution at the consumer level.
d. **Distribution infrastructure:** The distribution infrastructure which is used for delivering the service at the consumer level.

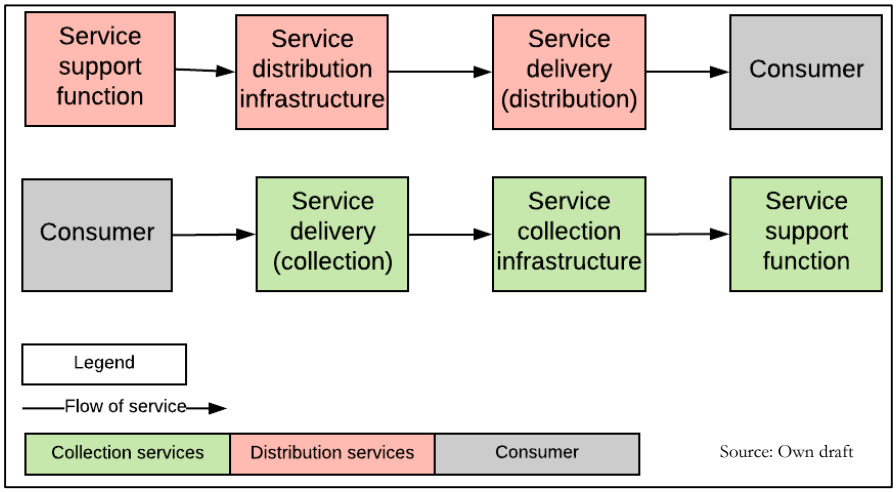



Figure 3: Distribution and collection based service chain

2. **Consumer:** In this study, the population of informal settlers are defined as consumers, consuming infrastructure services after paying a standard amount/cost fixed by service providers.

3. **Collection-based services**: Infrastructure service which caters collections of services (material) or outflow of from its consumers with collection based service support function and service infrastructure.
   a. **Collection infrastructure**: The collection infrastructure which is used for collecting the service at the consumer level.
   b. **Service support function/distribution infrastructure**: Service support function which is located within barangay receiving service (material) collected and brought down by service infrastructure to further transfer to another service infrastructure.
   c. **Collection infrastructure**: The collection infrastructure which is used for carrying the service from one service support function to another.
   d. **Service support function:** Service support function which is located at Barangay level and used to collect service (material) to service infrastructure for distribution or processing at next service support function.
4. **Interdependency or dependency of one service on another:** Infrastructure does not function in isolation. Services which rely on within or between two different services, for the final delivery of services are described as dependent service elements. The service delivery from infrastructure system is either dependent or interdependent on one or more than one infrastructure system. The dependency or interdependency can also be present within an infrastructure system to deliver services to its consumer. Different elements of infrastructure system can be dependent or interdependent on any element of a different infrastructure system depending upon the requirement of the element of the service chain to process or generate or transfer service material

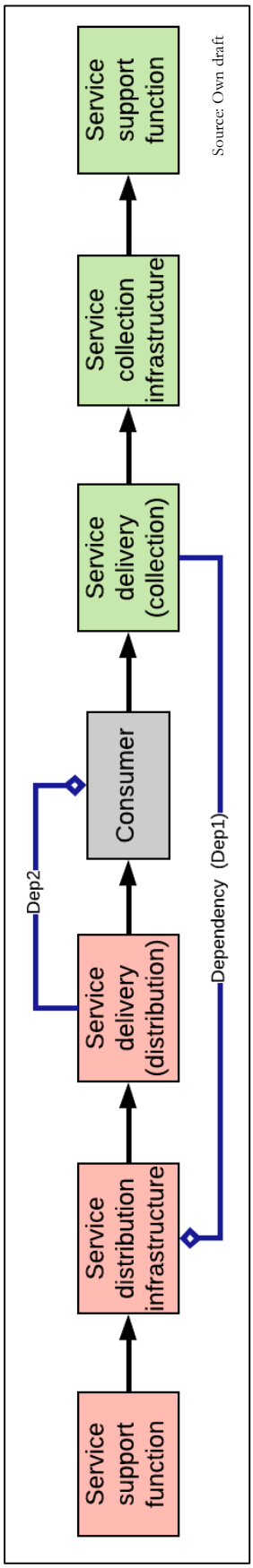



Figure 4: Service chain framework of infrastructure system

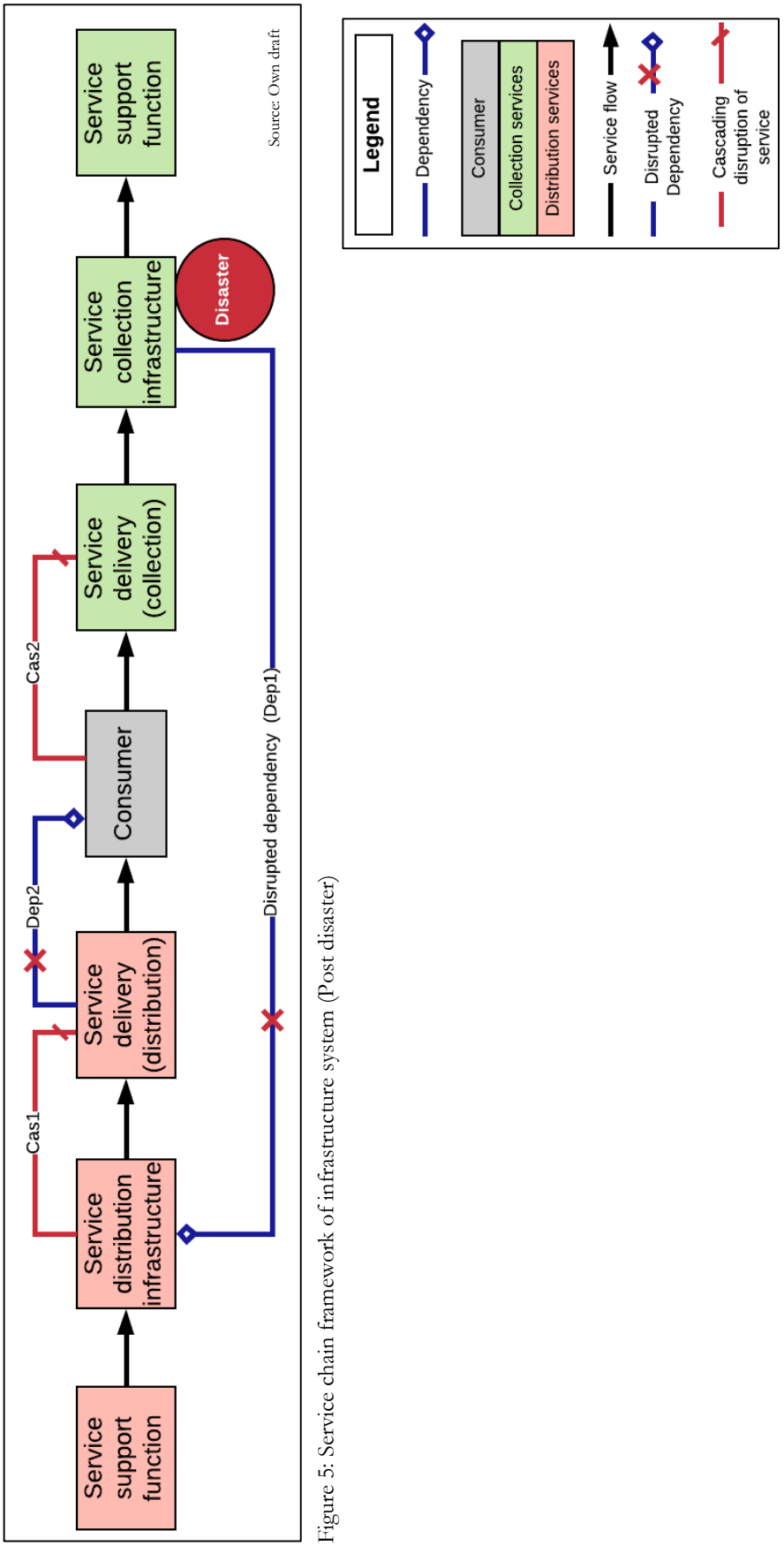



Figure 5: Service chain framework of infrastructure system (Post disaster)

Figure 4 describes an integrated framework of distribution and collection based service chain management framework. It also explains the dependency and cascading effects in normal (figure4) days and post-disaster conditions (figure5). The dependency link Dep1 in figure 4 describes that service distribution infrastructure is dependent on service collection infrastructure to continue delivery (distribution) of service to consumer (Dep2). However, if a sudden event (disaster) damages or disrupts (figure5) the service collection infrastructure, it will affect the service distribution infrastructure leading to disruption of service delivery and further with its impact on consumer (Dep2) (figure 5). Disruption of one element resulting in failure or disruption of one or more elements in a chain takes a form of the cascade (Figure5: Cas 1&2) and the resultant effects on different elements and the consumers of service chain, is defined as cascading effects (Rinaldi et al., 2001).

### 4.6. The anticipated value of Service Chain Management Framework

The service chain management framework is the main methodology in this study to analyse qualitative data on infrastructure services of water and sanitation from service providers to consumers in the study area. Service chain management framework in this study is assumed to offer simplification of complex impact of typhoon/floods on water and sanitation infrastructure services in informal settlements. This framework first breaks down the physical features of the infrastructure service system into sub-system and then each sub-system into smaller components. This twofold breakdown of infrastructure system characterizes the susceptibility of critical weak points for disruptions or failure triggered by a natural hazard, hence resulting in system failure with massive impact on the consumer of the services. Target infrastructures services in this study are presumed as a system consisting of a sub-system of specific services and are interdependent or dependent on each other for service delivery to its consumers. Concepts of service chain framework were used to identify service chain elements or smaller components of target infrastructure from primary data collected from service providers in the study area. Service chain with service elements is defined as acknowledged service chain of target infrastructure as the elements of the service chain derived from the authorised documents/officials from infrastructure service providers.
In this study, the application of the service chain management framework for assessing cascading effect has contributed to evaluating the service chain of target infrastructure. Each component of the service chain is assessed for pre and post-disaster conditions to identify cascading effect triggered by the typhoon on the target infrastructure and its impact on the population of informal settlers. Assessment of each component of service chain has also facilitated identification of critical weak points of target infrastructure which has further helped in identifying strategies and actions to reduce cascading effects triggered by the typhoon.

### 4.7. Data analysis using service chain framework model and thematic analysis

Primary and secondary data is analysed using different forms of thematic analysis by integrating it with service chain management framework. Data analysis is an inductive thematic analysis (Flick, 2014) which develops codes and themes from the data but also aligned with service chain framework. Thematic codes that have emerged from the data have been organised as the elements of service chain framework under distribution and collection based services. The service chain elements have been taken up as codes and categories from the existing service chain of target infrastructure of the study, in Malabon City. Unit of data analysis is FGD groups (HOA), spatially placed in the different location of study area.

**Thematic codes:** Coding is an explicit and iterative process in which the researcher alters and modifies the analysis as reflected by the data and as ideas emerge (Rabiee, 2004).

**Thematic category:** Some categories may contain clusters of coded data that merit further refinement into subcategories. Moreover, when the major categories are compared with each other and consolidated in various ways, it begins to transcend the "reality" of data and progress toward the thematic, conceptual, and theoretical (Saldana, 2008).

Table 5: Thematic structure of codes and categories for service chain

| Service chain management framework | Existing (Acknowledged) service chain | Status of the service chain | Data source |
|---|---|---|---|
| **Distribution Service chain (service chain elements)** | **Sub-system (Category) 1** | Indicative Statements from field data referring to codes | Interview and focus group discussion and secondary data |
| | Components **(service elements)**: Codes from empirical data | | |
| **Collection Service chain (service chain elements)** | **Sub-system (Category) 2** | Indicative Statements from field data referring to codes | Interview and focus group discussion and secondary data |
| | Components **(service elements**): Codes from empirical data | | |

**Thematic structure of codes and categories**: Table 5 defines a structure of codes and categories emerged from data and aligned as equivalent to elements to service chain which also emerged from primary data, developed based on codes emerged from field data (refer to annex1). Thematic structure (Saldana, 2008) is used to organise primary data (FGD and interview transcripts) to identify statements referring to service chain elements as codes or building blocks of the service chain. This is followed by organising identified statements under specific codes into categories of target infrastructure. The process of generating thematic codes and identification of statements referring to thematic codes was performed manually using transcripts of focus group discussion and expert interviews (wherever required). The thematic structure of codes is modified with pre and post-disaster (typhoon/floods) conditions to bring out data analysis for the status of water sanitation services to achieve research objectives of the study.

Qualitative data from interviews and FGD have been organised in a structure of codes and categories to bring out the pattern of codes and frequency of answers to specific questions and report on results for each research objectives. Figure 6 elaborates a workflow process flow of identification and organisation of field data in service chain framework model.

Table 5 is further developed into a detailed thematic structure of codes based on data collected from the field (annex1). This table is used as a guide for organising and elaborating details of water and sanitation infrastructure services using service chain framework (figure 4 & 5) for pre and post-disaster conditions to identify cascading effects in the service chain.

**Descriptive narrative** is used within thematic analysis to elaborate results on service chain framework. Results are explained for different service chain elements related to water and sanitation infrastructure and the events that disrupted the service chain after the occurrence of typhoon/flood. The narrative further supports in identifying the weak elements of service chain triggering cascading effect that emerge from the experiences shared by informal settlers in Barangay Catmon. Descriptive narrative is supported by quantitative data on the health of informal settlers of the study area to will triangulate primary qualitative data.

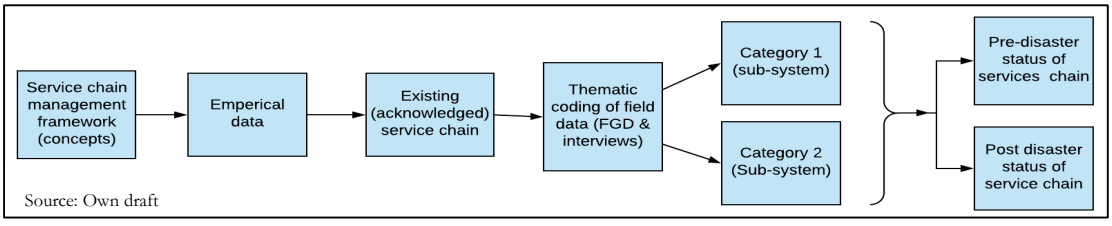



Figure 6: Workflow process

**Descriptive statistics** are used to organise and visualise health status of post-typhoon/floods condition.

Steps followed in obtaining results using service chain management framework model and thematic analysis to assess cascading effect. The generic model of the framework is used to describe existing status of water supply services and sanitation covering solid waste and faecal waste management services. Service chain elements for target infrastructure are further elaborated based on empirical data and service delivery plan of Malabon City Administration.

1. **Analysing existing status of infrastructure services in informal settlements**: Thematic coding of field data from Malabon City Departments and expert interviews followed by content analysis (descriptive narrative) resulting in a schematic representation of service chain framework of water and sanitation. The framework follows pre-disaster condition where no disruption has occurred. Service chain elements are the outcome of thematic coding from primary data as an acknowledged chain of service elements based on development plans in official documents. The schematic diagram of service chain is further used to organise FGD data from informal settlements into a service chain for water and sanitation services. This service chain for informal settlements is further compared with acknowledged service chain to identify the difference in service provisioning to informal settlers.

2. **Assessing cascading effects on disrupted infrastructure services triggered by typhoon**: The resultant schematic representation of the existing status of water and sanitation service framework is used for further visualisation of 'post-disaster' condition describing the disruption of target infrastructure that has taken place after the occurrence of a disaster. Results are presented using thematic coding and content analysis of field data. Cascading effect are assessed at this stage using the outcome of disrupted elements of service chain and the resultant impact on the community of informal settlements. The schematic presentation of service chain framework is modified for each cluster of informal settlements (figure 4) to visualise the differences in service chain and associated disruption triggered by the typhoon. Thematic analysis and thematic coding have been integrated with service chain framework to organise empirical data and visualise service chain based on pre and post-typhoon status of infrastructure services. Quantitative data on the health of informal settlers of the study area is used to triangulate primary qualitative data assessing cascading effects.

3. **Identification of critical weak elements in a service chain:** Elements of water and sanitation services which are weak and may be frequently disrupted by a disaster leading to cascading effects (critical weak points). Critical weak points will be referred as critical weak elements hereafter to follow service chain elements.
   The impacts caused by cascading effects on informal settlers is further aggregated using thematic codes (or quantitative codes) to bring out the weak elements of the service chain.

4. **Content analysis for (suitable measures):** Current actions of the community to reduce disaster impact, regulation practices of government and private actors, followed by identification of suitable measure to reduce cascading effects. The weak elements of service chain are used to identify suitable measure to reduce cascading effects.

## 4.8. Outline of research methodology

Figure 7 gives an overview of the research methodology followed in this research study.

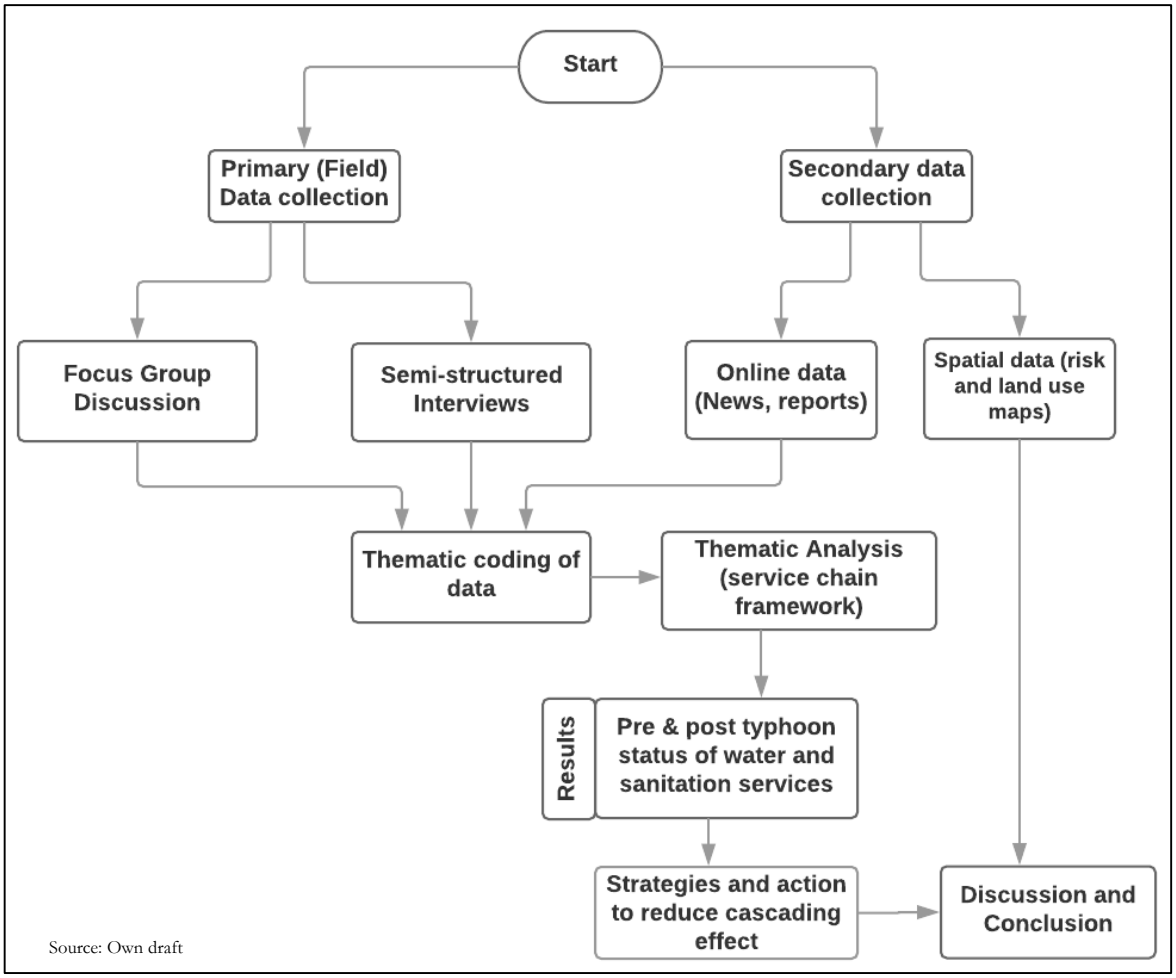



Figure 7: Research outline

# 5. RESULTS

This chapter explains the obtained results from data collected from focus group discussions and interviews in the study area. Results are presented for each sub-objective of research followed by a schematic representation of water and sanitation infrastructure services chain developed referring to service chain management framework. Water and sanitation service chains are explained using content analysis integrated with service chain management framework for normal days and post-typhoon conditions. The chapter concludes with current strategies and actions of informal settlers and Malabon City Administration for reducing the impact of the typhoon.

## 5.1. Overview of water and sanitation services in formal[9] settlements of Barangay Catmon

This section presents an overview of water and sanitation services in formal and authorised settlements of Barangay Catmon, Malabon City Administration. Description for an overview is captured from expert interviews with officials at Malabon City and Barangay Catmon, supported with secondary data from City Planning and Development Department of Malabon City. An overview is further used to develop service chain for water and sanitation services, based on service chain management framework (see figure 4 & 5), referred as 'acknowledged service chain'(annex1). The service chain developed, presents different service elements responsible for final service delivery to the formal settlements of Barangay Catmon.

### 5.1.1. Water Supply services

Water supply services in settlements of Barangay Catmon, are run in public-private partnership and are managed by Maynilad water services Inc. also being responsible for other cities and municipalities in the west zone of Metro Manila serving over nine million people currently. The agency works on a contract basis with Metropolitan Waterworks and Sewerage System (MWSS), a government agency. The water supply pipe network facility is owned by MWSS but managed by Maynilad for distribution of water from treatment plants to people (Metropolitan Waterworks and Sewarage System, n.d.). Maynilad supplies water in Barangay Catmon using different facilities, majorly by a deep well facility at Dona Juana Subdivision., Barangay Dampalit. This facility consists of a network of pipelines, elevated water tanks and reservoirs, which process and transfers water into the distribution network to further direct it to individual houses (Maynilad, 2015). Maynilad is responsible for regular repair and maintenance of distribution pipelines. The spread of pipeline is mostly underground (picture 4, source [10]) except in areas where laying underground pipe is difficult especially in a swampy area, landfills or near drainages. Water supply pipelines had asphalt lining and covered with cement to protect the pipes. As assessed by Maynilad, the water supply facility and distribution network are at high risk of getting affected by typhoons, heavy rains, landslide and mud/debris resulting in physical (high turbidity), chemical and microbial contamination (Maynilad, 2015).

Water distribution pipe network further extends from supply facility to individual houses with a metered water pipes at household level/business/semi-business (picture 5, Source[11]). Water meter connections are allocated by Maynilad after a legal application process by individual household/business. A monthly charge is paid for the amount of water used by a household; 118 pesos /month, varies for business and semi-business connection. A onetime payment of 2500 Pesos as connection charge is also paid. The interested household/business group must have a legal residential address, to obtain a household/business water meter connection.

[9] Urban settlement authorised by the administration

[10] http://www.mayniladwater.com.ph/media-photos.php


Picture 4: Water distribution pipeline network, Maynilad


Picture 5: Water meter, Maynilad

Based on figure 4 & 5, service chain elements are identified and developed into a service chain for water supply service built on primary and secondary data collected from service providers (section 5.1.1) within the geographical extent of Barangay Catmon, i.e., a service provider to consumers. In this service chain framework, water supply is defined as distribution based service delivery to its consumers (figure 8).
(Codes: W1: Maynilad water supply facility in Barangay Catmon, W2: Maynilad water network of water distribution pipes, W3: Maynilad water meters, W4: Individual water supply pipes connected to water meters. Dot lined service chain represents service chain management framework, and black lined service chain refers to water supply service chain).

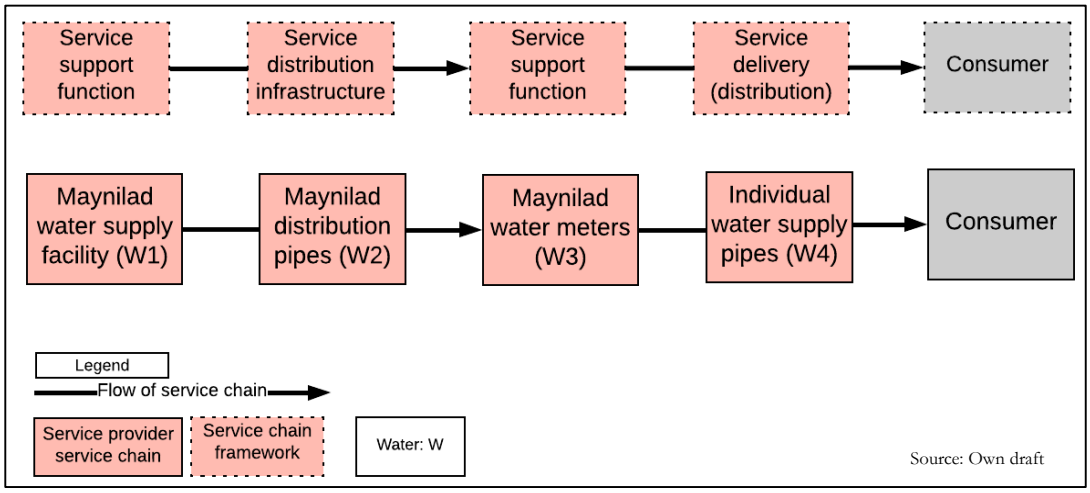



Figure 8: Water supply service chain in Barangay Catmon

### 5.1.2. Sanitation services

Sanitation services in this study are analysed including faecal and solid waste management under the same umbrella of sanitation as discussed in the literature (see section 2.1. 4, pg.6). However, both the services are managed by two different service providers in Barangay Catmon.

**Faecal waste management:** Maynilad manages wastewater in Barangay Catmon in the form of sewerage services. It involves the treatment of wastewater conveyed via a sewer network to Maynilad's sewage treatment plants. Maynilad also offers services for cleaning/desludging services for houses not yet connected with sewage line. This is a free service that is scheduled every five-seven years. The waste collected/cleaned from sewer network/septic tanks is further transferred to waste treatments plants for final disposal (figure 9) in Caloocan City (Maynilad, 2015).

**Solid waste management:** Solid waste management being a major challenge in Cities of Metro Manila (Westfall & Allen, 2004), Cities function on a country-wide law on ecological solid waste management[11]. But non-compliance with this law has become a challenge in almost all major cities of Metro Manila (Ranada, 2014). In Malabon City, Solid waste management is managed by the Department of City Environment and Natural Resources Office (CENRO). Presently, a solid waste management plan is under implementation in Barangay Catmon. Barangay has been allotted waste disposal locations, waste collection vehicles, human resources, and equipment. Each location has specific collection time daily/weekly, followed by transfer of waste at collection facilities. Also, in areas where it is difficult for the community to walk a long distance to discard garbage, pushcarts have been arranged to collect waste from each household. Solid waste is then transferred to a sanitary landfill in the neighbouring Navotas City for processing and final disposal (CENRO, 2015).

The sanitation service chain is developed (figure 9) based on service chain framework in figure 4 (pg.23). The service chain of sanitation is divided into faecal waste and solid waste service chain to distinguish between different service chain elements. Codes are assigned to service elements for reference purpose in further sections of results.

Faecal waste: FW1- Waste captured in toilets, FW2- Maynilad collection of waste by sewage network/desludging, FW3- Waste transfer to Maynilad waste treatment units, FW4- Waste treatment for final disposal

Solid waste: SW1- Waste disposal by consumers, SW2- Waste disposal facility provided by CENRO (Malabon Administration), SW3- Waste collection by CENRO, SW4- Waste treatment by CENRO.

[11] Republic Act No.9003: An act providing for an ecological solid waste management program, creating the necessary institutional mechanisms and incentives, declaring certain acts prohibited and providing penalties, appropriating funds therefor, and for other purposes.

Dot lined service chain represents service chain management framework, and black lined service chain refers to sanitation service chain)

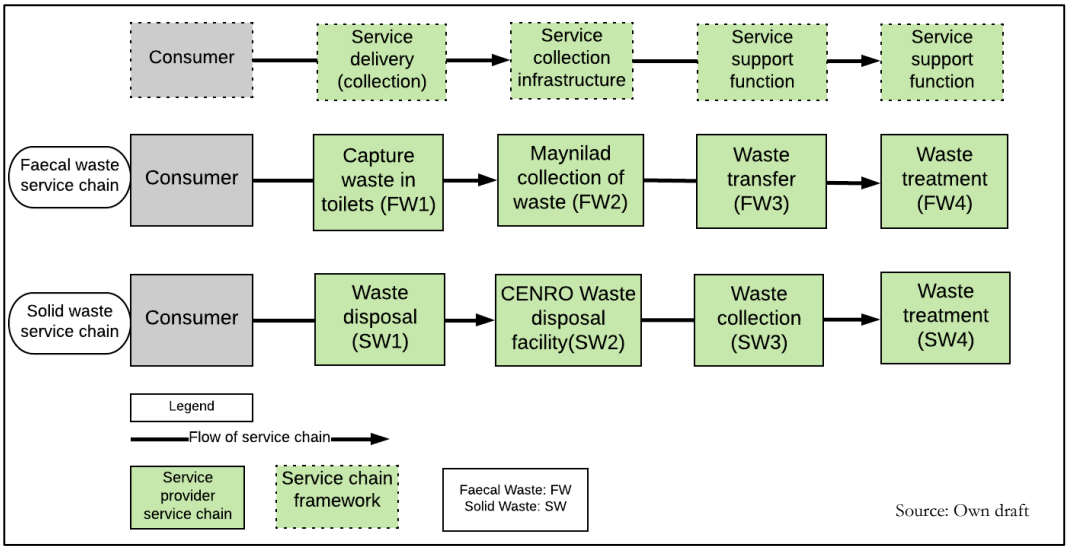



Figure 9: Sanitation service chain in Barangay Catmon

**Supporting services**

This study has also included electricity and drainage system as supporting services on which service delivery of water and sanitation services is dependent. Following is a brief description of how electricity and drainage system supports water and sanitation services:

**Electricity supply (E):** is privatised and run by Meralco, a private agency in collaboration with the Government. In this context, electricity has emerged as supporting service to assist water supply support function at Dampalit water supply station to run machines to supply water through the water pipes network in the assigned Barangays.

**Drainage system (D):** It is important to keep the areas clean, which consist water supply pipe network supplying water to its consumers, to maintain the quality of water supplied by Maynilad. As already mentioned in section 5.1, pipe network which is on surface needs more monitoring and safety to maintain water quality. There are certain parts of water pipe network which passes through or are close to drainages, requires frequent cleaning of drainage to prevent clogging and hence reduce the chance of water contamination, in case water pipes have leakage or damage due to some unforeseen circumstances. Department of CENRO is responsible for cleaning of drainages on a regular basis. Barangay Catmon is yet to get a planned network of drainages, but some of the priority areas which gets waterlogged frequently, have been provided with drainages to have an improved drainage system at Gov.Pascal Avenue Road (see Map 6, pg.23).

Figure 10 explains the acknowledged service chain of water and sanitation with its interdependent and dependent features. Maynilad water supply (W1) is dependent (Dep4) on electricity supply (E). Similarly, service elements (W2, W3 & W4) are dependent on its previous service element. Individual water supply pipes (W4) are dependent on (Dep4) on clean drainages (D) for continuous clean water supply. Likewise, W4 is also dependent (Dep2) on regular solid waste collection from disposal facility (SW2) to prevent clogging of supply pipes (W4). Toilets (FW1) are dependent (Dep1) on water supply (W4) to facilitate capturing faecal waste safely.

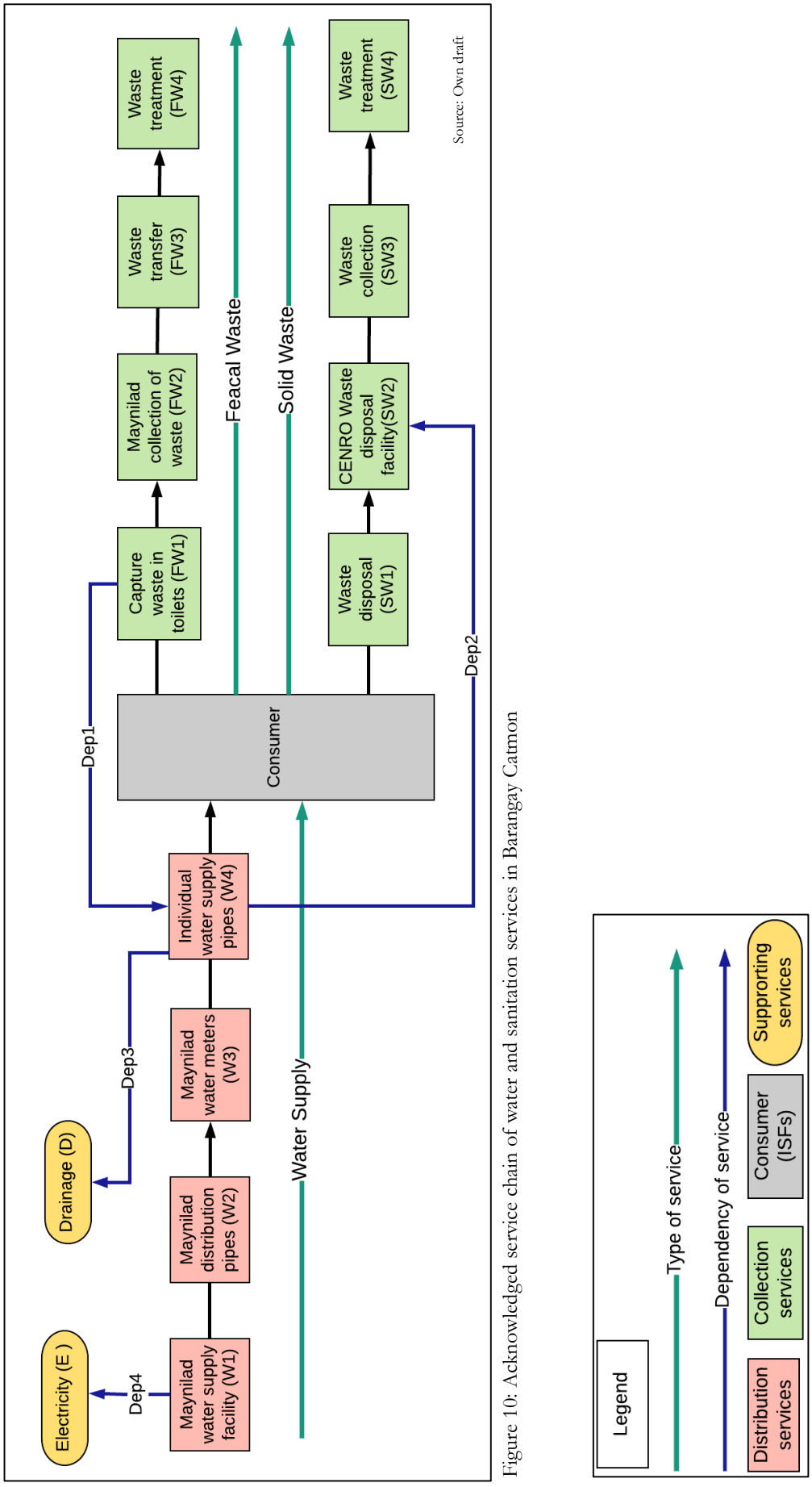



Figure 10: Acknowledged service chain of water and sanitation services in Barangay Catmon

In table 5 (pg.28), a thematic structure of codes was developed based on the service chain framework, for water and sanitation service chain for informal settlements in Barangay Catmon for normal (Pre-disaster) and post-disaster conditions. Annex1 is referred to develop service chain for selected Clusters of an informal settlement in Barangay Catmon.

## 5.2. Existing status of water and sanitation services in Clusters of informal settlements of Catmon

This section elaborates on availability, accessibility, quantity and quality of water supply and sanitation services, as captured from focus group discussion with informal settlers and expert interviews from Malabon City Administration (table 6). The results also highlight the services supporting service delivery of water and sanitation to its consumer. This section concludes with explaining interdependency and dependency of water and sanitation service chain.

Results presented in this chapter explains water and sanitation services for two Clusters of informal settlements in Barangay Catmon (see section 4.4, pg.21 ). The explanation also includes secondary data for selected informal settlements but are presented as Clusters of informal settlements. The flow of service chain is explained from Barangay level to consumer level (informal settlers-ISFs).

Table 6: Water and sanitation units and population ratio in selected informal settlements

| Cluster no. | Group No. | Informal Settlement | Total Population | Garbage collection points | Total Taps | Population & Tap Ratio | Total Toilet seats | Population &Toilet Ratio |
|---|---|---|---|---|---|---|---|---|
| Cluster 1 | Group1&2 | Gulyan Pilapil | 2640 | 1 | 0* | 0* | 440 | 6 |
| | Group5 | Gulayan | 6000 | 2 | 100 | 60 | 95 | 63 |
| Cluster 2 | Group3 | SANAPU | 2700 | 3 | 540 | 5 | 540 | 5 |
| | Group6 | UPNA | 552 | 1 | 95 | 6 | 92 | 6 |
| | Group7 | CVHOA | 1236 | 2 | 90 | 14 | 206 | 6 |
| | Group8 | Samapil | 1260 | 1 | 144 | 9 | 176 | 7 |
| | Group9 | Solid Bisig | 918 | 1 | 138 | 7 | 145 | 6 |

* Based on field data, group1 & 2, few families of informal settlers own water meter connection, but are installed close to a group5 settlement, and hence are calculated for group5, leaving zero value for group1 & 2 (Source: Human Cities Coalition).

### 5.2.1. Water supply service

Both Clusters of informal settlements receive water supply (figure 4) by Maynilad, as explained above via a network of water supply facilities, and **deep well facility (W1)** is one of them neighbouring Barangay Dampalit. The facility is dependent on **electricity (E)** to stay operational and continue supply water using a network of **water distribution pipelines (W2)** throughout the study area. To have access to these water pipes to collect water, informal settlers (ISFs) receive an endorsement letter from their Barangay Head to apply for **water meter connection (W3)**. The endorsement letter is given to ISFs for not having land title, as residential address proof is essential for water connection application. Participants from Cluster 2 stated that *"Only Maynilad provides water meter to informal settlers without the land title"*.

All the participants have their water meter connection. However, water meters are not installed at their doorstep, unlike formal settlements. Water meters are installed at the roadside (picture 6, image 1), due to the lack of space within the informal settlement, legal requirements and to prevent theft of water. Also, all informal settlements, selected for this study are located in either landfills or swamps making it difficult to lay water pipeline within the settlement


Picture 6: Water supply in Cluster 1 through swamp water

Images in picture chart 6 describe the flow of water supply from hosepipe to individual houses, starting from water meter at the roadside (image1). Water meter (image 1) is located next to solid waste disposal facility (picture 9, pg.41). Hosepipes further cross swamp water (image 2) under floating houses (image3 &4) clogged with solid waste and faecal waste. Some parts of Cluster 1 have raised pathways (image5) to walk within the settlement. Lastly, water collection takes place at the household level (image6).

Maynilad water meter connections are further connected with pipes to supply water to individual houses, hence called **individual supply pipes (W4)** installed by Maynilad in case of formal settlement. However, in both Clusters of informal settlement, individual supply pipes also known as **hosepipes** are installed by water meter owners. The connection holder also bears the cost of placing the hosepipes which are about 3000 Peso for 100-meter-long pipe and the cost increases with increase in distance of house to the water meter. It was observed that water hosepipes are made of plastic and are of poor quality. They were often damaged and poorly masked with plastic rags to prevent leakage. More than half of the FGD participants expressed that their water supply pipes are placed in bunches (picture 6, image 2) and reach their respective household only after crossing through garbage, drainage, swamp, dirty and stagnant water within the informal settlement, which frequently results in water contamination. Picture 5 describes the flow of water from the water meter to individual houses via hosepipes (W4).

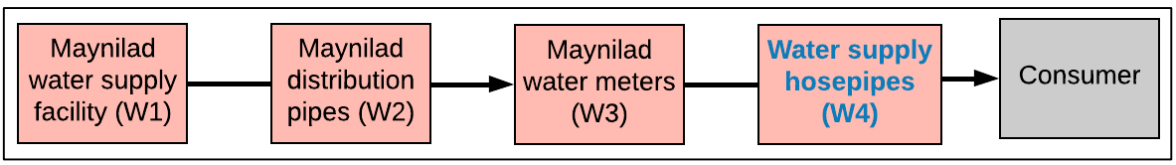



Figure 11: Water supply service chain in selected Clusters of informal settlements in Barangay Catmon

W4 in figure 11 indicates a change in service delivery mechanism of water supply different from acknowledged service chain formal settlements. Service chain element of water supply **(W4)** is dependent **(Dep4)** on electricity **(E)** via **W1** element for a continuous supply of water. **W4** is also dependent **(Depp3)** on Drainage **(D)** for clean water supply from unlogged drainages, dependent (Dep2) on efficient solid waste disposal **(SW1)** to prevent absorption of dirt from littered garbage by damaged hosepipes (figure 15 & 16).

**Perception of water supply service among informal settlers**

In terms of quality and quantity of water supply, different experiences were shared by FGD participants.

**Quantity**: All FGD participants expressed that water supply from Maynilad is available for 24 hours. The quantity of water is sufficient to carry out their daily chores including washing, cleaning and cooking purpose.

Table 6 is an approx. water tap and population ratio among which Cluster 1 has a very high dependency on water taps. Population from Group1& 2 are dependent on water taps installed in group5. Families who cannot afford to have an individual water meter connection borrow or pay for water from water meter owners. Water collection time for such families is 10-30 minutes. Money paid for water is 10-20 peso higher than the monthly fee paid to Maynilad. Hence, such families tend to reduce consumption of water quantity to save money. The ratio of Cluster 2 varies from 5-14 people /water tap, indicating people have better access to water service. However, table 6 is an approximation and does not give a clear indication of how many ISF households are dependent on other water meter owners.

**Quality:** it was a uniform consensus among all the participants that Maynilad water cannot be used for drinking purpose as they have faced health issues in the past. Their families, especially elderly and children, have suffered from diseases such as diarrhoea, stomach ache and dysentery after drinking Maynilad water.

*"Water hosepipes gets damaged as they pass through road, drainage and swamps or wastewater resulting in contamination of water". (*The participants from Cluster1).

However, participants also agreed that Maynilad water quality is good and safe till the time it reaches water meter. The major issue is believed to be the hosepipes vulnerability to damage and contamination.

Informal settlers purchase drinking water from local vendors selling potable water, preventing health issues from contaminated water supply form Maynilad (picture 6). Water purchased is in re-fill containers of 5 gallons costing 400-500 peso per month for a household size of 4-5 members. Though, paying an extra cost for drinking water in addition to the fee for Maynilad water supply is a burden for informal settlers due to their low economic background. However, they consider this expenditure as a small investment in health rather than spending a huge amount for waterborne diseases caused by Maynilad water supply.

### 5.2.2. Sanitation service

The service chain for sanitation delivers service in the form of a collection of refuse or waste from the consumer which is further transferred via different service chain elements for safe disposal or treatment to maintain a safe and hygienic environment for improved public health.

**Faecal waste management:**

As discussed earlier, it is mandatory to construct a septic tank or connect with sewage line for residents of Barangay Catmon, which is also applicable to informal settlers. However, results brought out two different types of waste capturing mode in informal settlements presented in here as service chain of faecal waste management in a Cluster of selected informal settlements in Barangay Catmon.

***Service chain for Cluster 1***

As explained earlier (see profile, pg.17), Gulayan being low lying waterlogged swamp, has a marshy growth and heaps of solid waste floating on the water surface, has no scope of concrete construction of septic tanks in the area. The community has adopted a makeshift measure, to **capture waste safely (FW1).** A wide pipe of diameter 2-3 meter is connected from the toilet at the raised platform and is placed 4-5 feet deep in the ground. The pipe crosses stagnant water to reach ground level and release waste 2-3 feet deep underground.

"If waste is released directly on the surface of the water, it gives very bad smell and is unhygienic", agreed by 18 participants from Cluster1. The approx. the ratio of people and toilets (table 6), access to a toilet in Gulayan is poor regarding the availability of toilets. However, all participants agreed that majority of families

have access to toilets wither individual or neighbour's toilet. However, there are few families with no access to toilet opt for open defecation or disposing of faecal waste along with domestic garbage.

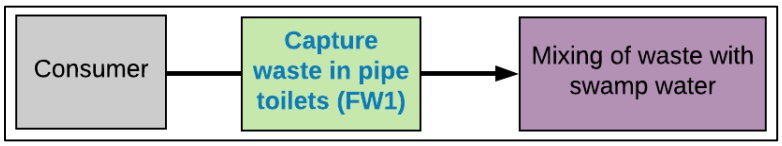



Figure 12: Cluster 1 Faecal waste service chain Source: Own draft

"The stagnant water area is covered with water lilies which lay above approximately 2 ft deep faecal waste (picture 7, red mark). Sometimes the waste rises or floats on the stagnant water making it difficult to use the toilet", shared by the participant from Gulayan. Faecal waste is not cleaned nor collected due to water logging in the area. Therefore, the service chain for Cluster 1 ends after service element FW1 (figure 12), resulting in the mixing of waste with swamp water leading to the unhygienic environment. Toilets (FW1) are dependent (Dep1) on the water supply to flush out faecal waste for safe disposal (figure15).

***Service chain for Cluster 2***

All the participants from Cluster 2, confirmed having their septic tanks as a mode of **capturing waste from toilets (FW1)**. They have solid flat ground to construct septic tanks in their settlement area. Barangay made it mandatory to construct septic tanks for informal settlements in Cluster 2. Table 6 describes that informal settlers from Cluster 2 have access to toilets with a good ratio. Following is the faecal waste management service chain for Cluster 2, which is similar to acknowledged service chain (figure13).

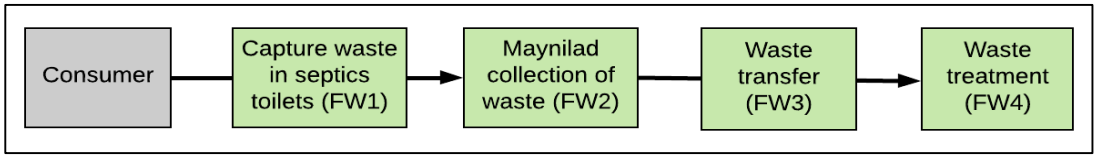



Figure 13: Cluster 2 Faecal waste service chain Source: Own draft

**Maynilad cleans septic tanks (FW2)**, only when the community has an endorsement letter approving that informal settlers can avail septic tank cleaning facility irrespective of land title issue (Expert Interview 8, pg.17). **Waste transfer (FW3**) is managed by Maynilad in case of septic tank cleaning for individual houses, and **waste treatment (FW4)** is carried out in Maynilad waste treatment facilities. Toilets (FW1) are dependent (Dep1) on water supply for flush out faecal waste for safe disposal (figure16).


Picture 7: Toilet pipes released in swamp water (Cluster 1)

**Solid waste management:**

Selected informal settlements located on flat, low lying terrain, are highly susceptible to floods. What worsens the flooding are the heaps of garbage that clog drainage systems and natural flow of water in and around these settlements. It has become a major challenge in flood management as well as maintaining a hygienic environment for the community residing in flood-prone areas. Following is an explanation of service chain of solid waste management developed referring to acknowledged service chain of Barangay Catmon.

The practice of **waste segregation** before disposal **(SW1)** is not very common among the residents of selected informal settlements in Catmon (picture 8). People dispose of mixed waste including plastics, clothes, scraped iron, glass pieces, kitchen and faecal waste and sometimes hazardous waste which can cause health issues. But the majority of families' dispose of waste in a plastic bag. Participants from Cluster 1 shared that few people in their community practice segregation of waste only to pick out waste such as iron pieces, wood or things which can be sold at a junk shop. All the participants agreed that landfill is filled with sacks made of garbage and solid soil. Sometimes this layer breaks resulting in littered garbage around that area.

A **disposal facility (SW2)** point has been allocated outside (picture 9). All the selected informal settlements and each disposal point have been allotted specific time for the collection trucks to collect waste. However, not many informal settlers visit disposal point to dispose of their waste. All FGD participants agreed that people prefer to throw waste near their house or dump it anywhere. Participants from Cluster 2 shared that the disposal facility in their area is located next to drainage, but people prefer to dispose of their waste in drainage than at the right place. Table 6 describes a number of garbage collection points in both the Clusters and frequency of garbage collection is regular (Expert Interview2, Pg.17). But the location of a disposal facility in each settlement is not favourable in terms of walking distance people cover for waste disposal. People residing far from the facility end up disposing of waste either in drainage or nearby river or close to their surroundings.

**Waste collection (SW3)** from the informal settlement is carried out by CENRO, daily or weekly as per their schedule from disposal facility. CENRO staff engaged in collecting waste finds it difficult to collect mixed waste from disposal facility.

*"People throw liquid and solid waste together. Sometimes they also dispose of faecal waste along with solid waste. We have to segregate waste at a different waste collection unit before sending it for final disposal. Segregation process makes it even more time consuming and increases our work".* (Expert Interview 2, pg.18*)*

All collected waste is then transferred to a sanitary landfill in Navotas City for **waste treatment (SW4)**. Waste is transferred from Malabon city to Navotas City using a trawler via Manila Bay.

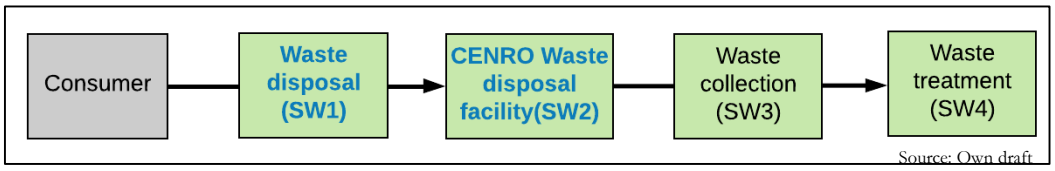



Figure 14: Solid waste service chain in selected Clusters of informal settlement in Barangay Catmon

Solid waste service chain developed (figure 14) based on results obtained. Service chain elements SW1 and SW2 are managed by CENRO, but all the elements are majorly affected by the role played by informal settlers. Due to lack of discipline to follow the rules on proper solid waste disposal, CENRO is unable to manage the service chain of solid waste effectively and efficiently. Remaining elements of service chain (SW3 and SW4) are affected by SW1 and SW2, resulting in delaying or mismanagement of the entire service chain. The service chain is same for both the Clusters of informal settlements.

**Perception of informal settlers about sanitation services**

Regarding faecal waste management, all participants in FGD agreed on having good access to usage of toilets. But communities staying in swamp areas (Cluster 1), have challenges of unhygienic surroundings in lack of septic tanks. For management of solid waste, all FGD participants expressed their concern for challenges of littered garbage is a major contributor towards the unhygienic environment, majorly due to of the residents' undisciplined waste disposal behaviour. They want Government to be strict with monitoring and strict implementation of regulations.


Picture 9: Floating solid waste in Cluster 1


Picture 8: Waste collection from disposal facility, Cluster 1

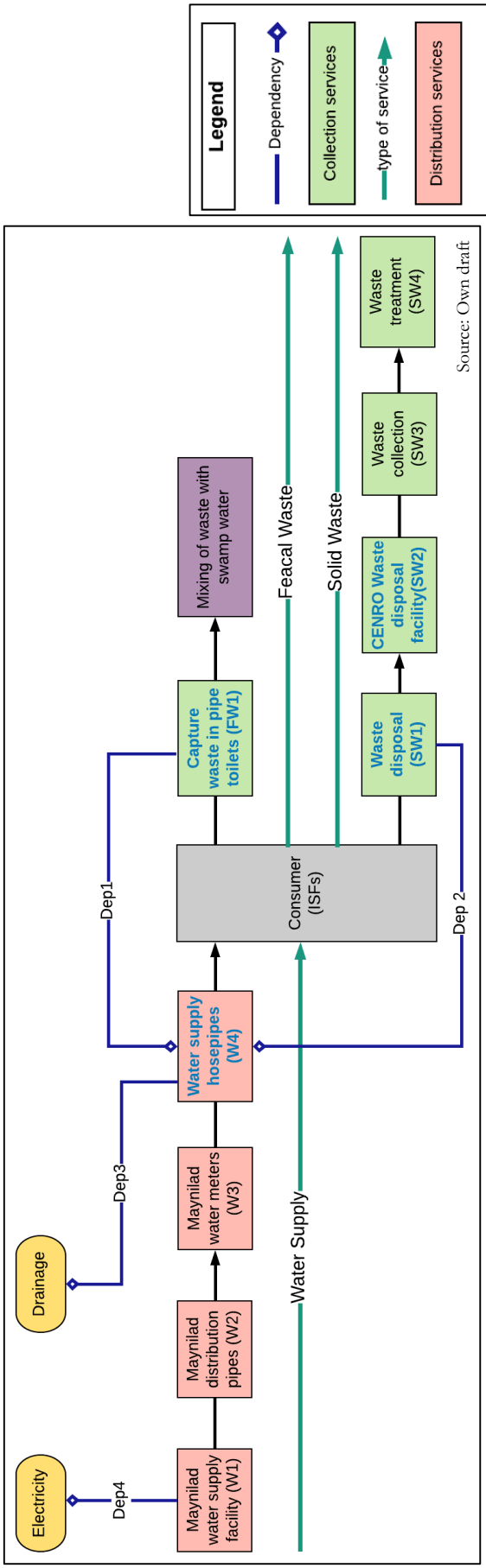



Figure 15: Water and sanitation service chain in Cluster 1

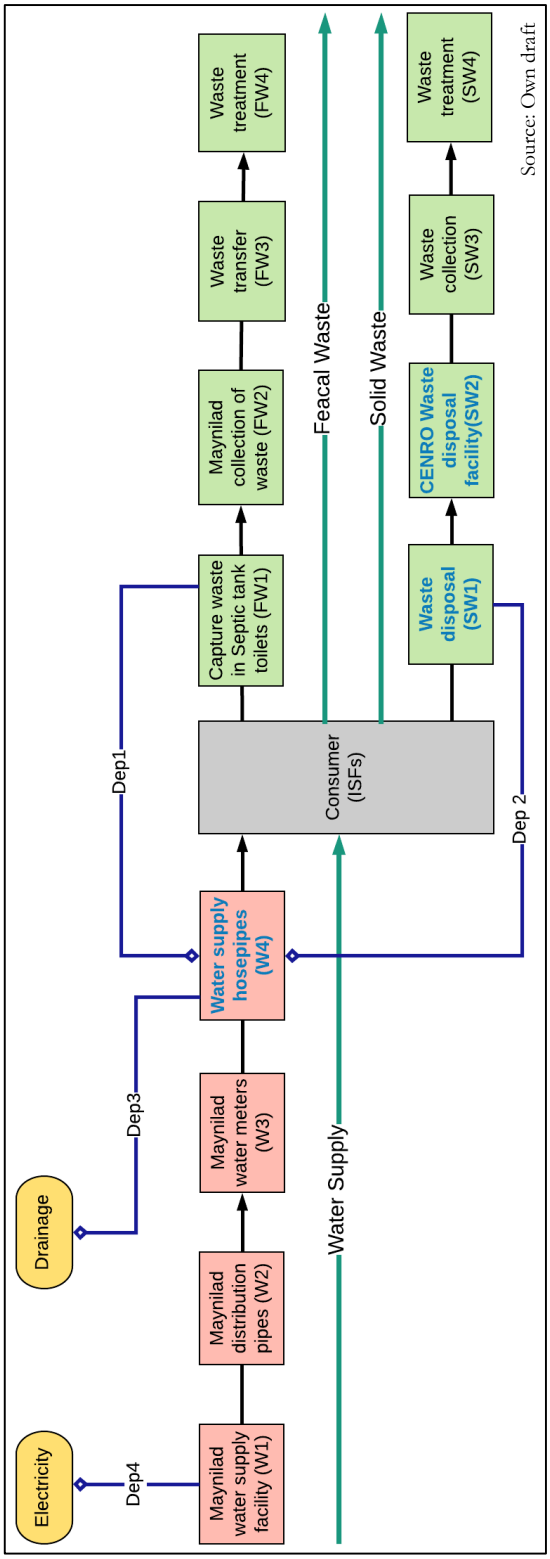



Figure16: Water and sanitation service chain in Cluster 2

## 5.3. Cascading effects on water and sanitation services and informal settlers post-typhoon Glenda 2014

This section assesses cascading effects on water and sanitation services in informal settlement clusters, after the occurrence of typhoon Glenda in July 2014. It first explains the impact on service chain of each infrastructure service, followed by an explanation of cascading disruption of water and sanitation services using service chain framework. The service chain framework in this section also explains interdependency and dependency factors driving cascading effects on services and informal settlers.

### 5.3.1. Status of water and sanitation services after typhoon Glenda

**Water supply service in Cluster 1 and 2**

**Water supply (W1)** from Maynilad was irregular during the occurrence of typhoon Glenda. FGD participants shared that reason for intermittent water supply was **power cut (E) and blocked drainages (D**). However, water was available with low pressure at irregular intervals even during heavy rainfall and floodwater inundation. **Maynilad distribution pipes (W2)** connected with **W1**, were functional as and when it released water supply. Maynilad water distribution pipes close to drainages and dump sites were irregular due to clogging, as reported by FGD participants. **Water meter (W3)** were functioning efficiently based on water received from distribution pipes. **Water quality from Hosepipes (W4)** reported by informal settlers was contaminated with a change in colour, odour and taste due to flood water inundation for more than 24 hours.

*"During typhoon Glenda, hosepipes placed without any support were shaking due to strong winds brought down by the typhoon, resulted in damage and leakage of hosepipes, in turn degrading the quality of water".* (participant from Cluster 1).

Damaged hosepipes absorbed dirty black sewage water from the swamp after flood water inundation, contributing to water contamination (picture 9).

*"Maynilad water we received 24 hours after heavy rainfall, was dirty and we used it only to flush toilets. We could not use it even for cooking and bathing purpose".* (FGD participant from Cluster 2)

Figure 17 & 18 present same status of disrupted water supply for Cluster 1 & 2.

**Sanitation service: Solid waste management in Cluster 1 and 2**

After floodwater inundation, **disposal of waste (SW1)** became more unorganized as people were unable to come to the waste disposal facility due to water inundation. Toilets became non-functional, resulting in the disposal of faecal waste along with solid waste in flood water or near their houses. During the progression of the typhoon, the practice of disposing of waste in the bag was also not practised. Solid waste was visible all around the settlements floating on the surface of flood water. Even the **disposal facility** (SW2) was submerged under water and could not be used for waste disposal**. Waste collection (SW3)** was not supported by CENRO to clean drainage and solid waste within the settlement. But floodgate in Cluster 1 was opened to release inundated water (picture 10). But due to clogging caused by solid waste in floodgate channel, the water level took 2-3 weeks to recede. No waste collection for 3-4 days left heaps of solid waste in and around settlements. During the headway of the typhoon, collected waste could not be **transferred (SW4)** to Navotas Sanitary Landfill, as mini ships carrying waste could not sail through Manila Bay (figure 17 & 18 present same status of solid waste service for Cluster 1 & 2).

**Sanitation service: Faecal waste management**

**Cluster 1:** Use of **pipe toilets (FW1)** was difficult after heavy rainfall, as swamp water level increased and all sewage waste wastewater had risen and pushed waste water in sewage pipes back in toilets. It made making non-functional for more than 48 hours. Also, toilets at a higher plinth which were functional, but could not be used due to intermittent supply of water. (figure17). All FGD participants agreed that they opted for open defecation in flood water. And some families dumped excreta in flood water in the plastic bag, making faecal waste floating on water surface which led to unhygienic surroundings.
**Cluster 2: Septic tank toilets (FW1)** within the informal settlements were functional after heavy rainfall and water flood water inundation. Participants from the FGD group confirmed having septic tanks underground with toilets high enough to stay functional during floods (figure18).
Collection of waste from the septic tanks and waste transfer for treatment is taken care by Maynilad which was not reported as a challenge after the typhoon.

### 5.3.2. Cascading effect on the physical infrastructure of water and sanitation

**Cluster 1**

Strong winds brought down by typhoon Glenda triggered the disruption of services in Cluster 1. With widespread disturbance **(Dep4)** of electricity **(E)** in Catmon (figure 17) resulted in intermittent water supply which led to insufficient access to water (Dep4). Due to disrupted dep4, it resulted in cascading effect **(Cas1 to Cas3)** on service elements **W1 to W3.**
24 hours of intense winds were followed by heavy rainfall, and floodwater inundation raised the water level of swamp water bringing up sewage **(FW1**) and solid waste **(SW1)** on the surface of flood water. Solid waste clogged the natural flow of water out of the community. High tides from river Tullahan brought in more water and solid waste in the community through the small water channel. Gulayan being a low lying area was under flood water for more than two days resulting in contamination of water supply hosepipes **(W4).** Toilets became non-functional in lack of water supply **(Dep1).** In some cases, toilets were submerged in flood water, and sewage waste was pushed back in toilets and the houses. Water supply **(W4)** got contaminated **(Dep2)** due to heaps of solid waste and sewage water. In Cluster 1, since toilets were non-functional, community opted open defecation and disposed waste on flood water, resulting contamination of flood water leading contamination water supply in hosepipes **(Cas4).** Similarly, due to the typhoon, a huge amount of solid waste **(SW1)** got accumulated **(Cas5)** in and around Cluster 1, in lack of waste collection by administration **(SW2).** This led to clogging of natural drainage **(Cas 6)** within the settlement, resulting in increased level of flood water inundation. Natural drainage channel (See section 4.1, pg.17) got clogged with heaps of solid waste and prevented flood water from subsiding through river water. The community was inundated with flood water for more than two days. Drainage clogging not only clogged hosepipes (dep3) but also contaminated water supply **(W4).** For Cluster 1, the impact of the typhoon and cascading effect was majorly on Hosepipes **(W4**), Pipe toilets **(FW1**), waste disposal **(SW1**) and waste disposal facility **(SW2)** service elements of water and sanitation service chain.

**Cluster 2**

Electricity **(E)** failure due to typhoon Glenda led to intermittent water supply affecting all the elements of the water supply service chain (figure 18). Informal settlers received insufficient water supply **(W4)** due to cascading disruption of water supply from **W1**. Water supply **(W4)** also dependent **(Dep3)** on drainages **(D),** service provider stopped water supply as drainages were clogged to prevent water contamination and damage to pipes especially for pipes passing via through concrete drainage on Governor Pascal Avenue road. All the informal settlements in Cluster 2 have septic tanks attached to the toilets and were functional during typhoon Glenda. However, due to intermittent supply, participants shared that they had to store water to use it for toilets during heavy rainfall and flooding.

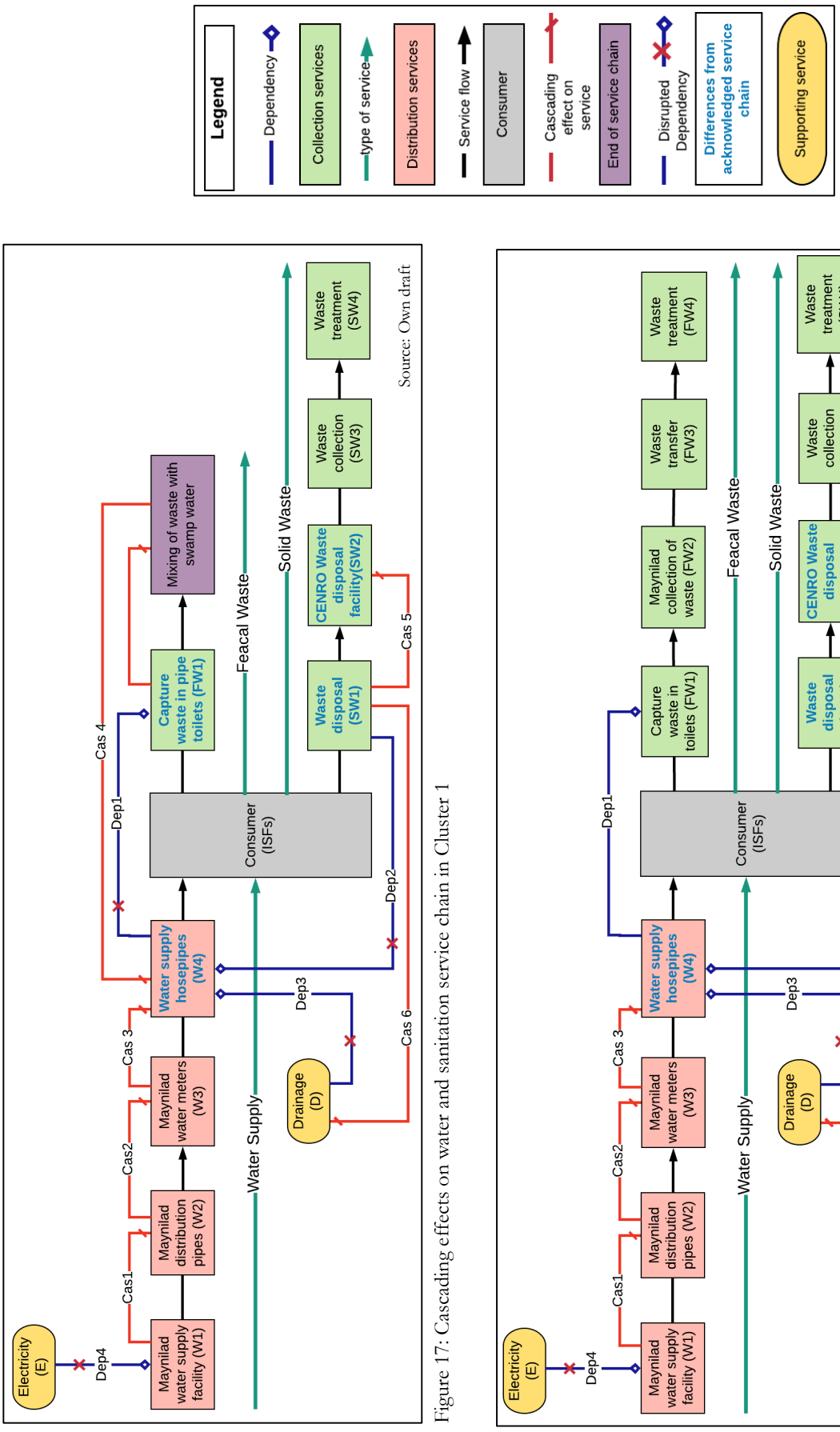



Figure 17: Cascading effects on water and sanitation service chain in Cluster 1




Figure 18: Cascading effects on water and sanitation service chain in Cluster 2

Accumulation of solid waste **(SW1)** within the informal settlements emerged as a major challenge as it clogged drainages **(D)** close to the settlement, resulted in contamination of Hosepipes **(W4).** Accumulation of solid was majorly due to delay in the waste collection from the administration **(SW2)** and unsystematic disposal of waste by the informal settlers **(SW1).**

Figure 18 elaborates on water distribution from the hosepipes **(W1))** is dependent **(Dep2)** on waste disposal **(SW1)** and disposal **(SW2)** by the informal settlers. However, after typhoon Glenda, quality of water supply was dependent on waste disposal, and unorganised waste disposal led to contamination of water via damaged hosepipes. Solid waste disposal during and after typhoon Glenda **(Cas5)** also affected **(Cas6)** drainage system **(D)** in Cluster 2, by clogging the drainages which further led to increased level of flood water for more than two days resulted in the inundation of hosepipes **(Dep3)** degrading the quality of water. Disrupted dependency here is also considered as cascading effect affecting associated service element in the service chain.

### 5.3.3. Impact of cascading effect on informal settlers

W4, FW1, SW1 and SW2, service elements being the last service delivery elements to informal settlers, left community affected after typhoon Glenda regarding health, socio-economic losses and disrupted access to water and sanitation services, essential for human well-being, as reported by the FGD participants.

**Cluster 1**

**a) Water and Sanitation service**

Due to degraded water quality from Maynilad, ISF community stopped using water for cooking and cleaning. Individuals especially children who either consumed Maynilad water or were in prolonged contact with the water fell sick.

People shared that they had to swim through sewage water which resulted in health challenges such as water-borne diseases and skin diseases. Maintenance of personal hygiene was also affected by lack of access to sufficient clean water also led to skin diseases. Informal settlers were unable to use toilets for 3-4 days until flood water receded after the occurrence of typhoon Glenda. People started practising open defecation or disposing of faecal waste in flood water. This resulted in highly deplorable and poor condition of cleanliness and unhygienic surroundings within the settlement.

**b) Health challenges:**

Few FGD participants reported that there were 7 cases of diarrhoea, 2 cases of dysentery and 5 cases of stomach ache especially among children who consumed Maynilad water. Cluster 1 is a low lying area also received solid waste from the neighbouring settlements along with flood water after heavy rainfall, degraded the living condition in the Cluster. Due to the huge amount of solid waste including food waste attracted many rodents resulted in cases of leptospirosis, skin diseases among people who had to swim through the wastewater. Consumption or prolonged skin contact with contaminated water led to health issues among informal settlers with the increased financial burden. In total 53 cases were reported among the families of FGD participants.

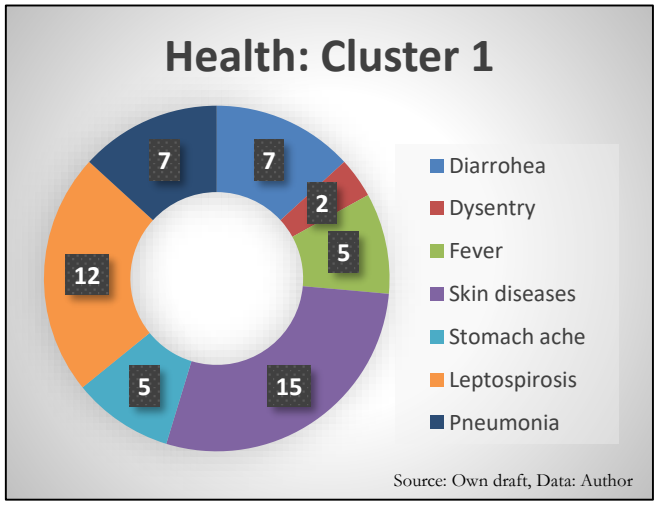



Figure 19: Health issues in Cluster 1

**c) Economic loss:**

**Purchasing mineral water:** The community was dependent on local vendors for drinking and cooking water after water supply was affected. Two participants shared that few local vendors increased the price of mineral water container by 10% than the usual cost, as the demand also increased after typhoon occurrence. Due to intermittent and not fit for use water supply from Maynilad increased expenditure on purchasing mineral water due to inadequate water availability in the market.

**Loss of livelihood and mobility:** Huge amount of solid waste got accumulated on the surface of stagnant water. Waste collection by government staff delayed due to flood resulted in clogging of water within the settlement, delayed water subsidence from the community. Prolonged flood water inundation affected the community regarding the loss of daily wage livelihood, transportation, inability to reach health centre for medical assistance and other daily chores resulted in disabling the community for almost a week after Typhoon Glenda

## Cluster 2

**a) Water and sanitation services:**

Purchase of water from local vendors increased more than regular days, due to the disrupted and contaminated water supply.

*"After Typhoon Glenda, we received a bucket of water for each household from Fire department for our daily use. It was not sufficient, but we had no other option".* (Participant from Cluster 2).

Contaminated floodwater inundation for more two days resulted in skin problems and fungal infections among informal settlers who walked barefoot in flood water to avoid slipping on slimy pathways.

*"Excessive solid waste all around our settlement clogged the natural flow of flood water resulted in the inundation of water for a long duration in our area. Waste collection staff did not come immediately after the flood water recedes. We cleaned it as much we could, but it was not effectively cleaned".* (Participant from Cluster 2).

**b) Health challenges:**

Informal settlers shared that the surroundings became very unhygienic. It contaminated flood water with faecal waste, which was already dirty due to littered solid waste. With knee high flood water level, people had to swim across it to go out of the settlement. Prolonged exposure of skin to dirty sewage mixed water resulted in skin diseases and other water-borne diseases. It was also shared by participants that some women also contracted Urinary tract infection for using unhygienic toilets. Figure 20 gives a glimpse of health issues reported after typhoon Glenda in Cluster 2, with a total 34 cases among the families of FGD participants.

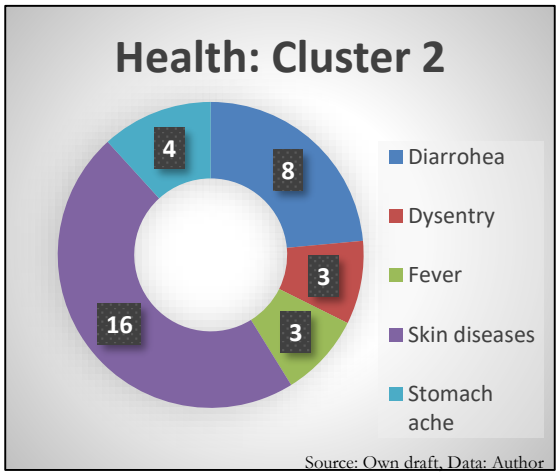



Figure 20: Health issues in Cluster 2

**c) Economic loss:**

**Purchase of mineral water:**

Purchase of mineral water increased, as demand increased due to the irregular and bad quality of water supply in informal settlements. Cost of mineral-water increased by 10% of actual price which affected informal settlers financially.

**Loss of livelihood/mobility:** People were unable to go out due to floods resulted in the loss of income and in some cases even livelihood. However, Cluster 2 had fewer challenges regarding mobility as the

settlements are connected to the major road of Barangay Catmon and were able to resume their routine due to easy access to road transportation when compared with Cluster 1.

### 5.3.4. Critical weak elements (points) of water and sanitation service chain

Though cascading effect on service chain was triggered by typhoon Glenda, but the poor condition of service delivery of water and sanitation services aggravated the impact on informal settlers. The results on assessment of cascading effects on service chain identified service elements responsible for disrupting dependent elements (figure 17& 18). The cascading effect triggered by typhoon Glenda majorly revolves around the following elements of service chain framework:

1. **Water supply: Distribution hosepipes (W4)**
2. **Sanitation: a) Solid waste disposal (SW1) and Waste disposal facility (SW2), b) Faecal waste capture (FW1)**

Above mentioned service elements of water and sanitation services triggered disruption of dependent services (figure 17 & 18). These elements are responsible for delivering the services (distribution and collection) directly to the customers (informal settlers). Above mentioned service elements are also the same elements identified as components with different service delivery process from acknowledged service chain of Barangay Catmon (figure 15 & 16). From the description of service delivery process in section 5.2, identified service elements are managed by informal settlers and therefore, lack a control mechanism on quality of service delivery.

Informal settlements (Cluster 1) located in swamps suffer more challenges regarding health and hygiene when compared with settlements located on landfills (Cluster 2). The difference in habitat condition of Cluster 1 (see pg. 22), resulted in extremely unhygienic conditions and disruption of water and sanitation services after the occurrence of typhoon Glenda. Health issues are higher in Cluster 1 in comparison to Cluster 2. Cases of leptospirosis are also high indicating the presence of rodents due to severe unhygienic surroundings in Cluster 1. Although Cluster 2 had major challenges regarding solid waste management which resulted in skin diseases, unhygienic conditions are not as severe as Cluster1.

Service delivery process of Cluster 1 & 2 indicates towards service elements directly connected to consumer (informal settlers) playing a major role in worsening the condition of water and sanitation services leading to health issues. Moreover, factors such as less or no external disaster relief support, inability to afford health services and increased burden of expenses resulted in increased health issues were reported more in Cluster 1 than in Cluster 2. Next section elaborates factors exacerbating the service delivery process in informal settlements.

### 5.3.5. Factors worsening the impact of cascading effects in Informal Settlement

The service chain management framework facilitated the assessment of water and sanitation service chain to identify cascading effect and the critical elements responsible for the disruption of service delivery to its users. However, there are some underlying factors which played a crucial role in worsening the impact of cascading effect on service infrastructure and informal settlers.

**a) Government response to support informal settlers after typhoon Glenda**

FGD participants from both the Clusters reported that they received evacuation warning on July 13th for Typhoon Glenda. However, they decided to stay back in their houses as they were afraid that families are looking for house space as informal settlers may occupy their space. 5 participants from Cluster 1 shared that they have experienced this forceful occupancy of space in the past and hence are afraid of leaving their houses even when it is risky to stay back. ISF families who evacuated and took shelter in the evacuation

centre at Barangay Hall were supported for 3-5 days by Department of Social Welfare and Development, Malabon City with food, water and medicines. However, families who stayed back in informal settlements were not supported by the government. However, as shared by DSWD, that families or individuals who were in the evacuation centre, were supported with relief irrespective of their status as informal settlers or not.

**b) Health care services**

In case of health issues, informal settlers have access to the health centre at Barangay Hall located centrally in Barangay Catmon for basic health issues. But severe cases emerging after the occurrence of a disaster, are referred to private/public hospitals, which are unaffordable for the needs of informal settlers. Access to primary health care is not equitable for informal settlers. The government insurance system (imoney, 2018) does not cover informal settlers due to their unrecognised residential status. However, low-income families if approved by the department of development and welfare are supported by insurance. Although, from primary data, it was clear that informal settlers are not recognised for such benefits (PhilHealth, n.d.). Therefore, expensive health care opted by informal settlers leads to the financial burden on the affected family and a long-term impact due to recurring economic losses caused by frequent disasters in the area.

*"We prefer not to visit hospital unless it is very serious, we cannot afford expensive medical treatment. Moreover, after typhoon Glenda, the services provided by the hospitals assisted by the government were not sufficient. It became very chaotic to collect medicines and created conflicting situation because of too many patients". (*FGD participant from Cluster 2).

**c) Exclusion of informal settlers from the formal mechanism of disaster management**

As discussed in result section, informal settlers reported no or negligible support from government system after typhoon Glenda. However, people who moved to evacuation centres were supported with relief goods. There is no formal mechanism to support families from informal settlements especially when evacuation is not an option for such families. Exclusion from relief support and extended stay in an affected informal settlement with disrupted services increased the risk of health issues and increased expenditure on it.

**d) Land tenure security**

There is a close correlation between land tenure status, access to services, and public health. Lack of land tenure security pushed informal settlers to occupy space in landfills and swamps with dirty and unhygienic surroundings. Installation of basic service infrastructure in landfills and swampy land type incurs a huge cost for service providers. Also, as part of legal requirements, it also required authorised residential status to have access to such services. Therefore, in case of informal settlers, it is difficult to have access to basic services of water and sanitation leading to acquiring temporary access through Barangay or illegal access. In both, the cases service quality and reliability are compromised leading to public health challenges. Also, some settlements also face the challenge of eviction threat from private landowners and hence, government prevents a service provider from providing services in informal settlements. Informal settlements registered under community mortgage programme, do not face eviction threats. But due to the condition of land (landfill and swamps) service provision is still challenging.

**e) Spatial location of water and sanitation service infrastructure for informal settlements**

As presented in section 5.1, the negligent behaviour of informal settlers towards usage of water and sanitation facilities is one among the major factors resulting in cascading effects in the service chain. However, spatial placement of water taps and solid waste disposal facilities plays an important role in the negligent behaviour of people. In both the Clusters of informal settlements (see map 6, pg.23), these facilities are located either on the periphery of the informal settlement or close to road network to monitor, lack of space and avoid high installation cost of services on landfill and swamp, as shared by Barangay Head. It has increased the distance between facilities and houses of informal settlers. It emerged from focus group discussion that to save time and effort of walking; people end up disposing garbage near their houses,

resulting in contamination of water hose pipes **(W4).** There is a lack of coordination and interaction between local administration, service provider and service users (informal settlers) to integrate user preferences for the placement of service infrastructure.

**f) Service provisioning in encroached risk zones**

Due to the land deficit in Barangay Catmon, migrants from other provinces of the Philippines encroached risk zones as informal settlers close to the river and other waterways. Such informal settlements are called as 'dagat-dagatan' (for areas that are frequently flooded) (Ragragio, 2003). While there is an acceptance that informal settlements are illegal, informal settlers perceive themselves as legal citizens awaiting government action for housing provision and continue staying on encroached land with poor living conditions. Department of Disaster Management of Malabon City have listed such encroachments as factors worsening the impact of floods and sometimes a reason to cause flood during monsoon season. Government is relocating such informal settlers, by force eviction and prevents service providers to install services close to such areas. For, eg. Gulayan Pilapil HOA in Cluster 1 is close to river Tullahan and hence are dependent for water supply on Gulayan HOA also in Cluster 1.

**g) Exposure to multi-hazard risk**

Informal settlements in Barangay Catmon also susceptible to the earthquake (Severe-degree VIII[12]), high risk of liquefaction and storm surge (see annexe 6, pg.76). Illegal electricity connection with unsafe wiring within informal settlements also makes it prone to frequent fire accidents. The combined effect of multi-hazards and poor living conditions in informal settlements traps informal settlers in a vicious circle of recurring economic loss due to frequent disasters making them even more vulnerable to future disaster and associated risks. This vicious circle of recurring disasters and economic loss leads to resilience attrition over time among the informal settlers.

Above mentioned factors affect access to physical service infrastructure in one or the other way. They are intertwined with each other and are directly or indirectly associated with the formal mechanism of service provision of local government. The government implemented programmes and regulations to support informal settlers to reduce the impact of disasters. Some were successful, and some failed to yield the target objective. Informal settlers developed their own coping mechanism which is mostly dependent on their social network. The following section describes the current actions and regulations for informal settlers by the local government, external agencies (NGOs) and informal settlers.

## 5.4. Current actions and regulations to reduce the impact of typhoons

This section describes the current practices and regulations adopted by informal settlers and local administration to reduce the impact of typhoon/floods.

### 5.4.1. Informal settlers' current actions to reduce the impact of typhoon/floods

Barangay Catmon is frequently exposed to natural disasters, and the inhabitants of the informal settlement have developed local practices to reduce impacts of typhoon/floods. Following are some of the practices developed in both the Cluster of selected informal settlement.

**Cluster 1**: Gulayan area being a waterlogged swamp, families have raised the plinth of their houses on wooden poles to stay safe. However, high floor plinth does not help much during high flood levels. The community has also constructed raised pathways (picture 7, pg.44) with community funds called *'Bayanihan'* translates to cooperation in Tagalog. Raised pathways connected them with major road and within the

[12] Modified Mercalli Intensity scale

settlements. Some households also have to makeshift boats which are used during floods to navigate through swamp water. For management of water and sanitation services, the community does not have specific practices. However, some households practice storing water once an early warning is released for flood/typhoon. Some families boil water for infants and elderly. From focus group discussion, participants shared that their settlement has severe hygiene issues which result in health challenges, especially among children. But safe hygiene practices are not very prevalent in the community and also not encouraged within a household. It was also observed that awareness regarding safe hygiene practices is not very high. However, people do practice some basic like hand washing and boiling water, but not practised by the entire community.

**Cluster 2:** Informal settlements in Cluster 2 have better access to toilet and sewage system, which makes an informal settlement in this Cluster less susceptible to vector-borne water diseases. To reduce the impact of typhoon/flood, families who can afford have constructed the second floor in their houses, though it's temporary but saves them during flood water inundation. -FGD participants shared that within their community few families run business for food, medicines, water and other household utilities. They perceive it as a support mechanism to help each other during the crisis with resources they have.

As a precautionary mechanism to continue staying in the settlement, families usually prefer to stay back in their houses during floods instead of evacuating, as they fear that their house space will be occupied by other ISF families, as there is no recognition for land title. Community in both the Clusters follows savings group run by Homeless People's Federation local NGO to support their families during emergencies. Also, informal settlers in both Clusters are active to register their settlement for Community Mortgage Programme which will help them to buy land title for the land they have occupied currently. With the land title in their name, informal settlers will be eligible to construct their own houses and get the benefit of basic infrastructure like any other authorised resident of Barangay Catmon.

### 5.4.2. Regulations and practices of local government and non-government organizations to reduce the impact of the typhoon.

**Malabon City Administration**

**a) Disaster Management plan**

Barangay Catmon Administration under Malabon City is currently implementing a robust disaster management plan which includes disaster risk reduction and preparedness, disaster response and relief, and rehabilitation and recovery for residents of Barangay Catmon. The current structure of disaster management plan consists of well-established disaster response operations, adequate and prompt assessment of needs and damages at all levels, safe evacuation, temporary shelter needs, basic health services provided to affected population whether inside or outside evacuation centre and coordinated, integrated system for early recovery implemented in coordination with other departments such as Housing, City Planning and Development Department, DSWD and CENRO. However, these plans are applied uniformly to Barangay residents, which directly or indirectly have excluded informal settlers from many formal mechanisms of disaster management and risk reduction plans. Informal settlers are supported with government relief and shelter support in evacuation centres when a disaster occurs. However, people who choose to stay back in the settlement are often neglected and are unable to receive relief support on the pretext of not reaching evacuation centre or Barangay Hall to collect relief.

### b) Housing for informal settlers

Barangay Catmon suffers from the land deficit; housing is not only difficult but economically unrealistic for informal settlers pushing them to stay in a high-risk area prone to disasters. The current government is on a crusade to address this problem by planning to relocate the families staying in the high-risk area, however, which faced opposition in Barangay Catmon, as informal settlers developed their social network and shared identity with the place. However, the government recognises land occupied by ISF families as informal settlements in current land use plan (see annexe 7, pg.77), and simultaneously implementing 'Community Mortgage Programme' (see section 3.3, pg.13) to facilitate the process of buying a land title by the informal settlers from its owners. Buying land title will allow informal settlers to construct their own houses and have access to authorised basic infrastructure. Government is also engaged in relocating informal settlers from the risk zones to safer areas, especially families staying along waterways, outside the City or Metro Manila. But relocated ISF families keep returning to Catmon as new housing location does not provide options for livelihood or source of income. It has become a challenge for the government to find space for informal settlers within the city.

### c) Slum upgrade programmes

Currently, City of Malabon is implementing slum upgrade programme in collaboration with Human Cities Coalition, a partnership of Dutch businesses and organizations, with an aim to contribute to the improvement of the lives of informal settlers through the development of an inclusive business case. Barangay Catmon is one of their focal areas where the government is implementing CMP through homeowners' associations (HOAs). Programme implementation is coordinated with Housing department and City Planning and Development Department of Malabon City.

### d) Solid waste management project-CENRO

City Environment and Natural Resource Office at Malabon City administration is currently implementing a rigorous solid waste management plan to achieve the vision of 'Clean Malabon' by 2020. However, managing waste from informal settlements is difficult as there is lack of discipline and neglectful attitude towards solid waste disposal mechanism. The community has been issued instructions by the Barangay to segregate waste and dispose it at right disposal facility, but due to lack of discipline among ISFs, rules are not followed. Malabon City has approved an ordinance on "untidy or littering in the city of Malabon" for people littering solid waste, will be apprehended and penalised with the fine of 500 Peso. Strict regulations are not very helpful in maintenance of waste-free surroundings.

*"Very often people's behaviour is a major factor in littering solid waste. For, e.g., if the collection time is 7 am, people waking up late, not able to bring garbage in time, and end up leaving the garbage at collection point or dump it anywhere. People end up leaving garbage outside their houses, and it becomes a problem of the city. People are not obeying the right collection time".* (Expert Interview 2, CENRO).

However, it was also shared by ISF participants as well as barangay Head that location of solid waste disposal facility does not favour people. Also, these facilities are less in number which does not cater the need of a large population per settlement. This leads to unorganised waste disposal. Although, it was different situation before 2005 when there were large and closed disposal facilities placed along the roadside, which were not time bound and monitored by guards. Collection trucks collected waste from locations where it was easy for people to walk.

*"Situation of solid waste was better than now. After a change in policies after 2005, it has gone from bad to worst as people are least interested in walking a long distance and end up littering waste".* (Expert Interview 8, Barangay Catmon Head).

**External Agencies (Non-Government Organisations)**

**a) Urban Resilience project- ACCORD**

A non-government organisation ACCORD, in collaboration with CARE Nederland., Action Against Hunger and Plan International, is implementing 'Move UP Project-Moving Urban Poor for resilient community' (2016-17) in Barangay Catmon along with other four Barangays of Malabon City. The objective of the project is to demonstrate systems and models for alternate temporary shelter and livelihood to increase the resilience of local government units and urban against natural disaster in Metro Manila. The project has implemented phase 1 with assessment and will enter phase 2, once approved by Malabon City Administration.

**b) Solid waste management programme- Mother Earth Foundation**

A local organisation 'Mother earth Foundation' in collaboration with ACCORD is implementing the project on managing solid waste to reduce the impact of flooding in densely populated Barangays of Malabon City, since 2015. They have successfully initiated the practice of efficient management of solid waste in 'Potrero', a neighbouring barangay of Catmon. The organisation is currently implementing the same project in Barangay Catmon. The project started not with solid waste management, but with the barangay assessing the risks and causes of flooding in their area. Assessment brought out the need for managing waste to solve the challenges brought down by flood water inundation. However, implementing waste management programme with informal settlement brought its challenges.

*"Initiating a programme is not a challenge, the major difficulty comes with making that programme sustainable. Behaviour change is a time taking process but if implemented correctly brings a sustainable change. We are hopeful for that".* (Expert Interview 12, Mother Earth Foundation)

From above results, it can be summarised that occurrence of cascading effect on water and sanitation services are not just driven by interdependent and dependent features of the service chain. The underlying factors discussed in this study also play a crucial role in driving and aggravating cascading effect when a sudden shock in the form of disaster hits the area. These factors are intertwined with each other further exacerbating disrupted water and sanitation service chain, combined with the negligent behaviour of informal settlers regarding usage of service, attributed to spatial placement of water and sanitation facilities near informal settlements. Current regulations and practices are majorly focussed on the provision of the shelter units and relocation projects (Ragragio, 2003) than on slum upgrading. Basic water, sanitation and hygiene needs were not targeted adequately to keep up with the requirements of informal settlers. The perpetual degradation of service quality resulted in economic, social and health implications. However, such implications can be reduced gradually with efficient implementation, monitoring and maintenance of water and sanitation services by its service providers as well as users.

## 5.5. Strategies and actions to reduce the impact of cascading effects

Based on the results obtained and ongoing initiatives of informal settlement development, there is a need to take up strategies which can close the gap between service providers and service users considering underlying factors playing a role in access and availability of water and sanitation services. Following strategies are proposed based on pre-existing policy and programmes which are still under implementation, and some of them have been withdrawn. Proposed strategies highlight the possible actions within the established system of governance.

**Water supply**

***Samahang Tubig Maynilad'* Programme:** As reported by informal settlers, water quality is degraded at last point of service delivery in the service chain. There is a possibility to resolve it by the implementation of Maynilad's programme *'Samahang Tubig Maynilad' (*STM*)*. The programme has been designed for low-income households to avail good quality water and also livelihood opportunity. A master meter with a faucet is installed close to the settlement, whereby a Community-based organisation (CBO) would need to be formed to manage the system. The responsibility of CBO would be to collect from the meter and distribute it to each household and collect payments (daily/immediately). Maynilad trains CBO members for the system management. It also offers an opportunity to earn from re-selling the water to the community (purchased from Maynilad at a lower rate than that of residential rates). The cheaper water provided by the STM translates to monthly savings of P300-500 per household (Padawangi & Li, 2013). The programme has been implemented only in few parts of Maynilad service zones, but not in Catmon.
It may prove to be a good strategy to implement a pilot master meter in one of informal settlement of Catmon, and once successful, yielding sustainable results maybe then replicated in other settlements as well in Barangay Catmon. It may have challenges initially as Maynilad water supply is not trusted by ISFs. CBO members may also be provided with training on regular sensitization and civic education programme to informal settlers, on benefits of utilization of STM water supply for improved quality and low price of water in comparison to water bought from local vendors.

**Re-implementation of Temfacil programme:** Temporary Supply Facility (Temfacil) was implemented from 2005-2009 by MWSS[13], as a cost-effective solution to address problems of water leaks and illegal connections. Under this programme, galvanised iron pipes are laid above ground and act as temporary water distribution system till permanent water distribution is installed (Torio, 2016). Given the habitat condition of informal settlements, Temfacil may prove to be a good alternative. The approach has benefitted 30 hectares with 3,000 households, suitable for habitat condition (see pg 21) which do not allow standard pipe service delivery or is not a cost-effective option (McIntosh, 2014). Temfacil system can be easily installed and dismantled in informal settlements which have land tenure security challenge. Temfacil was discouraged after 2011, and permanent structures were preferred (Torio, 2016), however, with the current situation of poor quality water supply from Maynilad, Temfacil system might be a good strategy to implement in collaboration with ***Bayanihan Bayan Tubig*** **(BBT)** programme of Maynilad.
*BBT* programme provided water meter connection for individual households and no land title needed for the connection (Padawangi & Li, 2013). However, the beneficiary installs their water pipes bearing all the expenditure of pipes which are made of synthetic plastics which gets punctured easily leading to contamination of water with increased health risks. Re-implementation of Temfacil in collaboration with Maynilad may allow informal settlers to get access to Galvanized water pipes which are meant to last for 5 years (Torio, 2016). These pipes can be made available to informal settlers at subsidized rates or free of cost, with the community-driven maintenance of water supply network providing labour and operational maintenance. Training and orientation on operation and maintenance of pipe network provided by Maynilad would also facilitate onsite maintenance of water supply. The quality of water may improve manifolds, further leading to reducing the expenditure of purchasing drinking and reducing health risks.

**Sanitation**

**Integrated operation and maintenance of water and sanitation services:** Water and sanitation services need each other to progress well. The coordination and integration deficits between utilities create uncertainty and disorder in an informal settlement (Criqui, 2015). There is a need for the integration of

[13] MWSS: Metropolitan Waterworks and Sewerage System

operation and maintenance of water and sanitation services including faecal and solid waste. The possibility of establishing strong coordination mechanism between Malabon City administration and Maynilad services may be explored under public-private partnership setup of water supply and sewage management. It may not have a major financial requirement. However, a strong coordination mechanism would be needed to operate faecal (Maynilad) and solid waste management (Malabon City) services in informal settlements. Incorporation of coordinated maintenance and operation of services by both the agencies may allow undisrupted access to services to its users especially when flood affects informal settlers. Integrated maintenance and operation will make service cost-effective, efficient and improved flood management.

**Capacity development of informal settlers**

**On operation and maintenance of services:** Strengthening the capacity of informal settlers and their institutions (Homeowner Associations) to engage with local administration and service providers for the sustainable provision of services. Homeowner Associations are active representatives of informal settlers and could be mobilised and trained to orient informal settlers on efficient operation and maintenance of services. Best practices from different provinces of the Philippines (Ranada, 2014) can be adopted for similar cultural and socio-economic and demographic context. Generation of more income-generation activities for informal settlers (livelihood opportunity with SMT programme), and community-managed savings and credit schemes would enable ISF families to invest in management and maintenance of service infrastructure at the community level. Collaboration with NGOs active in mobilising and operating sustainable savings group (Homeless People's Federation) to engage people in investing in savings group. Engagement of community in maintenance and management of services would provide a sense of ownership among informal settlers, will gradually lead to change in behaviour.

**On solid waste segregation and disposal**: Mass scale implementation of solid waste management programme run by Mother Earth Foundation. The NGO has successfully implemented the programme in Barangay Potrero, and a similar programme is under implementation Catmon. With strong support from in terms of funds and human resource from City administration to the NGO might help to escalate the process and programme outreach to a larger group. Allocation of dedicated human resource for regular sensitization and incentivization of waste segregation for recyclable material might help motivate informal settlers to follow the regulations of the citywide solid waste management programme.

**Health care service**

**Equitable access to health insurance for informal settlers post-disaster:** Almost all the people in Barangay Catmon can access health services from local government, particularly at the Catmon Barangay Hall Health Center in normal days. However, these services are inadequate to support a large number of informal settlers during and after the occurrence of a hazardous event. Possibility to re-design the health insurance for 'Indigent members' supported by government units (Philhealth, 2018) may be explored to cover informal settlers under the same category, with the subsidized amount of premium. Department of health may lay down different of premium amount for different categories of informal settlers based on their paying capacity. Families and individuals with lowest paying capacity may be provided insurance free of cost and people with higher paying capacity may be charged with some premium amount. The insurance card provided to the individuals should be valid at all private and public health care centres and should also allow cardholders to have access to cashless insurance coverage in a post-disaster situation. To fill up the financial gaps in the health sector, City administration may look up to other departments of the administration, rich philanthropist, individual donations and corporates. Possibility to gain financial support under corporate social responsibility may also be explored. Public-Private Partnership may also be looked into for effective health care service delivery to informal settlers.

**Strategies to extend service infrastructure based on location and user behaviour**

**Community mapping and collaborative planning:** It is essential to understand the behaviour of informal settlers towards usage of services, to improve the service delivery of water and sanitation services. The pattern of user behaviour will guide service providers and decision makers to plan the location for the installation of service infrastructure. It will also allow decision makers to extend infrastructure network by gathering information on the location they intervene in. Such information can be produced by community mapping exercises, which are significant in understanding the need and challenges of informal settlers.

Department of City Planning and Development, Malabon City, has a strong technical setup to generate and analyse such information with the help of mapping tools and software. However, City Administration would need to train and orient human resource to facilitate community mapping and collect relevant data. Students and volunteers from different informal settlements might be trained to facilitate mapping and collect data using technologies such as mobile phones and Google maps. Malabon Administration would have a strong database to improve urban coherence by publicly generating such information and sharing with other coordinating departments.

Collaborative planning and community mapping with informal settlers and different stakeholders of service provision would be an effective tool to enhance interaction, and integration of community preferences for efficient usage of service infrastructure. It has the potential to guide authorities to take decisions on placement of service infrastructure to influence user behaviour based on their preferences. Change in behaviour will gradually direct towards the reduction of cascading effects and break the vicious circle of resilience attrition over time with recurrent disaster in Barangay Catmon.

# 6. DISCUSSION

This chapter provides a detailed discussion of the obtained results in relation to the literature. It attempts to present a critical review of the achieved results, methodological approaches and a reflection on the limitations of this study.

## 6.1. Discussion of results

This section presents a critical review of achieved results in relation to the literature reviewed.

### 6.1.1. Water and sanitation services in the informal settlement

Based on the results obtained from empirical data, informal settlers in the study area, all have access to water and sanitation services, contributed in meeting 'Millennium Development Goals' for the Philippines (WHO, 2015). The majority of them have access to legal water supply connection, but due to the quality of water, people spend a hefty amount of money on purchasing drinking water. However, taking the case of Barangay Rizal, Makati City (see section 3.5, pg.16), water quality from Maynilad is not trusted by the residents of formal settlements. They purchase mineral water from local vendors to prevent health issues. This indicates towards quality control mechanism of water supply infrastructure of the service provider and resource dependency (Boaru & Bădiţa, 2008) on local vendors for the purchase of drinking water with increased expenditure.

Results emphasised that toilets and solid waste management services are also available and accessible to informal settlers in Barangay Catmon. However, management of faecal and solid waste is poor and unhygienic and often leads to multiple health issues. Data analysis highlighted that there is lack of responsible behaviour towards efficient management of faecal and solid waste management results in unhygienic surroundings and poor water quality. Such irresponsible behaviour can also be attributed to lack of firm implementation of regulations for waste management. Also, City Administration had to withdraw the City ordinance to ban Plastic packaging in 2013, due to official reasons (Francisco, 2017), another factor contributing to the generation of solid waste. However, Makati City has effectively reduced the amount of waste generation with the enforcement of the Solid Waste Management ordinance[14] (Rappler.com, 2017). During FGD, participants from Rizal shared the positive changes in waste management that emerged after the implementation of the ordinance and strict monitoring. They were oriented properly by the Barangay to segregate and dispose of waste properly in 2016. The government also successfully banned the use of plastic packaging under a City Ordinance. Flood levels have reduced its impact, and it's much safer in comparison to past years.

Regarding informal settlements, presently Rizal do not have informal settlements. Majority of informal settlers were relocated to other Cities of Metro Manila or nearby provinces under housing programmes (Ragragio, 2003). These families were provided monetary support and livelihood opportunities to sustain as reported by Barangay Head.

[14] City Ordinance No. 2003-095, Ecological Waste Management Act (http://ap.fftc.agnet.org/ap_db.php?id=153&print=1)

*"Makati City Administration was able to enforce the solid waste law and relocate informal settlers with strong financial support, administrative management and its necessity as the financial capital of the Philippines".* (Expert Interview, Barangay Head, Rizal).

Moreover, there is also a gap in coordination between agencies operating maintaining water supply and solid waste. Quality of water is also dependent on efficient solid waste management which needs attention in terms of maintenance and operation of the service chain. It can be summarised here that informal settlers from selected clusters in Catmon are yet to achieve quality access to water supply and sanitation services to improve upon health challenges emerging from the poor quality of services. Improved water and sanitation services and hygienic surroundings will contribute majorly towards the improved socio-economic well-being of residents of informal settlements (UN-HABITAT, 2003).

### 6.1.2. Cascading effect on water and sanitation services and informal settlers

Service chain for water and sanitation services for selected informal settlements was assessed for post-disaster (typhoon Glenda) condition based on the experience shared by informal settlers. The purpose was to identify the service chain elements disrupted by typhoon due to interdependency or dependency drove cascading effect. The assessment highlighted four key elements in water and sanitation service chain, i.e., water supply hosepipes (W4), Faecal waste capture mode (FW1), Solid waste disposal (SW1) and Solid waste disposal facility (SW2). These four key elements can be defined as critical or weak elements of service chain which disrupts final service delivery to informal settlers.

Assessment of critical elements also assisted in the identification of different forms of interdependencies which contributed to triggering cascading effects. Regarding the spread of cascading effect across time, it progressed through different phases of the typhoon, i.e. strong winds followed by heavy rainfall and floodwater inundation. The maximum disruption which triggered cascading effect occurred during flooding when water and sanitation services were inundated in flood water for more than two days. Such conditions are also defined as common component interdependencies (Boaru & Bădiţa, 2008) where service elements failed at similar times. As discussed in results (section 5.3), four key elements triggered cascading effect on each other as they are not only interdependent for service delivery but also share common space where water supply pipes are placed in a space with sewage-filled swamp and solid waste landfill informal settlements called as spatial interdependency (Rinaldi et al., 2001).

The interdependency and cascading effect on critical elements continue impacting the service delivery of water and sanitation (Rahnamay-Naeini & Hayat, 2016) till flood water receded. Other than negligent attitude and low level of hygiene awareness from informal settlers, service chain also witnessed cascading effect due to a delayed response from the local administration for cleaning of solid waste and drainages after the occurrence of the typhoon. Also defined as organisational interdependency (Boaru & Bădiţa, 2008), Staff from CENRO was dependent on Engineering department for cleaning of drainages which in turn delayed collection of waste leading to contamination of water supply pipes. Delayed response from local administration worsened the sanitation condition of the sanitation condition of the settlements.

In both, the Clusters, cascading effect on water and sanitation services came with short term and long term impact. Short-term impact was majorly related to immediate access to water and sanitation services resulted in health issues. Unaffordable health care services increased the burden manifolds leaving affected population unable to cope economically. Another form of organisational dependency on health care which resulted in more severe consequences (Lange et al., 2015). Longer recovery periods here are defined as the spatial spread of cascading effect (Zimmerman & Restrepo, 2009) when ISF families are not able to recover the level of resource consumption before next disaster strikes. They find themselves in the vicious cycle of

a poverty trap (Thouret et al., 2014) and persistently reduced income and resilience underpinning poverty continuously.

### 6.1.3. Implications of cascading effect on Slum (informal settlements) upgrade Programmes

With increasing frequency of floods in Barangay Catmon, it has become a 'new normal' for informal settlers (Mondragon, 2015). Challenges which come with frequent typhoon/floods and heavy rainfall are considered as part of routine life, and no longer a priority to prepare for floods. It could also be seen as gradual resilience attrition of informal settlers and if the time between events reduces then overall resilience will decline, in lack of timely preparedness to cope with disasters.

The community tries to cope with such challenges with the social network they have developed after staying for a longer duration in the same space. Land tenure security for the same space is a major priority for informal settlers instead of fleed preparedness. Families of informal settlers work hard to make ends meet and save up to buy land title to have their own house, which brings water, sanitation and safe hygiene practices down on the priority ladder. Water and sanitation are necessities for their survival but are not considered as a solution to reduce the impact of floods/typhoons.

Negligence of safe water, sanitation and hygiene practices degrades the quality of services and weakens the service chain, resulting in inevitable disruption of service chain with the sudden event of a disaster. The disruption caused in the service chain brings in challenges with different intensity for different households of informal settlers. Families with relatively very low-income background suffer from more severe consequences and a long-lasting impact on family income and coping capacity for future events.

A stable income flow for families of informal settlers is also an important factor for the ongoing community mortgage programme in Barangay Catmon. The government is implementing CMP project (see section 3.3) to allow informal settlers to buy the land title for the land they are staying on or nearby land. However, it is a lengthy process of 5-10 years to start the process and another 25 years to complete (Ballesteros et al., 2015). The process involves payment of amortisation money in instalments to the landowner. Informal settlers with low-income background find it difficult to pay money when they are frequently hit by typhoon or floods every year. It has become challenging for the government as well to support informal settlers to continue paying for the instalments and have implications for the development of informal settlements.

Implementation of programmes on solid waste, sanitation and hygiene has its own set of challenges while working with informal settlers. It is difficult to implement such programmes due to a large number of people living in limited space and fleeting population leading to less social cohesion and more challenges to manage people. To bring change in sanitation and hygiene behaviour in a transient population of informal settlers, it has to change in all aspects of daily routine including home, school and work. Such change also needs the sustainable support of water and sanitation services from local government, which is difficult in case of informal settlements, in lack of quality and authorised installation of service infrastructure.

## 6.2. Critical reflection on research methodology

Identification of cascading effects of the typhoon on water and sanitation services and informal settlers, needed an approach to bring out the impact in a more straightforward way to visualise and analyse empirical data. It needed a methodology to break down the flow of infrastructure services to assess the disruption caused in service delivery to its final users (Gonzva et al., 2016). A disaster or an accident can trigger cascading effect anywhere in components of infrastructure services, which are not resilient enough to cope

with the sudden shock (Boaru & Bădiţa, 2008). Therefore, it was essential to understand the service flow of water and sanitation services and service elements which are prone to sudden disruption affecting service delivery to the user. The study proposed 'Sequential Time and Event Plotting' (STEP) as a research methodology, to assess cascading effect. STEP is an incident investigation method used to identify and construct a sequential plot of time and events to bring out the details and different levels of cascading effect triggered by an accident/disaster on critical infrastructure (Arvidsson, 2015). However, plotting of time and event sequence turned out to be too complex, as experiences shared by FGD participants were not detailed enough to plot them in a sequence of time to assess cascading effects. Therefore, the study adopted existing concepts of supply chain management framework to develop service chain management framework to assess cascading effects on water and sanitation services in a much simpler way.

To assess the details of service delivery, service chain management framework was developed elaborating each component of service delivery. However, it was performed only for a small geographical extent but facilitated to bring out the details of dependent service disruption in water and sanitation service chain. It was also useful in evaluating the spread of cascading effect over the temporal progression of the typhoon with its characteristics such as strong wind, rainfall and flooding. Therefore, this research presents results based on a simple model developed by existing concepts of less explored service chain management, to analyse the impact of natural disaster on affected community also a less explored aspect in disaster management. Service chain management framework is a generic model and can be applied to another critical infrastructure service with context-based modifications. This thesis presents a method for studying cascading effects which can be applied in situations where the documented information of the hazardous event is limited.

However, as with most research methods, this methodology also has its limitations. It was challenging to strike a balance between being specific and contextual enough to be useful while remaining general enough that it can be applied in varied contexts. Service chain management concepts have not been much explored for research in the field of urban disasters and informal settlements, and hence the service chain framework has been kept small within a limited geographical extent (Barangay to informal settlements). There is a high possibility of occurrence of cascading effect on service chain out of the geographical context. For, e.g., water supply is from a water dam in the outskirts of Metro Manila and can affect in the wake of a disaster. However, it was not possible to include a larger network of service chain, which would have shifted the emphasis of research on physical infrastructure rather than the affected community.

## 6.3. Limitations of the study

During field data collection, Barangay Catmon was also engaged with rounds of surveys conducted by NGOs (see section 5.5.2) for programme implementation in an informal settlement in Catmon. People from different informal settlements were invited to take part in assessment and research surveys. It created expectations among the FGD participants about the programme deliverables, which in turn influenced their answers to the questions asked as part of this research study. Participants were exposed to multiple typhoon and flood events in past years, and hence it was difficult to recall the events from specific disaster, as they face more or less similar challenges frequently. A detailed FGD with a small number settlements would have given better results. It would have allowed having more groups from same settlements to collect richer qualitative data. Field verification for all the selected settlements could not be done due to security reasons and that slightly limited visual triangulation of data collected from FGD participants. Also, a literature review is an important part of any research as it helps to identify the scope of research carried out so far. However, in this research, there was very limited literature on the impact of cascading impact on the disaster-affected

community, especially on informal settlements. Hence there were limited scholarly papers addressing this research problem.

## 6.4. Ethical Considerations

Written consent was obtained from the City Mayor of Malabon City to conduct data collection in informal settlements of Barangay Catmon. Confidentially of government data is maintained and due acknowledgement has been provided wherever required. While conducting expert interviews and focus group discussion informed consent was taken, to audio record it. It was ensured to provide incentives to FGD participants after data collection as a token of appreciation as well as facilitation. Participants were consistently explained on purpose of the research, data collection, data access, usage and distribution of the information given. Anonymity was maintained for participants who were not willing to share their details. However, they consented to take pictures of the focus group discussion process.

## 6.5. Further research needs

This research has contributed to the academic literature for identification of cascading effect on water and sanitation services triggered by typhoon using a service chain management framework. This could be furthered through conducting similar research for different natural disasters in different geographical and socio-economic context with other critical infrastructure services. Different context will help to build up a more generic and usable framework. After that, specific and more complex research could be conducted to assess cascading effects triggered over time and space with the occurrence of cascading disasters. Future research could also look into inconsistencies observed in this research and find underlying reasons to make service chain framework more robust.

# 7. CONCLUSION

This research study contributes to the literature on assessment of cascading effect on critical infrastructure services triggered by a natural disaster in an urban area. Cities and disaster create a nexus shaping urban fabric with interconnected and interdependent features, and when a massive natural disaster strikes the city, it leaves a cascade of impacts affecting feature and systems of the region. The main objective of the study was to identify how to reduce the impact of cascading effects on water and sanitation services, triggered by the typhoon in a slum community. In this regard, it is evident that water and sanitation being interdependent and critical services for the human well-being and become even more essential for human survival when a disaster hits an area, especially if it affects an informal settlement in an urban region. Water and sanitation being interdependent services also witness cascading effect when disrupted affecting informal settlers pushing them to a perpetual cycle of poverty. To gain understanding on cascading effect on water and sanitation services, three sub-objectives were established in this research, 1) To assess the existing status of utilization of water and sanitation services in the slum community (informal settlement), 2) To assess cascading effects on water and sanitation services triggered by typhoon/flood event. 3)To identify strategies and actions to reduce the impact of cascading events and improve community resilience.

The application of the service chain management framework revealed that, although have the informal settlers of Catmon have access to water and sanitation services, the quality of service is poor as service delivery elements of the service chain lack regular maintenance and efficient use of services. Water and sanitation services are run by a public-private partnership except for solid waste management which is managed by local administration. The status of these services was severely affected by typhoon Glenda (2014). The analysis identified critical weak elements responsible for triggering cascading effects with contributions from supporting services of electricity supply and drainage system. The major reasons contributing to the occurrence of cascading effects on water and sanitation services were the negligent behaviour of informal settlers, land tenure security and extreme exposure to multi-hazard risk combined with a low economic background of informal settlers. The lack of effective implementation of laws related to solid waste management also contributes to groundwork for triggering the disruption of water and sanitation service after a severe hazardous event. These impacts affect informal settlers with longer recovery periods and persistently reduced income and resilience underpinning poverty continuously.

The impacts of triggered by cascading effect can be reduced with suitable intervention, such as the SMT programme of Maynilad, Temfacil programme, integration of water and sanitation services and equitable access to health care may be helpful in ensuring access to services to informal settlers in post-disaster conditions. Also, collaborative planning with informal settlers and key stakeholders might be useful in charting out community preferences and hence improving service provisioning of water and sanitation.

However, this study covers a small geographical extent limiting the expanse of service chain network of water and sanitation services. This limited the possibility of inclusion of cascading effects which has occurred out of the study area network. The study provides information on critical weak elements of services chain of water and sanitation services, responsible for triggering cascading effects. It may further guide the local authorities and other stakeholders to understand the characteristics of cascading effects varying with time and nature of the impact. It may enable city authorities and other urban actors to improve and adapt their work without negatively influencing the interconnectedness of urban risk. The formulation and adaption of pro-informal settlers' strategies and actions will gradually facilitate reduction of the impact of cascading effects and improve the resilience of the informal settlers. Furthermore, this study provides an opportunity for future research application of service chain management framework on critical infrastructure services in an urban environment prone to disasters.

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# ANNEXE 1

Service chain management framework with acknowledged service chain of Barangay Catmon (Source: Own draft)

Table 7: Thematic structure of service chain codes and categories

| Service chain management framework | Acknowledged service chain | Status of service chain based on primary data |
|---|---|---|
| **Distribution Service chain** | **Water Supply (Category1)** | **Indicative statements referring to codes in category 1:** |
| Service support function | Maynilad water supply facility (W1) | Water supply facility in Barangay Catmon |
| Service distribution infrastructure | Maynilad distribution pipes (W2) | Water distribution pipes at Barangay Catmon |
| Service support function | Maynilad water meters (W3) | Installation of Water meter for individual connection |
| Service delivery (distribution) | Individual water supply pipes (W4) | The connection of individual pipes from the water meter |
| Consumer (ISFs) | Consumer (ISFs) | Perception of availability, accessibility, quantity and quality of service |
| **Collection Service chain** | **Sanitation (Category 2)** | **Indicative statements referring to codes category 2- Faecal waste:** |
| | **Faecal Waste (Toilets and Sewage)** | |
| Service delivery (collection) | Capture waste in toilets (FW1) | Defecation mode |
| Service collection infrastructure | Maynilad collection of waste (FW2) | Waste collection after capture |
| Service support function | Waste transfer (FW3) | Waste getting transferred from the place of collection |
| Service support function | Waste treatment (FW4) | After transfer, if the waste is sent for treatment |
| Consumer (ISFs) | Consumer (ISFs) | Perception of ISFs on availability, accessibility and quality of service |
| **Collection Service chain** | **Solid Waste (Garbage)** | **Indicative statements referring to codes- category2 – Solid waste:** |
| Service delivery (collection) | Waste segregation (SW1) | People disposing of segregated or mixed waste |
| Service collection infrastructure | CENRO Waste disposal facility(SW2) | Designated place of waste disposal |
| Service support function | Waste collection (SW3) | waste collection by the designated team/people |
| Service support function | Waste treatment (SW4) | Waste transfer to waste treatment unit by a designated team |
| Consumer (ISFs) | Consumer (ISFs) | Perception of ISFs on availability, accessibility and quality of service |

# ANNEXE 2

Table 8: List of informal settlements in Barangay Catmon

| Sr. No. | Name of Informal Settlement | Official Name HOA |
|---|---|---|
| 1 | UPNA | United People Neighborhood Association |
| 2 | SANAPU | Samahan ng mga Naninirahan sa Purok |
| 3 | S6BCHA | Sitio 6 Basketball Court HOA |
| 4 | ANGELA3 | Angela - 3 Home Owner Association |
| 5 | SUNRISE | Sunrise Home Owner Association |
| 6 | SAMAPIL | Samahang Masigasig ng Pilapil |
| 7 | SMC | Samahang Maralitang Catmon |
| 8 | SDHI | Samahan sa Dulo ng Hernandez Inc |
| 9 | KHSC | Kaunlarang Sam Hernandez Catmon |
| 10 | STKCC | Sam Tungo sa Kaunlarang Komunidad |
| 11 | SAPADACA | Samahang Pagkakaisang Dumpsite Catmon |
| 12 | PCHR | People's Coalition for Housing Rights |
| 13 | GMHOA | Green Meadow |
| 14 | CVHOA1 | Catmon Ville HOA 1 |
| 15 | MPV1 | Malabon People's Village Phase 1 |
| 16 | MPV2 | Malabon People's Village Phase 2 |
| 17 | CVHOA2 | Catmon Ville HOA 1 |
| 18 | UVHOA | United Village HOA |
| 19 | NADHAI | Nagkakaisang Damdamin |
| 20 | SBKB | Samahang Kapit Bisig in Catmon HOA Extension Upper Sit |
| 21 | CMF | Cornillo Martinez Francisco NA |
| 22 | GULAYAN | Gulayan |

(Source: Human Cities Coalition)

# ANNEX 3

**Questionnaire for Focus Group Discussion**

**General Questions**

1. How frequent you face floods / typhoon in your area?
2. When did the last flood/typhoon event occur which affected your community badly?
3. For how many days your area was inundated with flood water?
4. What are the challenges you face after a flood hits your area? First three important challenges
5. What are the essential services affected by floods?
6. Which are three most important service required immediately after floods? (Such as Electricity, Water supply system, Sanitation, Sewage system, Health Care, Road, Transportation, Emergency Response System)

**WATER SUPPLY**

**General Questions**

1. What type of water supply you have in your community?
2. Are there different sources of water for drinking, washing and other household work?
3. Was the available water sufficient for daily consumption? Was the water supply reliable?
4. What is the daily/weekly frequency of the water supply?
5. Is water supply dependent on any other services in your community? For e.g., Electricity, transportation etc., if yes, which service?

**During and after strong winds (within 24 hours of typhoon occurrence)**

1. When did you realize that water supply is affected?
2. What happened to the water supply? (For e.g., Damaged, broken pipes, contaminated sources etc.)
3. What were the drinking and household water sources functional after the typhoon?
4. Was the water available at the source enough for short-term and longer-term needs for all groups in the population?
5. Are water collection points close enough to where people live? Are they safe?
6. Are these water collection points near any dumping ground, open defecation sites or unhygienic location?
7. Are there any common water collection points?
8. Were they damaged too?
9. What are the key hygiene issues of damaged water supply?
10. Does water supply gets affected if any other service is not functional, such as electricity, transportation etc., if yes, which service?

**During and after heavy rainfall and floodwater inundation (within 72 hours of typhoon occurrence)**

1. What happened with the water supply after flood inundation? (For e.g., Damaged, broken pipes, contaminated sources etc.)
2. Were the drinking and household water sources functional after 4 days of water inundation?
3. Was the available water sufficient for daily consumption? Was the water supply reliable?
4. Were you purchasing water from private business groups?
5. Was the water available at the source enough for drinking and cleaning needs for all groups in the population?
6. Was the water collection points safe (quality) to collect water?
7. Which group of the population was affected majorly by the damaged water supply and why? (Women, men, children, elderly)

8. What are the key hygiene issues of damaged water supply? E.g., diseases, unhygienic living conditions?
9. Water supply was affected due to non-functionality of some other service, such as electricity, transportation etc., if yes, which service?

**After 1-2 weeks of typhoon occurrence**

1. What was the status of water supply sources after 1-2 week of disaster occurrence? Were they still functional/non-functional, restored?
2. Who restored water supply (govt./NGO/local community)? When did the restoration take place?
3. What were the major challenges even after 1-2 weeks after the disaster (first three)?
4. What are the new challenges related to affected water supply after 1-2 weeks of disaster?
5. Which group of the population was affected majorly by the damaged water supply and why? (Women, men, children, elderly)
6. What were the financial implications due to affected water supply (Eg: expenditure on purchase of water, health, transportation etc.)?
7. Water supply was not functional even after 1-2 weeks of disaster due to the failure of any other service, such as electricity, transportation etc., if yes, which service?

**Emergency Response system**

1. What are the key strategies to manage affected water supply at the community level? (refer list for probing questions)
    - Enough water containers of the appropriate size and type?
    - Do they treat water before consumption after the typhoon?
    - Is there any support from the government for the disinfection of water especially drinking water or provision of water tankers?
    - Do they have alternative water sources nearby?
    - Any traditional beliefs and practices related to the collection, storage and use of water?
2. Did they receive any emergency relief for water supply (for e.g., packaged water, water tankers etc.) from government or NGOs/local community initiatives? Name of NGOs?

**SANITATION**

**General Questions**

1. What type of sanitation system you have in your community?
2. Individual sanitation units or communal?
3. Do you have a sewage system for the toilets?
    a. If yes, what type?
    b. If no, why?
4. How frequently are drainages/sewage systems cleaned in your community?
5. Do people wash their hands after defecation and before food preparation and eating?
6. How do you manage dependency of sanitation on water supply in normal days?

**During and after strong winds (within 24 hours of typhoon occurrence)**

1. What was the status of sanitation (toilets) units 24 hours of disaster occurrence? Were they functional/damaged/inundated?
2. Were toilets non-functional due to unavailability of water?
3. Open defecation (especially children) was adopted after disaster occurrence?
4. Was that practice a threat to water supplies (surface or groundwater) or living areas?
5. Were soap and water available for hand washing practice?
6. What were the key hygiene issues due to damaged sanitation units?

**During and after heavy rainfall and floodwater inundation (within 72 hours of typhoon occurrence)**

1. What was the status of sanitation (toilets) units 72 hours of disaster occurrence? Were they functional/damaged/inundated?
2. Were toilets non-functional due to unavailability of water?
3. Open defecation (especially children) was adopted after disaster occurrence?
4. Was that practice a threat to water supplies (surface or groundwater) or living areas?
5. Were soap and water available for hand washing practice after 72 hours?
6. Which group of the population was affected majorly by the damaged sanitation units and why? (Women, men, children, elderly)
7. What were the key hygiene issues due to damaged sanitation units?
8. Any emergency support mechanism to improve sanitation situation in your community? Was it by Govt./NGO/Local community? What was it (Were the sanitation units restored/new installation/temporary sanitation units)
9. Water availability for sanitation purposes with external support (govt/NGO/community)? Frequency and quantity of water availability?
10. The existing status of sanitation encouraged vector or water-borne diseases? How many cases of vector/water-borne diseases in your community within 72 hours?

**After 1-2 weeks of disaster occurrence**

1. What was the status of sanitation units after 2 weeks of disaster occurrence?
2. Were they still functional/non-functional,
   a. If functional, when these units were restored?
   b. If no, why sanitation units were not restored?
3. Who restored sanitation units (govt./NGO/local community)? When did the restoration take place?
4. What were the major challenges even after 1-2 weeks after the disaster (first three)?
5. What are the new challenges related to affected sanitation units after 1-2 weeks of disaster?
6. Which group of the population was still suffering due to damaged sanitation units and why? (Women, men, children, elderly)
7. What were the health implications due to affected sanitation (Eg: diseases, unhygienic living conditions etc.)?

**Community-level sanitation management**

1. What are the key strategies to manage affected sanitation at the community level? (refer list for probing questions)
   - Allocation of defecation site
   - Hand washing practices
   - Any traditional beliefs and practices related to the sanitation practices, excreta disposal?
2. How did you manage dependency of sanitation on water supply after the occurrence of flood/typhoon? (use contaminated water, flood water)

**<u>DRAINAGE SYSTEM</u>**

**General questions on the Drainage system**

1. What type of drainage system you have in your community area?
   a. If yes (ques.1), how frequently drainages are cleaned in your community?
   b. If no (ques1), why there is no drainage system in your community area?
2. What are the risks posed by the blocked/no drainages? (such as health, physical damage, blockage of roads etc.)?

**During and after strong winds (within 24 hours of typhoon occurrence)**

1. What are the challenges related to poor drainage and sewage system that emerge after 24 hours of disaster occurrence? (e.g. flooding shelters and toilets, vector breeding sites, polluted water contaminating living areas or water supplies)
2. What are the implications of blocked drainage and sewage on water supply and sanitation units and hygiene practices?
3. Do people have the means to protect their water supply and toilets from flood water?

**During and after heavy rainfall and floodwater inundation (within 72 hours of typhoon occurrence)**

1. What was the status of drainage system after 72 hours? (Cleaned/ more blockage)?
2. What was the impact on water supply and sanitation units?
3. Were there any health risks/cases of diseases (vector breeding sites on the stagnant water drainage- Cases of malaria, dengue etc.)

**After 1-2 weeks of disaster occurrence**

1. What was the status of drainage system after 1-2 weeks of disaster occurrence? (Cleaned/ more blockage)?
2. What was the impact on water supply and sanitation units?
3. Were there any health risks/cases of diseases (vector breeding sites on the stagnant water drainage- Cases of malaria, dengue etc.)?

**HEALTH CARE**

1. What are health services available to the affected population? e.g. hospital, clinic, temporary health post, outreach system, health promotion
2. Is the health service provision adequate for the needs of the affected population? (e.g. accessible in terms of cost and distance, sufficient in terms of provision of trained staff, facilities, medicines, vaccines)

# ANNEXE 4

**Questionnaire for Expert Interviews**

**Questions to Government Departments**

1. What are the daily work activities of your department in service provision to maintain functional water, sanitation and hygiene services in Malabon?
2. What are service management structure of your department to maintain services in Malabon?
3. How does your department respond in case of floods/cyclones? (disaster response plan*)
4. What are the specific actions taken to mitigate or reduce the risk of flood/cyclone on water and sanitation service provision?
5. During the last flood/cyclone event, did your department experience any problems triggered by dependency on service provision of another department? (Electricity, Water supply system, Sanitation, sewage system, Healthcare, Road transportation, Emergency response system*).
    a. Can you give examples of these problems caused to your department? (how your department is dependent on other department service provision*).
6. What were the specific preconditions which worsened the service provisioning of your department?
7. What were the preconditions that helped your department to cause less/no impact on service provision of your department?
8. What measure did your department take to improve the service provision of water, sanitation and hygiene services in Malabon?
9. What would have improved your organisation's performance of its responsibilities?
    a. During the disaster event?
    b. After the disaster event?
10. What organisations depend on the proper functioning of your organization?

**NGOs working on Urban Disaster Resilience/Risk reduction**

1. What is the mandate of your organisation?
2. Is your organisation targeting any specific goals in terms of disasters (such as emergency responses, disaster preparedness, resilience building, coping capacity, strengthening local adaptation measures*) for Catmon Slum/any slums in Manila in terms of disaster risk reduction?
3. Is there any specific flood/cyclone response plan for slum population in Catmon Brngy? Or any slum (If not Catmon)
4. If yes, (ques.2), what are the components of the plan?
5. If no, (ques.2), why there is no flood/cyclone response plan for slum community in Catmon barangay? Or any slum (If not Catmon)? (What are the obstacles*)
6. Are there any future plans to take action for Catmon/any slum for disaster preparedness and risk reduction? (Land use planning*)
7. Are there specific projects dedicated to the future action plans on disaster preparedness/risk reduction?
8. Can you share the details of such projects which are either implemented or in the pipeline?

**Questions to Emergency response teams (Government team and NGOs)**

1. What is the mandate of your organisation?
2. Is your organisation targeting any specific goals in terms of disasters (such as emergency responses, disaster preparedness, resilience building, coping capacity, strengthening local adaptation measures*) for Catmon Slum in terms of disaster risk reduction?
3. Did you respond to last flood/cyclone in Catmon Brngy, Malabon city?
4. What was the duration of emergency response?
5. What were the components of the emergency response?
6. What was the target area (*if responded to specific patches of Catmon Brngy)?

7. How did you decide on the target area? (Slum dwellers, non-slum population*)
8. Was it a generic response or sector-based response (WaSH, Livelihood, Shelter etc*)?
9. If it was WaSH, what were the components of the emergency response?
10. Is there any ongoing or past project implementation on disaster risk reduction/ disaster preparedness programmes?
11. Can you please elaborate more on the programme? (Such as duration, target community, project targets and outcomes.
12. Can you share the report about the project, if any?

**Government department of Urban Risk and Development**

1. Is there a disaster response plan for Catmon Brngy Malabon City?
2. Is there any specific flood/cyclone response plan for slum population in Catmon Brngy by the government?
3. If yes, (ques.2), what are the components of the plan?
4. If no, (ques.2), why there is no flood/cyclone response plan for slum community in Catmon Barangay? (What are the obstacles*)
5. Are there any future plans to take action against Catmon slum for disaster preparedness and risk reduction? (Land use planning*)
6. Are there specific projects dedicated to the future action plans on disaster preparedness/risk reduction?
7. Can you share the details of such projects which are either implemented or in the pipeline?

# ANNEXE 5

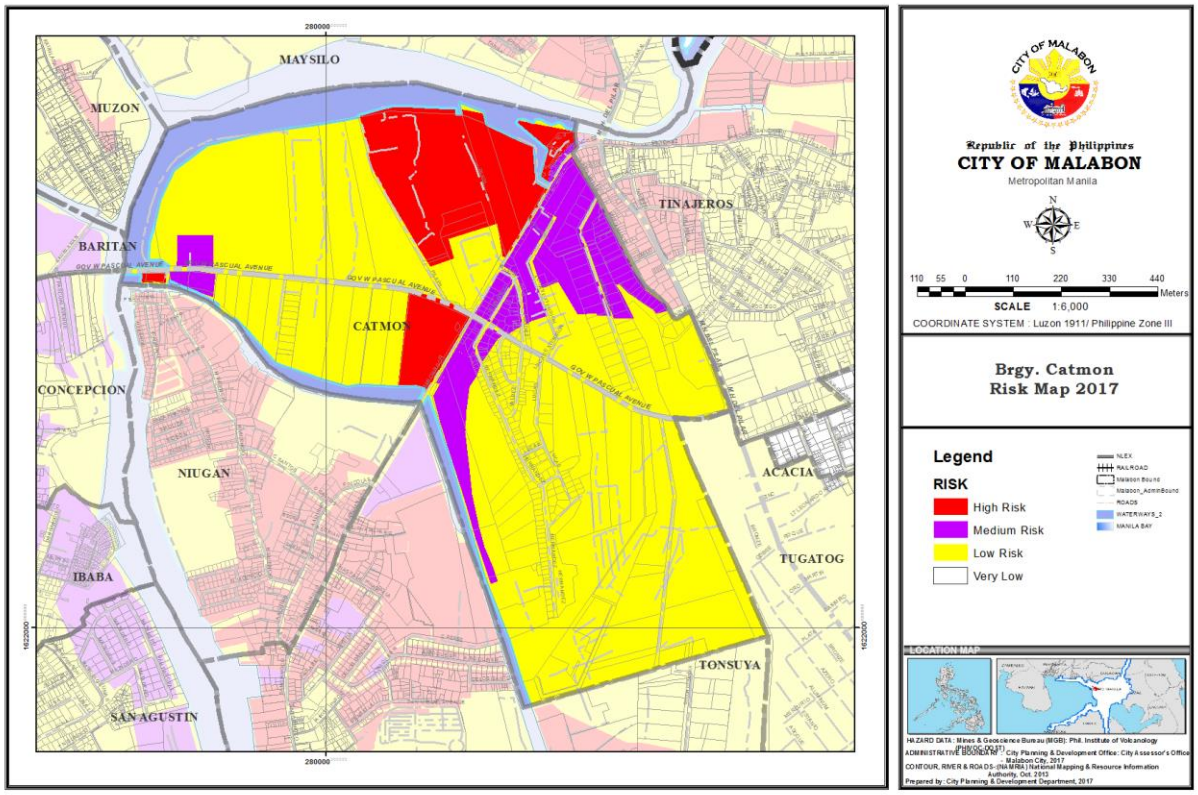
Quantitative data collection format from Informal settlers on water and sanitation service access and health status after typhoon Glenda.

Table 9: Format of quantitative data collection

| Sr.No. | Date | Gender | Age | Name | Area of stay | Drinking Water Supply | | Water for cleaning | | Toilet | If yes, for toilet | | Toilets during floods | | Disease after cyclone/flood | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | F/M | Yrs | | | Buy water | Water meter | Buy water | Water meter | Y/N | Pipe Toilet | Septic tank | Own toilet /Neighbour's | Open defecation /throw in open | Disease type | No. of Cases |
| | | | | | | | | | | | | | | | | |

# ANNEXE 6

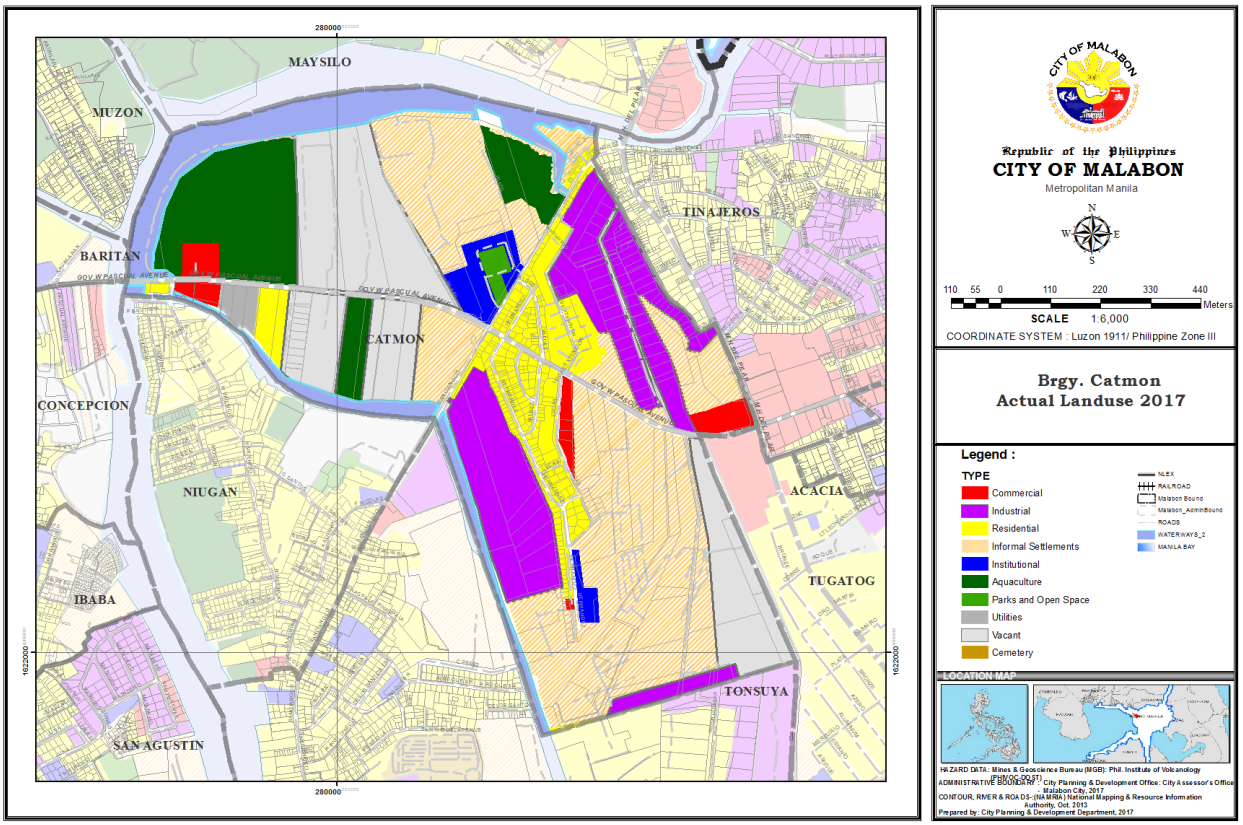
**Multi-hazard risk map of Barangay Catmon:** Map was generated by combining the risk of flood, earthquake, liquefaction and storm surge. (Source: City Planning and Development Department, Malabon City)




Map 7: Multi hazard risk map, Barangay Catmon

# ANNEXE 7

**Land use map of Barangay Catmon:** Land use map which recognised informal settlements on the occupied lands. (Source: City Planning and Development Department, Malabon City)




Map 8: Actual land use map of Barangay Catmon

# ANNEXE 8

Additional pictures from the field to provide more visual information about informal settlements.


Picture 10: Informal settlers house close to river bridge (Cluster 2)


Picture 11: Informal settlers houses in swamp


Picture 12: Informal settler family in Cluster 1


Picture 13: A plastic junkyard close to the river (Cluster 2)


Picture 14: Use of net to prevent solid waste blockage (Cluster 1)


Picture 15: Boat made of water containers for flood days