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Title: **ICT Diffusion within the Local Climate E-Governance in Metro Manila, Philippines**

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Summary

Climate Change has already affected many parts of the world, making many developing countries more vulnerable due to both high exposure to climate related hazards and lack of overall capacity to adapt. Within countries, cities face the most risks due to urban characteristics such as high concentration of people and properties. Also, many cities are not able to manage rapid urbanization well resulting to lack of basic services for the people, and increasing urban poor. This makes urban areas more vulnerable to climate risks. As such, it is vital to implement effective measures for climate change adaptation and risk management among cities, above all, in developing countries.

A type of tool that has been recently leveraged in this regard is ICT or Information and Communications Technologies. ICTs are technologies that can collect, analyze, store, and communicate data and information. Many governments have already adopted ICTs to improve public service delivery including climate action. The use of ICT by the government is called 'E-Governance'. With respect to climate action, the use of ICTs contribute, in general, through facilitation of climate related data and information. However, studies that link ICTs with climate change adaptation and risk management have been limited so far. Hence, this study aims to contribute in this area by looking into the state of ICT diffusion, or what and how ICTs are being used within the e-governance for climate action. This study specifically focuses at the local government level through the case of Metro Manila, Philippines which is among the countries in the world with high climate risk vulnerability and slow e-governance progress. This study employed both quantitative - survey and descriptive statistics, and qualitative - case study and process tracing analysis, measures to describe ICT diffusion within the local climate e-governance.

This study found that the most used ICT for Metro Manila is social media followed by wireless broadband technologies, Geographic Information Systems (GIS), and mobile technologies. Aside from these, many LGUs also make use of web-based (e.g. NOAH and MSDI) and mobile-based (e.g. Batingaw) applications. In terms of quality of use, the findings suggest medium to high extent of use which means, according to this study's parameters, that some LGUs utilize ICTs just for effectiveness and efficiency while others deem ICT-use to be crucial in the achievement local climate e-governance tasks, specifically monitoring of climate change and impacts, disaster management and climate change adaptation. The case of Marikina revealed three (3) main processes where the use of ICTs could lead to climate change adaptation and risk management: 1) facilitating execution of tasks; 2) collecting data/information; and 3) processing and analyzing data/information. However, the findings also suggest, with the current state of diffusion among Metro Manila LGUs, ICTs do not necessarily play a crucial role in the actual achievement of climate change adaptation and risk management objectives but makes their accomplishment more effective and efficient.

The biggest barrier to ICT adoption among Metro Manila LGUs is lack of ICT-specialists or inadequate ICT-capacity of personnel and officers. For this reason, this study recommends implementation of incentive schemes to attract ICT-specialists to work for LGUs and to conduct ICT-related capacity-building activities for members of LGUs. The case study revealed that one of the underlying issues to ICT adoption for climate e-governance is the seeming gap between the ICT-capacity of the LGUs and their climate action responsibilities. Many more advanced ICTs are operated at the national level but major climate action responsibilities are devolved to LGUs. As such, the LGUs do not reap the benefits of collecting and analyzing firsthand climate-related data. The general recommendation therefore is to integrate ICT-use into the climate action framework of the whole government to better align the distribution of ICTs with the national-local government dynamics for climate action.

Keywords

Climate Change, Climate Change Adaptation, Local Government, Information and Communications Technology (ICT), E-Governance

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Abbreviations

AD	Adoption-Diffusion
AKP	Adaptation Knowledge Platform
ARG	Automatic Rain Gauges
AWS	Automatic Weather Stations
CA	City Administrator
CBMS	Community-Based Monitoring Survey
CCTV	Closed-Circuit Television
CEMO	City Environment Management Office
CENRO	City Environment and Natural Resources Office
CLUP	Comprehensive Land-Use Plan
CPDO	City Planning and Development Office
DENR	Department of Environment and Natural Resources
DICT	Department of Information and Communications Technology
DOST	Department of Science and Technology
DRRMO	Disaster Risk Reduction and Management Office
DTS	Data Tracking System
EFCOS	Effective Flood Control Operating System
EMB	Environmental Management Bureau
FACTS	Food and Commodity Tracking System
FEWS NET	Famine Early Warning Systems Network
GDP	Gross Domestic Product
GeSI	Global e-Sustainability Initiative
GIS	Geographic Information System
GISS	Goddard Institute for Space Studies
GMMA	Greater Metro Manila Area
HLURB	Housing and Land Use Regulatory Board
ICT	Information and Communications Technologies
IISD	International Institute for Sustainable Development
IP	Internet Protocol
IPCC	Intergovernmental Panel on Climate Change
ITU	International Telecommunications Centre
JICA	Japan International Cooperation Agency

KOICA	Korea International Cooperation Agency
LDRRMF	Local Disaster Risk Reduction and Management Fund
LGU	Local Government Unit
LTO	Land Transportation Office
MDSI	Met-Hydro Decision Support Infosys
MGB	Marine and Geosciences Bureau
MISCC	Management Information Systems and Call Center
MMDA	Metro Manila Development Authority
NCR	National Capital Region
NDRRMC	National Disaster Risk Reduction and Management Council
NIPA	National IT Industry Promotion Agency
NOAH	Nationwide Operational Assessment of Hazards
NRM	Natural Resource Management
OECD	Organisation for Economic Co-operation and Development
PAGASA	Philippine Atmospheric, Geophysical and Astronomical Services Administration
PGIS	Participatory Geographic Information System
PhiVolcs	Philippine Institute of Volcanology and Seismology
PM	Particulate Matter
PO	Planning Office
QRF	Quick Response Fund
RA	Republic Act
SDG	Sustainable Development Goal
SLA	Sustainable Livelihoods Approach
SMS	Short Message Services
UD	Use-Diffusion
UN	United Nations
UNCTAD	United Nations Conference on Trade and Development
UNFCCC	United Nations Framework Convention on Climate Change
UNOSAT	United Nations Institute for Training and Research Operational Satellite Applications
WHO	World Health Organization

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Chapter 1: Introduction

1.1 Background

Globally, the effects of climate change have increasingly affected various populations (Tollin et. al, 2017). These effects occur in various forms – from sea level rise, melting of ice shields to increasing frequency and intensity of weather events such as rainfall, extreme heat waves and droughts (*Climate Change Consequences*, n.d.). The Centre for Research on the Epidemiology of Disasters recorded that for the first seven years of the 21st century, the number of disasters has doubled compared to the period from 1987 to 1997, and this was mainly due to the increase in weather-related disturbances (Warner & Zakieldeen, 2011). As such, life and societal necessities and facets; e.g. access to water, food production, land-use, and physical and natural capital among others, are continuously threatened due to climate change (Marchal et. al, 2011). Climate Change also affects human health. Patz et. al (2005) provides that an estimate of over 150,00 lives are killed anually for the past 30 or more years due to climate change. They further report that many human diseases such as cardiovascular mortality, respiratory illnesses and malnutrition can be linked to climate fluctuations. The effects of climate change on health can be direct or indirect (McMichael et. al, 2006). On one hand, the direct health impacts can occur when climate change related hazards themselves result to an environment that increases the risks for or aggravates certain types of diseases. For instance, bacteria such as salmonella and cholera can proliferate more rapidly at higher temperatures, and this consequently increases the risks of acquiring infectious diseases. Heatwaves could also exacerbate pre-existing cardiovascular and respiratory diseases. The indirect impacts, on the other hand, are manifested through the social, economic and political disruptions as results of climate change. The negative effects of climate change on food security, for example, could lead to malnutrition. Land-use changes influenced by the changing climate could also affect transmission of infectious diseases (Patz et. al, 2005).

Although there are no exceptions when it comes to the adverse impacts of climate change, the extent of vulnerability among countries vary due to differences in the capacity to adapt (United Nations, 2008). Hence, developing countries are especially more vulnerable to climate risks because of constraints in social, technological and financial resources (United Nations, 2007). A report by the European Capacity Building Initiative provided that in the past 25 years[1], over 95% of deaths due to natural hazards took place in developing countries (Warner & Zakieldeen, 2011). Also, according to the global reinsurance company Munich Re, low-income countries have incurred economic losses over twice the amount in comparison with high-income countries in the last decade. Climate change and its effects could continue to worsen as per business-as-usual scenario where level of greenhouse gas emissions could double between 2008 and 2050 (OECD, 2009). The Intergovernmental Panel on Climate Change (IPCC) reported that with continued emission of greenhouse gases, climate change would lead to increased *"likelihood of severe, pervasive and irreversible impacts for people and ecosystems"* (IPCC, 2014, p.17). The World Health Organization (WHO) also estimates that climate change-related health risks would more than double by the year 2030 (Patz et. al, 2005).

Within countries, especially among least-developed, urban areas and cities are at greater risks to climate hazards. Many features of cities such as high concentration of people and properties make them more susceptible to climate risks (McBean & Hensta, 2003). With rapid urbanization, lives, livelihood, and assets in cities are increasingly exposed to climate risks (UNISDR, n.d.). Among developing countries, rapid urbanization has resulted to cities not

[1] 2011 as reference

being able to accommodate and provide for the needs of the increasing population which contribute to cities' increasing vulnerability (World Bank, 2012a). Also, among low to middle income countries, almost half of the populations of cities live in slums which are usually within areas with high exposure to climate hazards. Moreover, slum dwellers typically live under poor quality housing, and limited access to basic services such as water and energy (World Bank, 2012a). As such, it is really necessary for countries, especially among least developed, to implement measures to adapt to the impacts and manage risks of climate change, prioritizing urban areas and cities.

In the study of climate change adaptation and management of risks, in general, the use of Information and Communications Technologies (ICTs) has emerged. ICTs are technical equipment and facilities with the capacity to covert, process, save and transfer a variety of information in digital form (Niebel et. al, 2013). It includes multi-media broadcasting, radio networks, computer networks, mobile phone communication technologies etc. (Lallana et. al, 2002). As the use of ICT for development has grown, it was only natural that eventually ICTs are leveraged in addressing climate change challenges (Karanasios, 2011). ICTs enable adaptation processes such as assessment of climate impacts and vulnerability through its capacity to improve availability and accessibility of relevant climate data and information (Ospina et. al, 2012). In many developed and developing countries, as ICT helps facilitates exchange and transfer of knowledge and information, it is already being utilized for climate change adaptation in various sectors such as agriculture, and health (Imam et. al, 2017).

The use of ICT in adaptation and management of climate risks may be discussed within the realm of 'ICT for Development (ICT4D) which is basically the use of ICTs to support development (AEDEV, n.d.) and 'e-governance' which, as defined by Dawes (in Bannister & Connolly, 2012, p. 2), *"comprises the use of information and communication technologies (ICTs) to support public services, government administration, democratic processes, and relationships among citizens, civil society, the private sector, and the state."* Many studies have shown that the level of ICT diffusion, or simply the process in which ICTs are adopted and used (Peansupap & Walker, 2004), in a country correlates with its level of socioeconomic development, economic growth and poverty reduction (Hameed, n.d). Moreover, they have presented diverse applications of ICTs in governance, for example, through improved information dissemination, efficiency of public services, measures of transparency and accountability, and enhanced citizen participation (Bhatnagar, 2014).

1.2 Problem Statement

Among developing countries, one of the most vulnerable to climate risks is the Philippines. The Global Climate Risk Index (Kreft et. al, 2017) and World Risk Report 2017 (Kirch et. al, 2017) both ranked the Philippines among the top 5 most vulnerable – 5^{th} and 3^{rd} respectively. The geographic circumstances of the Philippines make it prone to natural hazards (World Bank, 2005) where at least 60% of the country's total land area and 74% of the population are exposed to multiple hazards such as typhoons, floods, and tsunamis (World Bank, 2011). Moreover, similar to the trend worldwide, extreme weather events have also been more frequent in the recent decades. From 2000 – 2017 alone, within a span of only 17 years, a total of 269 disasters were recorded, equivalent to around 15-16 disaster occurrences, on average, per year (EM-DAT, n.d.). This is a huge increase when compared to the numbers recorded from 1900-2000 with a total of 333 disaster occurrences, equivalent to an annual average of only 3-4 disasters. Comparing the average number of disaster occurrences between the two periods, the Philippines presently experiences around 12 – 13 disasters more than in the 20^{th} century. In terms of losses and damages, only $6 Million disaster-related damages were incurred from

1900 to 2000 while from 2000-2017, the country had already lost $19.8 Million. Though this may also be the result of development, inflation and many other factors, it nevertheless suggests that disaster-related damages are huge and increasing. Attributable to the country's vulnerability as well is the absence of land barrier to protect itself against climate impacts and the accelerating environmental deterioration, unsustainable development practices, and population growth (DILG, n.d.).

While the e-governance or ICT-use within the government may provide significant contribution to climate change adaptation and risk managment, developing countries such as the Philippines, however, are not able to achieve high level of ICT diffusion due to low per capita income. This fosters the 'digital divide' among countries where disparities and gaps exist between the ICT capacity and diffusion of developing and developed countries. The onset of e-governance in the Philippines may be traced way back to 1971 with the creation of the National Computer Centre which enabled the automation of governance processes. Since then, significant developments have occurred especially within the recent years such as the creation of the "E-Government Master Plan" for 2016 to 2022 (iGov, n.d.) and the passage of Republic Act (RA) No.10844, a law that creates the Department of Information and Communications Technology (DICT) which became "*the primary policy, planning, coordinating, implementing, and administrative entity of the Executive Branch of the government that will plan, develop, and promote the national ICT development agenda.*" (DICT, n.d.). Despite its early inception, the growth of e-governance or ICT4D in the Philippines has been relatively slow compared to neighbouring countries (Lallana et. al, 2002). This is reflected in the country's low level of ICT infrastructure (NCC & NIPA, 2012). An assessment (2012) on e-governance development in the Philippines conducted by the National Computer Center (NCC) of the Philippines and the National IT Industry Promotion Agency (NIPA) of South Korea provided that the relatively low level of e-governance in the Philippines was not due to lack of or limitations in e-governance policies and plans but rather due to inability to actualize and realize these policies and plans despite being well-built. Nonetheless, the Philippines is making progress and is in the momentum in terms of its pursuit of e-governance. In 2012, a United Nations' (UN) ranking of e-government index rated the Philippines 88th (NCC & NIPA, 2012) in the world, now, the country sits at 71st place based on the recent 2016 ranking (United Nations, 2016).

The role of ICT for development and governance can particularly be significant at the local level in the Philippines where Local Government Units (LGUs), such as cities/municipalities, are tasked to deliver major public services including the implementation of climate action measures (ECDPM, 2006). RA no. 9729, Section 14 provides that *"The LGUs shall be the frontline agencies in the formulation, planning and implementation of climate change action plans in their respective areas…"* (LGA, 2014). A study, however, by Siar (2005) showed minimal adoption of e-governance and underutilization of ICT tools among cities in the Philippines. The use of ICT could actually help bridge data and information gaps that hamper effective management of climate risks and adaptation among LGUs in the Philippines (World Bank, 2011). The Institute for Climate and Sustainable Cities also emphasizes the necessity of improving the science and use of climate and other relevant data and knowledge in order to properly recognize and address local climate change impacts and risks (ICSC, n.d.).

Leveraging ICTs for local climate action could provide significant contribution to help vulnerable cities in the Philippines adapt to and manage climate risks. Many cities in the Philippines are included among the most vulnerable to sea level rise and intensifying storm surges (DILG, n.d.). Among the cities vulnerable to climate risks are those within the National Capital Region (NCR) or Metro Manila which is among the largest urban agglomerations in the world (CDRI, 2010). It serves as the political and economic center of the Philippines (Singru et. al, 2014) with a population density that is more than 60 times the national population density (PSA, 2016). The rapid urbanization, as a result of continuous migration and births in the region, makes it more sensitive to climate risks not just because of the increasing concentration of people and assets but also due to the inability of the government to cater to the increasing demand for basic services (CDRI, 2010). Porio (2014) reported that around 40% of Metro Manila inhabitants are informal settlers within risky areas with limited access to adequate services and facilities. Adding to the region's vulnerability is its exposure to typhoons and also flooding as it is surrounded by water bodies such as the Manila Bay, and Laguna de Bay (Bankoff, 2003). Francisco and Yusuf (2009) ranked Metro Manila as the highest among all regions in the Philippines in terms of climate change vulnerability. According to their report, Metro Manila is exposed to multiple climate hazards especially cyclones and floods.

The aim of this study, therefore, is to look into the ICT diffusion within the e-governance aspect of climate change adaptation and risk management of cities/municipalities in Metro Manila which is simply referred to in this study as 'local climate e-governance'. The main goal is to provide baseline information to support the utilization of ICTs in order to help LGUs adapt to climate change impacts and manage climate risks.

1.3 Research Objective

The main objective of this research is to build on existing studies on the role of ICTs in climate change adaptation and risk management by looking into the state of ICT diffusion within the local climate e-governance in Metro Manila, Philippines. Specifically, this study identifies the types of ICTs used by the cities/municipalities in the said region, how they are being used and to what extent in regard to local climate e-governance. How ICTs actually lead to better climate change adaptation and risk management is also discussed as well as the issues and barriers to ICT diffusion and the possible measures to strengthen ICT use in local climate e-governance.

1.4 Main Research Question

What is the state of ICT diffusion within the local climate e-governance in Metro Manila, Philippines?

1.5 Sub Research Questions

- What are the types of ICTs being used for local climate e-governance?
- How are ICTs being leveraged by LGUs for local climate action?
- What role do ICTs play in helping localities adapt to and manage climate risks?
- What are the issues and barriers to ICT diffusion within the context of local climate action?
- What appropriate measures can be done to strengthen ICT adoption in the local climate e-governance in Metro Manila?

1.6 Significance of the Study

Despite its growing recognition, the role of ICTs in addressing the challenges of climate change has remained limited in both theory and practice (Karanasios, 2011). Although ICT has been deployed in fields such as health and education, much are still yet to be explored in terms of its role in climate change adaptation (World Bank, 2012b). Ospina and Heeks (2010a) stated in their review of existing literature on the matter that within the systemic understanding of adaptation, the potential of ICT is not yet well integrated. Ospina and Heeks (2010b) also noted that despite the increasing recognition on the role of ICTs in reducing vulnerabilities in the context of climate change, further analysis and more studies should be done in determining its actual impact. As such, this study aims to contribute to existing body of knowledge as well as bridge some knowledge gaps by applying established theories within the context of local e-governance and climate action in the Philippines.

With respect to practice, Ospina and Heeks (2010b) reported that decision makers lack awareness when it comes to the benefits of ICTs in dealing with environmental issues. Moreover, there is lack of multi-stakeholder engagement in pursuit of ICT-based solutions; and lack of enabling policy frameworks. Pant and Heeks (2011) also said that despite the potential of ICTs to aid in climate change adaptation, its use has been impeded by the digital divide among vulnerable communities. This is especially true in the Philippines where the level of ICT diffusion in governance is still relatively low. This study could therefore be used to support the spur of e-governance and ICT4D, especially within the realm of climate change adaptation and management of risks. Given the country's high vulnerability to the impacts of climate change, this study could offer an innovative solution to manage and adapt to climate risks particularly at the local level where the major responsibilities for climate action are.

1.7 Scope and Limitations

While ICT diffusion and e-governance could be discussed and studied at different perspectives and scales, this study only looks into ICT diffusion within the context of local climate action. As such, ICT projects and programs implemented by the national government or by the private sector are not taken into account in this study unless the project or program involves partnership with the city governments such as when the city government implements the project/program or if it is a Public Private Partnership with the local government. For this study, local climate e-governance only involves climate change adaptation and management of risks. ICT use for climate change mitigation and sustainability are beyond the scope of this research.

In addition, this study does not intend to generalize in terms of methodology and results. The methodology employed, on one hand, is just one of many other ways to systematically assess the role of ICTs in local climate action. This study acknowledges that there may be better ways for measuring ICT diffusion but the methods employed in this study are chosen to fit within the time frame as well as the available resources provided for the implementation of this research. On the other hand, while it may provide insights as to the case of other cities outside of Metro Manila or the Philippines, the results can only be best generalized within the context of the region. It is also important to note that while ICT-use for local climate e-governance can be studied in greater detail, this study aims only to provide a snapshot or an overview for the case of Metro Manila, Philippines that could serve as baseline information and reference for future studies on the matter.

Chapter 2: Literature Review / Theory

2.1 Climate Change

Scientific evidences have already proven the authenticity of the climate change phenomenon. Although the climate does vary over time, accumulating evidence suggests that it has changed over and above its natural variation observed on certain time-scales (McMichael et. al, 2004). An analysis conducted by the Goddard Institute for Space Studies (GISS) has shown that the average global temperature has increased since 1880 by about 0.8 degrees Celsius (Carlowicz, n.d.). IPCC (2013) expects the climate situation to worsen as per assessments and projections. Climate change is caused by increasing concentration of greenhouse gases in the atmosphere. Greenhouse gases exist in the atmosphere to prevent the heat coming from the sun from escaping (*A Blanket Around the Earth*, n.d.). This is called the greenhouse effect. The greenhouse effect is actually a natural process to warm the earth, making the planet inhabitable (Department of the Environment and Energy, n.d.). However, due to human activities, there have been enormous increase in the concentration of greenhouse gases. There are four main greenhouse gases – Carbon Dioxide, Methane, Nitrous Oxide, and Flourinated gases. Human activities such as burning of fossil fuels, solid wastes, and wood products have resulted to increased carbon emissions. Carbon Dioxide, among greenhouse gases, is the most produced comprising around 64% of human-induced global warming and at present, the concentration of Carbon Dioxide in the atmosphere is 40% higher than during the pre-industrialization era (*Causes of Climate Change*, n.d.). The industrial revolution has resulted to more demand for burning fossil fuels for the production of energy thus, more carbon dioxide are emitted (Rosenzweig & Solecki, n.d.). The other greenhouse gases – methane, nitrous oxide, and fluorinated gases are also emitted by either agricultural and industrial processes and activities (*Overview of Greenhouse Gases).*

Aside from scientific observations on changes in the climate and concentration of greenhouse gases over time, the occurrence of climate change is also manifested in terms of its impacts. The manifestations of climate change could range from increasing ocean temperatures, sea level rise to intense and more frequent extreme events such as tropical cyclones, hurricanes, typhoons, flood droughts and heavy rain (United Nations, 2007). The IPCC reports that as climate change aggravates, its impacts would intensify as well (Watkiss et. al, 2005) and even a slight change in the climate; as small as 1 degrees Celsius, could lead to extreme climate events. Scientific findings show that a global average temperature 2 degrees celsius above pre-industrial levels would potentially result to a number of more severe climate related impacts and catastrophes (Luers et. al, 2007). It is as such that the target of the Paris Agreement is to keep the global rise temperature from the aforementioned dangerous level (*The Paris Agreement, n.d.)*. While climate change mitigation is necessary to prevent the continuous rise in global temperature, given that the impacts of climate change are already being felt and may most likely to increase, adaptation to climate change impacts and management of risks are equally, if not more, vital.

2.2 Vulnerability and Local Climate Action

An important concept in the study of climate change adaptation and management of climate risks is 'vulnerability'. The effects of climate change are differentiated among groups, sectors and individuals because of the various levels of vulnerabilities. The second assessment report of IPCC defines vulnerability as *"the extent to which climate change may damage or harm a system… (it) depends not only on a system's sensitivity, but also on its ability to adapt to new climatic conditions"* (Olmos, 2001, p.2). This suggests, as conceptualized by Ospina and Heeks (2010a), that vulnerability has two facets – one that is "outside" of a system which is the source of shocks, and another that is "inside" the system which is the subject of the shocks and variations. This is crucial in the understanding of vulnerability and in coming up with adaptation measures as it shows that vulnerability of systems depend not only upon its exposure to climate risks but also on their capacity to adapt to and manage these risks. Within the urban context, a study by Dodman et. al (2017) demonstrated how urbanization and urban form exacerbates the vulnerability of cities in the sub-Saharan region of Africa. According to their study, many of the cities and towns in in Africa are small to medium sized and thus, it is more difficult for them to achieve greater scale of economies leading to low urban productivity. They are also more likely to be less well-developed in terms of technical, institutional and financial aspects. Moreover, they lack adequate infrastructure that enable access to basic necessities such as safe drinking water and improved sanitation and most of the urban dwellers are largely poor. All these features make the cities more vulnerable to climate risks. The urban sub-saharan are not the only ones suffering from more vulnerabilities. Over half of the world's population are in urban areas and it is expected to rise. This is coupled with the fact that many cities are exposed to climate risks such as sea level rise and extreme weather events. In the Philippines, for instance, 60% of all municipalities and 10 of the largest cities where a rough 60% of the population is residing along the coast. This leaves a huge amount of population at risk from sea level rise and storm surges (World Bank, 2011).

The concept of vulnerability suggests the vitality of enhancing LGUs' capacity to reduce vulnerabilities and respond to climate change. Given the variability of vulnerabilities, the principle of subsidiarity – "*ensuring that decisions are taken, and services are delivered at the sphere of government closest to the people…*" (McCarney et. al, 2011, p.2) may best fit the implementation of climate action as vulnerabilities are localized and may be best recognized by LGUs. Recent developments in international climate change related negotiations have increasingly viewed cities and urban areas as strategic domains for climate action (Broto, 2017). The 2015 Sustainable Development Goals (SDGs), for instance, has for the first time included an explicit urban goal. The 2015 Paris Agreement emphasized on the crucial role of subnational levels in the implementation of climate action measures. Ospina and Heeks (2010a) also said that effective governance is necessary in adaptation processes. Provided these, it is important to equip cities/municipalities with tools and improve the capacity of LGUs to effectively confront the challenges of climate change challenges especially in countries such as the Philippines where major climate action responsibilities are devolved to LGUs. Section 14 of RA no. 9729 or the Climate Change Act provides that *"the LGUs shall be the frontline agencies in the formulation, planning and implementation of climate change action plans in their respective areas, consistent with the provisions of the Local Government Code, the Framework, and the National Climate Change Action Plan*" (*Republic Act 9729*, 2009).

2.3 ICTs for Climate Action

A tool that is now being used for effective climate change adaptation and risk management are ICTs. These are technologies with the capability to collect, store, edit and transfer data and information in various forms (Kundishora, 2010). The recent growth in the application of ICTs for development processes has resulted to ICT-use for climate change action (Karanasios, 2011). This recent growth is due to the capacity of ICTs to generate and disseminate information, to facilitate coordination of actors in and beyond government and to make public and private services more efficient (World Bank, 2012b). The usefulness of ICTs in climate change adaptation may be attributed to its capacity to facilitate a great deal of information which are necessary to effectively formulate and implement adaptation-related decisions (Dinshaw et. al, 2012). General usage of ICTs in the context of climate change include generation, organization and communication of climate change related information;

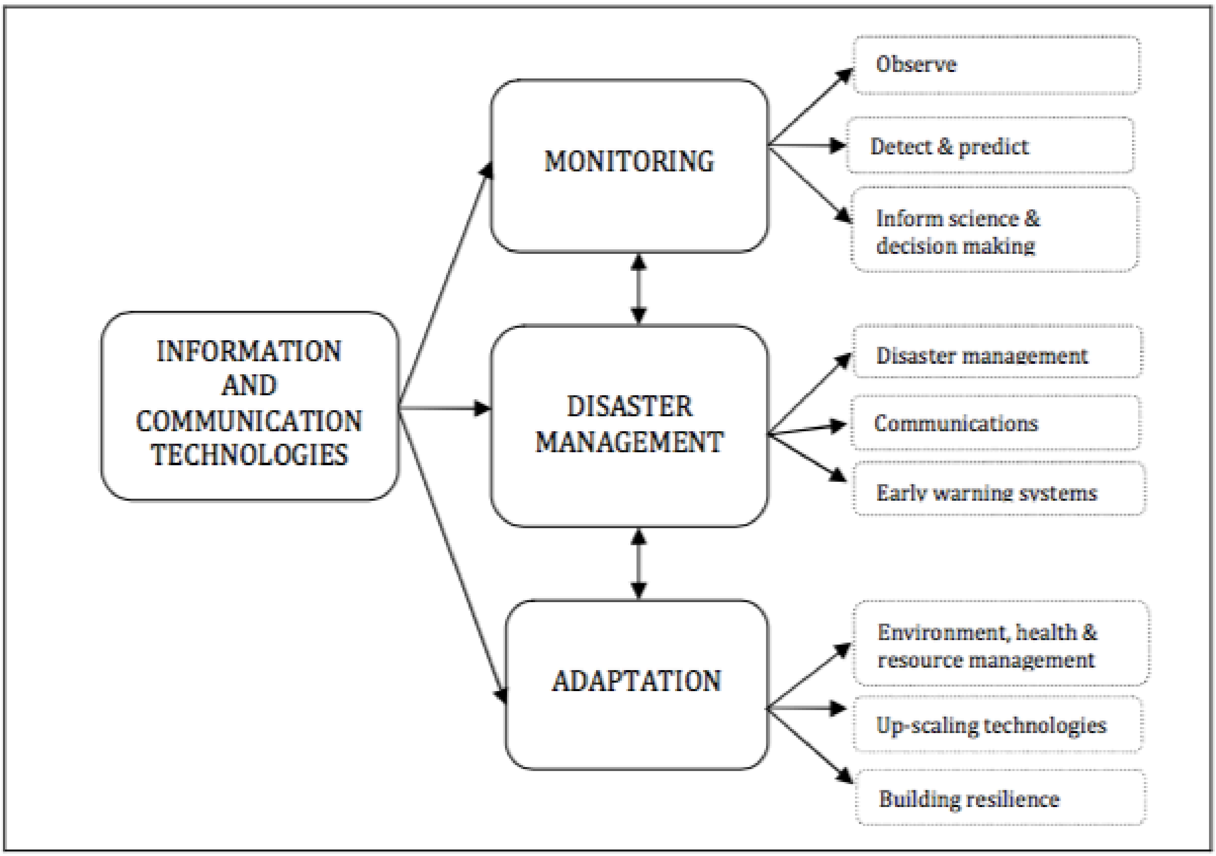
development of information systems; development of early warning and hazard risk information systems and development of ICT mapping tools (World Bank, 2012b). The United Nations Framework Convention on Climate Change (UNFCCC) has also acknowledged the role of ICTs in adaptation saying that it *"can be critical in predicting, identifying and measuring the extent of climate change; as well as in the development of effective response strategies to adapt to negative effects of climate change in sectors such as agriculture, employment, technology transfer and energy, among others"* (Ospina et. al, p.9). Pant and Heeks (2011), through their analysis of adaptive capacity development through a systems-based perspective, have drawn four conclusions in which the foundation of ICT in the adaptation context could depend upon: First, climate change adaptation entails data, information and knowledge resources; Second, adaptive capacity involves access, assimilation, creation and utilization of data, information and knowledge. Third, there is a need to integrate local and external climate knowledge and finally, adaptive capacity should be recognized both at the individual and collective levels.

A scoping study done by Ospina and Heeks (2010b) found that the role of ICTs in climate change started in the late 90s through how it could contribute to the achievement of sustainable development. In the early 2000s, it shifted focus from broader global environmental issues to how it can specifically help in climate change mitigation and in cutting down carbon emissions. These concerns, however, have focused mostly on the priorities of the developed world. Within the context of climate action, the priority in developing worlds is adaptation to climate change. Nonetheless, the literature exploring the potential of ICTs in climate change adaptation has grown. Ospina and Heeks (2010b) specifically identified three strands in the field of ICT and climate change: 1) Sustainable and Development and the environment; 2) Mitigation; and 3) Adaptation and Strategies. With respect to sustainability, and mitigation, Creech et. al (World Bank, 2012b) identified three types of impacts ICTs have on climate change. These are: 1) direct impacts as ICTs account for 2 to 2.5 percent of global emissions; 2) indirect impacts where ICTs could reduce emissions through improved efficiency and production; and 3) societal effects on social and economic behavior as a result of widespread ICT use such as changing patterns of trade, production and consumption. For the purpose of this study, the focus will be on the last strand - adaptation and strategies. This strand looks into how ICTs could reduce vulnerabilities and address climate risks. Its inception can be linked to earlier works conducted on how ICTs could aid in Natural Resource Management (NRM). Findings from this work, according to Ospina and Heeks (2010b), resulted to the recognition of the importance of communication processes in local NRM and in local livelihoods within the climate change discussion. The dependence of developing countries on natural resources for development paved the way for the study on how ICTs could help in managing these natural resources, consequently improving their climate change adaptation capacity.

2.3.1 Climate Change Application Areas for ICTs

Karanasios (2011) created a conceptual framework (see Fig. 1) in terms of how ICTs play a role within the climate change domain. It is important to note that the framework is within the context of developing countries. As such, activities such as mitigation, monitoring and evaluation and climate modelling were not within the scope of his study. The aim of Karanasios' study is to examine new and emergent technologies within the context of climate action in developing countries. Three (3) interrelated major application areas of ICT to climate change were identified by Karanasios: 1) monitoring of climate change and the environment; 2) disaster management; and 3) climate change adaptation.

Figure 1: Conceptual Framework: ICT's role in Climate Change (Stan Karanasios, 2011)



2.3.1a Monitoring of Climate Change and Impacts

Monitoring of climate change and impacts usually involves the formation of local and national observation networks to adequately understand and anticipate climate change impacts. It includes the establishment of meteorological and other specialized centers to monitor atmosphere, ocean and terrestrial systems. The monitoring stage, according to Karanasios' framework, is aimed at observation, detection and prediction of climate change related phenomena and the information or data produced could inform science and decision-making. A report made by the International Telecommunications Centre or ITU and the Global e-Sustainability Initiative or GeSI (2010) identified ICT systems for environment and climate monitoring: weather radars and satellites for hurricanes, typhoons, tornadoes, thunderstorms etc.; radio-based meteorological aid systems for collection and processing of weather data; and earth observation-satellite systems for obtaining environmental information. With such tools, many climate-related hazards such as rainfalls, landslides, forest fires, floods etc. are now being observed and monitored in many developing countries (Karanasios, 2011). An interesting project, for example, that took place in Accra, Ghana involves participatory environmental monitoring where a small group of taxi drivers were equipped with devices that allowed them to gauge air quality. As a result, they were able to come up with a map of air quality across the city. In such cases, it demonstrates that ICTs could not only help in monitoring the environment or climate but it could also harness participation in the field of environmental and climate action (Kinkade & Verclas, 2008). In the Philippines itself, a project called "Bantay Usok"[2] by the ABS-CBN Foundation and the Land Transportation Office (LTO), promotes reduction of air pollution in Metro Manila by making ICT platforms – e-mail, websites, phone, fax and mobile

[2] "Guarding for Smoke" in English

phones (through Short Message Services or SMS) as channels for complaints against smoke belching vehicles (Dongtotsang & Sagun, 2006). The project received outstanding recognition through awards and citations by various bodies. In this particular project, ICT was used not only in environmental monitoring but also in encouraging public participation and improving policy implementation.

2.3.1b Disaster Management

Disaster Management simply refers to response to natural hazards and this has emerged as a crucial aspect of managing climate risks among developing countries (Karanasios, 2011) especially in the Philippines considering that it is a disaster-prone country. Karanasios (2011) emphasized on ICT-use for emergency communications and early warning systems as major applications of ICTs for disaster management. Wattegama (2007) conducted a comprehensive study on how ICTs are used for disaster management. In his study, he explained ICT application in disaster management through three major phases: a) Disaster Prevention, Mitigation and Preparedness; b) Disaster Response; and c) Disaster Recovery. Note that the use of ICTs per phase is not mutually exclusive; hence, some ICTs such as the Geographic Information Systems (GIS) are used in all three identified phases.

A) *Disaster Prevention, Mitigation and Preparedness* – this phase involves analysis of risks and identification of measures for the prevention, mitigation and preparation for disasters. Many ICT channels are already being used for disaster warning from traditional to new channels of communication such as radio and television, telephone, SMS, cell broadcasting, satellite radio, internet/e-mail, amateur/community radio and sirens. Relevant disaster related data and information are also being collected using GIS which is *"a system of hardware and software used for storage, retrieval, mapping and analysis of geographic data."* (Wattegama, 2007, p. 16) as well as remote sensing which monitors the environment for possible hazards. The data and information from such ICTs aid in planning and in formulating measures for disaster mitigation and preparedness.

B) *Disaster Response* – this is the post-disaster phase which involves immediate response from the aftermath of a disaster. Web-based applications such as Sahana by Lanka Software Foundation, an open source disaster management software allows affected individuals to contact their loved ones after a disaster, develops a registry for tracking relief activities and record locations of temporary post-disaster camps and shelters. Access to satellite images and GIS also provide data and information that could show an immediate overview of a post-disaster situation. The United Nations Institute for Training and Research Operational Satellite Applications Programme (UNOSAT), for instance, provide these services that have been used by many countries such as India in 2004 when Indian Ocean Tsunami hit. After the tsunami, UNOSAT was able to create maps showing affected areas.

C) *Disaster Recovery* – this is also within post-disaster phase after disaster response where reconstruction of damaged assets takes place. Disaster management softwares such as DesInventar, which collects and stores disaster characteristics and effects, allows for disaster simulation and its impacts. The availability and ability to use such information are essential to carry out necessary measures for effective disaster recovery. Internet-based applications are also being utilized such as the Food and Commodity Tracking System (FACTS) which could facilitate and deliver multiple relief operations simultaneously. The information and data from GIS could also be used for disaster recovery.

In the Philippines, a type of ICT used by many cities for disaster management is social media. In a study by Alampay and Delos Santos (2016) on social media use for disaster management, specifically Facebook and Twitter, in Metro Manila cities, they found that all of them have Facebook accounts and only 1 out of 16 does not have Twitter. According to their analysis of the content of the social media posts, the cities use social media to post typhoon warnings and weather alerts, power interruption, declogging schedules, traffic updates and vehicular accidents, class suspensions, disaster safety tips, availability/schedule of disaster management related training, response teams and post-disaster activities and hotline numbers.

2.3.1c Climate Change Adaptation

Climate Change Adaptation involves adaptation to impacts of climate change. Again, crucial to the study of Climate Change Adaptation is the concept of vulnerability and thus, in terms of ICT-use, the choice depends on the local context. Climate change adaptation involves reduction of current and future vulnerabilities through sensitivity and risk exposure reduction, adaptive capacity enhancement and climate change opportunity maximization (Eakin et. al, 2014). Moreover, the goals of adaptation becomes broader within the development domain. This includes enhancement of social and environmental well-being as well as building of capacities to address future climate challenges. General examples of ICT-use for climate change adaptation include preparation of risk assessments, protection of ecosystems, improvement of agricultural methods, institution of better building designs, improvement of insurance coverage and development of social safety nets (ISDR, 2008; ITU, 2008 in Houghton, 2009). Communities plagued with water-related problems, for example, could use ICTs to improve water resource management. Finlay and Adera (2012, p.1), in their study of ICT use for Water Sector, said that ICTs could *"strengthen the voice of the most vulnerable within water governance processes; create greater accountability; provide access to locally relevant information needed to reduce risk and vulnerability; and improve networking and knowledge sharing to disseminate good practices and foster multi- stakeholder partnerships, among others."*. Another example within the domain of water management is the community-based Participatory Geographic Information Systems (PGIS) being implemented in Malawi where current and future needs are determined through a centrally located model. A USAID-funded network called the "Famine Early Warning Systems Network (FEWS NET)" composed of professionals from different parts of the world such as Africa, Central America, Haiti, Afghanistan and the United States makes use of ICTs to monitor the climate to extract and analyze relevant information that are used to assist decision makers address problems on food security (Houghton, 2009). Mobile technologies through SMS are also now being utilized by many local governments not only to disseminate information about upcoming hazards but also to enable residents to communicate with local authorities in case of emergency and in times of need (World Bank, 2012c).

It is important to emphasize that the three areas: 1) monitoring of climate change and the environment; 2) disaster management; and 3) climate change adaptation, are interrelated and each play a significant role to the accomplishment of one another. For instance, information gathered from monitoring the environment and the climate can be used to create vulnerability and risk maps that could aid in disaster management and climate change adaptation. The use of mobile technology that serve as a channel for people to communicate authorities in times of disasters could also assist the government in monitoring climate change impacts and in providing appropriate disaster response. The three areas, nevertheless, provide for an adequate framework in studying ICT application within the context of climate action.

2.3.2 ICT within the Adaptation and Risk Management Narrative

While the previous section focuses on the role of ICT with respect to the execution of actual climate action operations, this section discusses how the use of ICTs would actually lead to better adaptation and risk management. Ospina and Heeks (2010a) came up with an 'e-resilience' framework to illustrate the role of ICTs in climate change adaptation. Using the Sustainable Livelihoods Approach (SLA), the e-resilience framework (see Figure 2) provides for the analysis of ICT's role in climate change adaptation in two ways: first involves the dynamic links between ICTs and livelihood determinants - assets, institutions and structures to enhance adaptive capabilities while the second one is about how ICTs strengthen resilience sub-properties that adaptive capacities of livelihood systems are also built on (Ospina & Heeks 2010a).

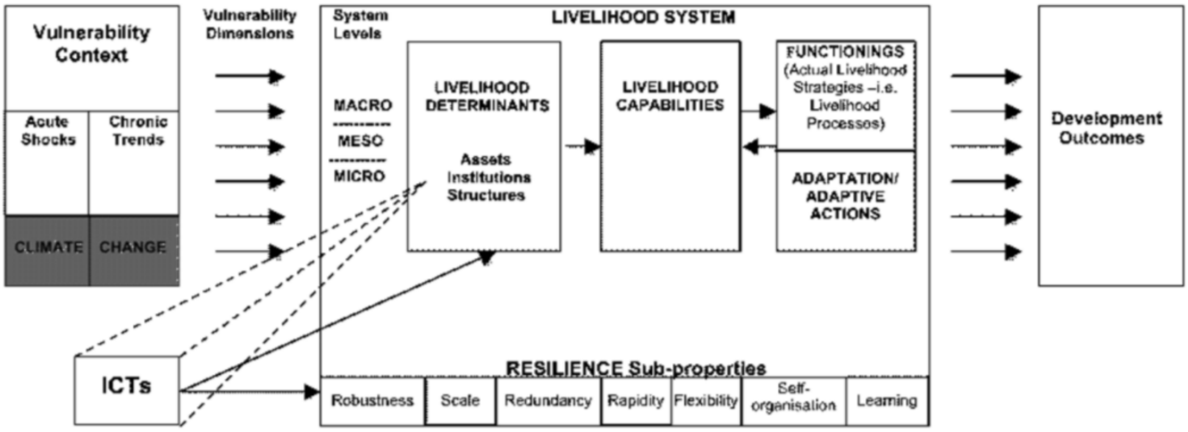


Figure 2: E-Resilience Framework (Ospina & Heeks, 2010a)

With respect to how ICTs could contribute to the formulation of adaptation strategies, Ospina and Heeks (2011), in another study, provided five (5) main domains: 1) informed decision-making; 2) stakeholder engagement; 3) adaptation delivery; 4) feedback and learning and 5) institutional capacity-building. Eakin et. al (2014) furthers this framework by integrating these five domains into the adaptation decision-making process (see Figure 3).

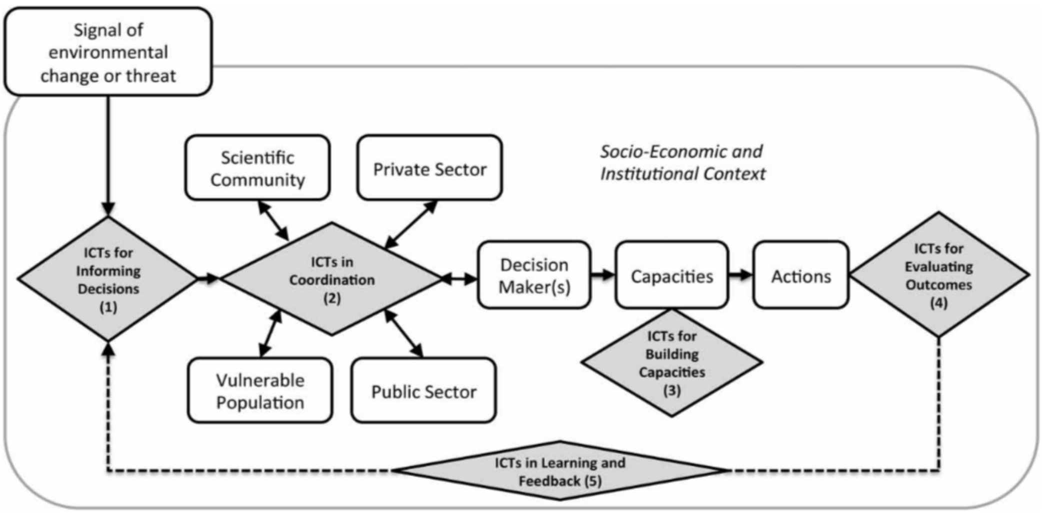


Figure 3: Eakin et. al's (2014) Analytical Model of ICTs in Adaptation

World Bank (2012b) developed a more general framework with respect to assessing ICT tools for climate change adaptation by making use of the four (4) adaptation entry points provided by the International Institute for Sustainable Development (IISD): 1) addressing the drivers of vulnerability; 2) building the response capacity of local and regional systems and communities; 3) reducing and managing risks related to climate variability and climate change; and 4) confronting climate change. This framework focuses more on the actual impact of ICT-use for climate change adaptation. The entry points, using examples from other literature, are further discussed below. It is important to note that these entry points also overlap. An approach therefore in understanding these points is not to treat them separately but as different aspects under the whole process of climate change adaptation and risk management.

2.3.2a Addressing the drivers of vulnerability

According to the framework, addressing the drivers of vulnerability involve interventions that address underlying factors that make a system vulnerable to climate change impacts. Lawali and Idrissa (2015), conducted a case study on how ICTs helped the reduction of vulnerability in rural households in Niger, Maradi. Niger is an agricultural country where farming and livestock occupy nearly 87% of the Nigerian population. In terms of economic contribution, it contributed to about 42% of the country's Gross Domestic Product (GDP). Rural farmers, however, are hampered by multiple constraints when it comes to marketing their products. Some of these constraints involve shortage and remoteness of markets from the production sites; isolation of pastoral area and lack of road infrastructure; and lack of access to agricultural inputs and livestock. These constraints contribute to their vulnerability. According to the study, many farmers use ICTs to try to overcome these challenges. ICTs enable them to access market information which allow them to get the best profits. Through ICTs, the farmers are able to follow dissemination of market products' prices allowing them to avoid abuse from intermediaries during transactions. ICTs also enable them to contact intermediaries and suppliers regarding instructions on sale, availability of market products and placing of orders. Moreover, they are also informed about impending catastrophes and crises. This could allow them to prepare and establish necessary measures to avoid losses and damages. Another example would be in Peru where a project was implemented establishing a small network of telecentres in the Huaral Valley, a climate vulnerable region (Ospina and Heeks, 2010b). Climate change negatively affects their agricultural production and local livelihoods. As such, through ICTs, an agrarian reform system was put up which provided farmers with access to information that they could leverage to increase productivity and improve marketing.

While the examples mentioned are in the context of agriculture, they provide insight on how ICTs could help reduce vulnerability. In this regard, Ospina and Heeks (2010b) identified key areas of where ICTs could play a significant role. These areas also provide insight on how ICTs could be utilized in local climate e-governance.

- **Socio-political:** opportunities to support capacity building, social networking, and awareness raising. ICTs could also foster inclusiveness and participation within the formulation of adaptation processes
- **Livelihoods and Finance:** capacities of ICTs to be leveraged within productive processes and local livelihood activities such as micro-enterprise development, access to credit and new financial transaction mechanisms.
- **Health:** potential of ICTs to enable information sharing, awareness raising and capacity building on climate change induced health related threats.

- **Habitat:** applications such as GIS could play an important role in urban planning and in monitoring and provision of relevant information to support decision making process with respect to human settlements.
- **Food:** enhanced food security through agricultural support. This mainly enabled by ICT-produced information about pest and diseases, planting dates, seed varieties, market prices, consumer trends.
- **Water:** through better water resource management, and awareness raising

2.3.2b Building the response capacity of local and regional systems and communities

For building response capacity of local and regional systems, the idea is strengthening the resources of local systems and communities to enhance their capacity to respond and adapt to climate change impacts. How ICTs could play a role in this regard may be understood using the 'e-resilience' framework by Ospina and Heeks (2010a). According to their framework, ICT could support human, financial and other capital that fosters the livelihood system by using different resilience sub-properties: *robustness; scale; redundancy; rapidity; flexibility; self-organization; and learning.*

- **ICTs and Robustness:** Robustness refers to the ability of a system to maintain its characteristics and performance after a shock. ICTs such as GIS and other similar tools could help provide information that would enable the formulation of effective measures to protect physical preparedness of assets and resources.
- **ICTs and Scale:** Scale is about the range of accessible assets and resources needed to effectively overcome or bounce from shocks. ICTs could bridge people and systems to more assets and resources. In terms of information assets, for instance, ICTs could help people get access to more information that could help them adapt more to climate risks. Also, using the previously discussed example on mobile applications for farmers, ICTs help farmers get integrated to the supply chains broadening the scale of their financial and physical capital.
- **ICTs and Redundancy:** Redundancy refers to the substitutability of assets and resources. This means that when particular assets or resources are, for instance, affected by shocks, there are other assets or resources with the same functions that could be used as substitutes. Same with the idea for ICTs and Scale, ICTs increase people's access to available assets and resources fostering redundancy.
- **ICTs and Rapidity:** Rapidity refers to how fast assets and resources can be mobilized to address shocks. ICTs enable quick access to financial capital, for example, through mobile banking and finance. Information resources, as already discussed, are also accessed easily and quickly through ICTs.
- **ICTs and Flexibility:** Flexibility is the ability to undertake different measures to adapt and address shocks. Given that ICTs could help access diverse assets and capital and as it could also help in identifying range of possible adaptation and risk management measures, it also enhances flexibility. The richness of information that can be found in the Internet alone could help local systems and communities come up with wide ranging measures for adaptation and climate risk management.
- **ICTs and Self-Organization:** Self-organization is a system's ability to reorganize in face of a shock. Crucial to self-organization is social capital and ICTs could help in facilitation and enhancing social capital. In the study of Alampay and Delos Santos (2016), for example, the use of social media for disaster management may somehow improve the trust and support of the public on the LGUs as they become more responsive, transparent and participatory.

- **ICTs and Learning:** Learning is the ability to gain or create knowledge to strengthen skills and capacities that enable systems to become more dynamic with respect to shocks. ICT channels such as social media and web-based applications could facilitate knowledge sharing and cultivate collective and systematic learning.

2.3.2c Reducing and managing risks related to climate variability and climate change

As per the IISD framework, reduction and management of risks related to climate variability and climate change involves interventions that help transform system lifestyles and behaviours in ways that make them more adaptive and sustainable in new climatic conditions through information and facilities. Upadhyay and Bijalwan (2015) said that ICTs could facilitate transmission of information to guide communities and people on how they could protect themselves against weather-induced crises as well as on lifestyle changes to secure lives and livelihoods in the long run. ICT-use, through the media for example, is critical in disseminating information about disaster risks through early warning and humanitarian updates during and after disaster events. These information from the media may influence public behaviour to prepare for impending disasters as well as to be informed of the post-disaster efforts of the government and other stakholders making them aware of different avenues to ask for assistance (UN-APCICT/ESCAP, 2011). Disaster management by cities in Metro Manila, for example, also make use of social media to provide safety tips and information on disaster preparedness measures which could influence the public's response to disasters (Alampay et. al, 2018). In the "bantay usok" project, the use of ICTs made it easier for people to complain. This resulted to many reports against smoke-belching vehicles which may have also disicentivized ownership of high emitting vehicles (Dongtotsang & Sagun, 2006).

2.3.2d Confronting Climate Change

Confronting climate change involves measures and interventions that directly address the physical impacts of climate change. Based on other studies such as those mentioned in this section, it seems that ICTs play an indirect role in confronting climate. For instance, As previously discussed, the capacity of ICTs such as GIS and remote sensing to collect relevant environmental and climate data and information allows for the formulation of effective measures to confront climate change impacts which could range, for example, from enhancing the drainage systems to building evacuation centers and sea walls. Given its nature, ICTs are mainly used to collect and analyze climate change related information which is then used for coming up with measures for confronting climate change. As such, ICTs, in this aspect, mostly play an indirect role.

2.4 Summary and Conclusion

Climate change is already happening and the role of local government is crucial in alleviating its impacts. A tool that has emerged in the field of climate change action is ICTs. Existing body of literature provide for the conceptual foundation on the role of ICTs for climate action. Many countries are also already utilizing ICTs in this regard. This is mainly attributed to the capacity of ICTs to produce, facilitate and manage data and information essential to design and execute measures for addressing climate change challenges. Karanasios (2011) makes a good summary of the areas where ICTs can be applied for climate action: 1) monitoring of climate change and its impacts; 2) disaster management; and 3) climate change adaptation. Among ICTs identified to play crucial role in these areas are GIS, remote sensing technologies, web-based applications, mobile technology, radio, televisions, social media, and specialized softwares. Related literature also show that the use of ICTs could fit within the climate change adaptation narrative. World Bank (2012b), for example, using the IISD framework, identifies four adaptation entry points: 1) addressing drivers of vulnerability; 2) building the response capacity of local and regional systems and communities; 3) reducing and managing risks related to climate variability and climate change and 4) confronting climate change where ICTs could play a role for climate change adaptation and risk management.

2.5 Conceptual Framework (see Figure 4)

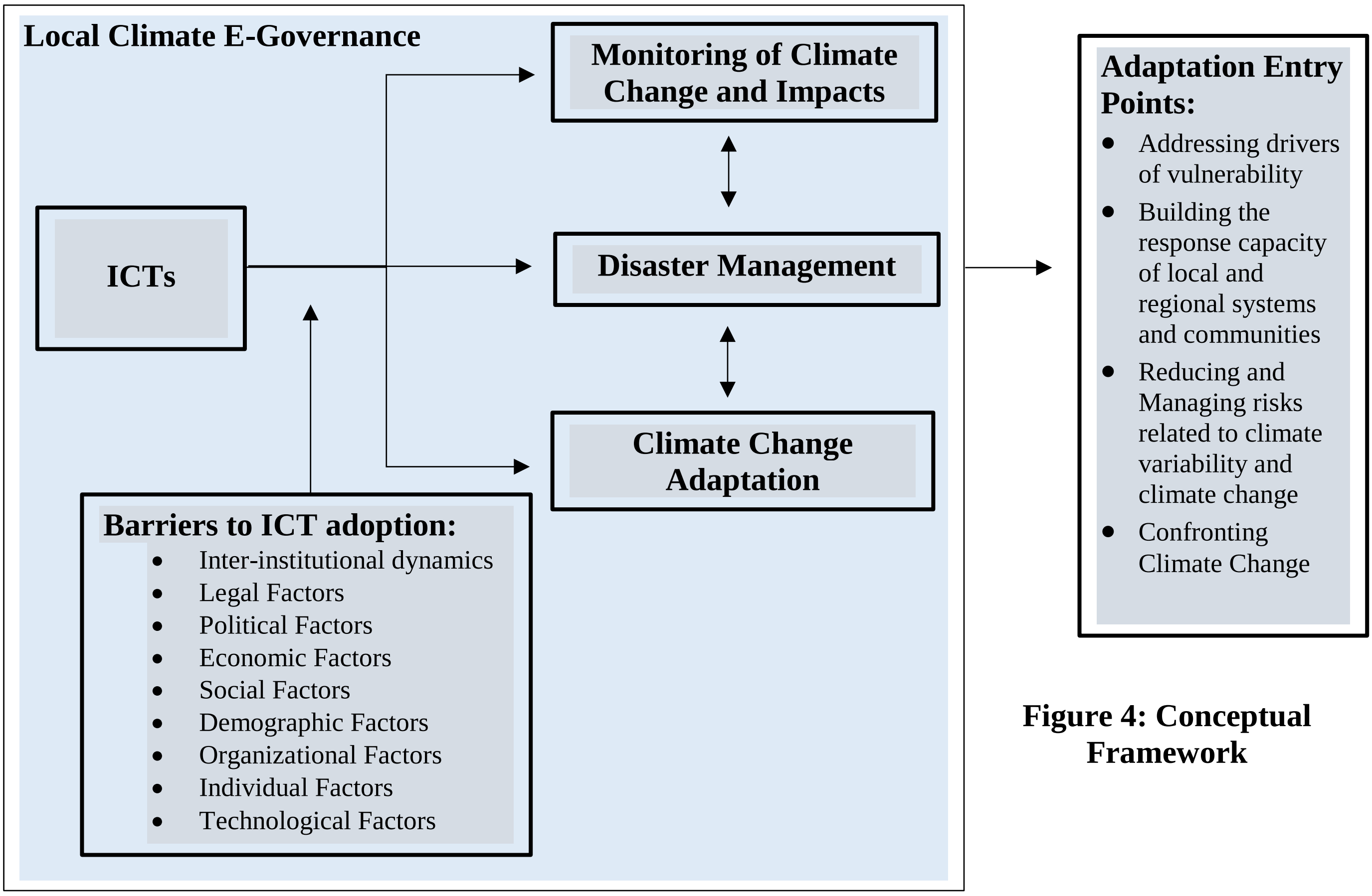


Figure 4: Conceptual Framework

While the role of ICTs for climate change action through this literature review was discussed in general, for this study, they are applied within the context of local climate action of LGUs in Metro Manila, Philippines. This is referred to in this study as 'local climate e-governance'. E-governance is "*the use by the government of web-based Internet applications and other information technologies, combined with processes that implement these technologies, to enhance the access to and delivery of government information and services to the public, other agencies, and other government entities or bring about improvements in Government operations that may include effectiveness, efficiency, service quality, or transformation;"* (Kumar et. al, 2014, p. 1). Using this basic concept of e-governance, this study looks into how ICTs enhance access to and delivery of government information and services that are related to climate action, specifically with respect to climate change adaptation and risk management. This is done by assessing the ICT diffusion, or the level of ICT-use and adoption, among LGUs in Metro Manila, Philippines using the framework of Karanasios (2011). Note that Karanasios (2011) did not specifically identify the three areas: monitoring of climate change and impacts, disaster management and climate change adaptation, within the context of e-governance. Nonetheless, his framework involves general application of ICT within climate change adaptation and risk management and since this study focuses on the ICT application for climate action among LGUs, the term local climate e-governance is used. This study examines the types of ICTs used and to what extent they are being used for the three application areas of

Karanasios (2011). After describing the ICT diffusion in local climate e-governance, this study then provides insights on how it contributes to climate change adaptation and management of climate risks using the adaptation entry points of World Bank (2012b). Barriers to ICT adoption are also identified in this study using the framework by Cucciniello et. al (2015) derived from a systematic literature review to determine barriers to ICT adoption and diffusion in the public sector. The framework identifies 10 types of factors that could hamper ICT adoption and diffusion in the public sector: 1) inter-Institutional dynamics; 2) legal factors; 3) political factors; 4) economic factors; 5) social factors; 6) demographic factors; 7) technological factors; 8) organizational factors; 9) individual factors; and 10) technological factors. Table 1, which is directly taken from the paper of Cucciniello et. al (2015), provides further elaboration on these factors.

Table 1: Main Determinants and Barriers to ICT Innovation, Adoption and Diffusion in the Public Sector (Cucciniello et. al, 2015)

CONTEXT *(Level 1)*	DIMENSION *(Level 2)*	DETERMINANTS AND BARRIERS *(Level 3)*
OUTER CONTEXT	***Economic factors***	▪ Economic growth and employment as positive determinants of e-government adoption (Nelson and Svara, 2012) and diffusion (Rodriguez Dominguez et al., 2011); ▪ Budget constraints can drive the adoption and spread of innovative work arrangements (Lonti and Verma, 2003); ▪ Unfavorable investment climate and market structures as barriers to implementation.
	Social factors	▪ The population's education can favor the adoption (Reddick and Norris, 2013) and diffusion (McNeal et al., 2007) of e-services; ▪ Stakeholder trust in institutions is a driver for the adoption of e-government (Kim et al., 2007); ▪ Providers and suppliers as pivotal actors in e-procurement: they can drive adoption sustaining a solid supply chain (Hawking et al., 2004) or raise barriers to upscaling if they are reluctant to change (Cattaneo, 2012); ▪ Public pressure – in terms of user demand – can drive adoption (Jun and Weare, 2011) and diffusion (Walker et al., 2011).
	Demographic factors	▪ The larger the context, the more likely the adoption of innovations (Moon, 2002); ▪ In diffusion dynamics, the size of the context is a more powerful facilitator for earlier adopters rather than for later ones (Kwon et al., 2009). ▪ No literature on demographic factors as barriers to innovation.
	Technological factors	▪ Lack of ICT infrastructures as barriers to innovation adoption (Ghani and Said, 2010), also in the case of telework (Unguream, 2007); ▪ Public ICT readiness as a determinant of adoption and diffusion (McNeal et al., 2007); ▪ Information security as a determinant of adoption of e-procurement (Gebauer et al., 2008) and telework (Booz-Allen Hamilton, 2002).
CONTEXT *(Level 1)*	**DIMENSION** *(Level 2)*	**DETERMINANTS AND BARRIERS** *(Level 3)*
OUTER CONTEXT	***Inter-institutional dynamics***	▪ Mimicking, learning and competition as determinants of adoption and diffusion (Bhatti et al., 2011); ▪ Mimetic pressures can determine the adoption of e-procurement (Kassim and Hussin, 2013) but may be insufficient to avoid diffusion with shallow patterns (Jun and Weare 2011); ▪ Upscaling is driven by "beacons" that promote innovations *vis-à-vis* later adopters (Mulgan and Albury, 2003); ▪ Isomorphism of later adopters as a driver of diffusion (Kwon et al., 2009); ▪ Beyond replication, innovations' adaptability as a necessary condition for adoption (Nasi and Steccolini, 2008), diffusion (Rogers 2003) and upscaling (Davis and Simon, 2013). ▪ No literature on inter-institutional dynamics as barriers to innovation.
	Legal factors	▪ Legal aspects can represent drivers or barriers to innovation: ○ The need to meet legal requirements drives the adoption of innovations (Nasi and Steccolini, 2008), but constitutional settings can be problematic in implementing e-government practices (Jaeger, 2002); ○ For e-procurement, upscaling can be either favored by the observance of regulations or impeded by their constraints (Cattaneo, 2012). ▪
	Political factors	▪ Political attitudes as determinants of adoption (Bingham, 1978) and upscaling (Davies and Simon, 2013); ▪ Traditional channels of political communication as barriers to innovations (Ahn, 2011); ▪ The form of government as a determinant of e-government adoption (Nelson and Svara, 2012); ▪ In diffusion processes, the manager-council form of government is more likely to characterize earlier adopters, while later adopters are more likely to present a mayor-council form (Kwon et al., 2009).

CONTEXT (Level 1)	DIMENSION (Level 2)	DETERMINANTS AND BARRIERS (Level 3)
INNER CONTEXT	***Organizational factors***	▪ Organizational factors are more impactful than environmental ones (Nasi et al., 2011); ▪ The adoption of technological innovations is influenced more by organizational slacks and specializations (Damanpour, 1987); ▪ Organizational slacks as determinants of adoption and diffusion (Bhatti et al., 2011); ▪ Organizational size can act as a driver (Homburg and Dijkshoorn, 2011) or a barrier (Gianakis and McCue, 1997); ▪ Implementation costs as a barrier to the upscaling of e-procurement (Cattaneo, 2012); ▪ The adoption of e-procurement is driven by organizational learning (Kassim and Hussin, 2013); ▪ Political and managerial leadership as drivers of adoption and diffusion (Nasi and Steccolini, 2008; Bekkers and Homburg, 2005); ▪ The need for organizational re-arrangements as a barrier to the adoption of telework (Hamilton, 2002); ▪ Bureaucratic attitude and risk aversion culture as barriers to adoption, diffusion and upscaling (Albury, 2005; Thenint, 2010), also for e-procurement (Eadie et al., 2007) and telework (Unguream, 2007); ▪ Inter-institutional networks and collaborations as determinants at every stage of the innovation process (Manoharan, 2013; Mulgan and Albury, 2003).

CONTEXT (Level 1)	DIMENSION (Level 2)	DETERMINANTS AND BARRIERS (Level 3)
OUTER CONTEXT	***Individual factors***	▪ Individual perceptions are crucial: ○ The perspective of improving independence, effectiveness and cost saving is a critical determinant of adoption (Cassell, 2008); ○ The relative advantage perceived as a driver of adoption and diffusion (Nedović-Budić and Godschalk, 1996); ○ The diffusion and upscaling of e-procurement and telework are positively impacted by the possibility of improved efficiency and effectiveness and negatively impacted by scarce awareness of benefits and skepticism (e.g. Rivera León et al., 2012; Cattaneo, 2012). ▪ Professionalism and ICT readiness as determinants of adoption (Nasi et al., 2011) and diffusion (Bhatti et al., 2011) – also for e-procurement and telework – that are more likely to influence earlier adopters (Kwon et al., 2009);
	Technological factors	▪ Technological complexity as a barrier to adoption (Raus et al., 2009) and diffusion (Rogers, 2003); ▪ The existence (Reddick and Norris, 2009) and the position (Nasi et al., 2011) of an IT department within an organization is a determinant of adoption; ▪ User capacity and organizational ICT readiness as determinants to the adoption and diffusion (Kalu, 2007; Gascó et al., 2013), also in the case of e-procurement (Gebauer et al., 1998).

Chapter 3: Research Design and Methods

3.1 Revised Research Question(s)

Consistent with Chapter 1, the main and sub research questions remain as follows:

3.1.1 Main Research Question

What is the state of ICT diffusion within the local climate e-governance in Metro Manila, Philippines?

3.1.2 Sub Research Questions

- What are the types of ICTs being used for local climate e-governance?
- How are ICTs being leveraged by LGUs for local climate action?
- What role do ICTs play in helping localities adapt to and manage climate risks?
- What are the issues and barriers to ICT diffusion within the context of local climate action?
- What appropriate measures can be done to strengthen ICT adoption in the local climate e-governance in Metro Manila?

3.2 Operationalization: Variables, Indicators

In general, this study employed both quantitative and qualitative data analysis. This was done by measuring, first, the level of ICT diffusion in local climate e-governance; second, how much local climate change adaptation and risk management objectives (IISD Adaptation entry points) are being achieved and lastly; what prevents the adoption of ICTs. These were used as variables to operationalize this study (Van Thiel, 2014). Table 2 provides for the definitions, indicators, and values that, for the purpose of this study, were used to measure the three variables.

Table 2: Variables, Definitions, Indicators and Values

Variable	Definition	Indicators	Values
ICT Diffusion in Local Climate E-governance	Degree to which ICTs are being used by the cities for the following local climate e-governance tasks: • Monitoring of climate change and impacts; • Disaster management; and • Climate change adaptation	Types of ICTs used	• Wireless Broadband Technologies (Wi-Fi, WiMax) • Wireless Sensor Networks (intelligent sensor nodes for monitoring environmental cues) • Mobile Technology • GIS Applications • Social Media (Facebook, Twitter); • Other Web-based applications • Other Early Warning System Technologies

			• Others • None
		Quality of use	• Low • Medium • High
Achievement of climate change adaptation and management of climate risk objectives	Degree to which the following are achieved: • Addressing drivers of vulnerability • Building the response capacity of local and regional systems and communities • Reducing and Managing risks related to climate variability and climate change • Confronting Climate Change	Perceived Performance	• Low • Medium • High
Barriers to ICT adoption	Factors that prevent the acquisition and usage of ICT for local climate e-governance	Types of barriers	• Inter-institutional dynamics • Legal Factors • Political Factors • Economic Factors • Social Factors • Demographic Factors • Organizational Factors • Individual Factors • Technological Factors • Other factors
		Extent of hindrance	• Low • Medium • High

The variables are defined using different concepts (see Table 3 for definitions) from various literature. Local climate e-governance is defined using the three climate change application areas for ICTs identified by Karanasios (2011). These are: monitoring of climate change impacts; disaster management; and climate change adaptation. For this study, these application areas are considered as tasks that comprise local climate e-governance. For the objectives of climate change adaptation and management of risks, the adaptation intervention points provided by the IISD is used namely: addressing the drivers of vulnerability; building the response capacity of local and regional systems and communities; reducing and managing risks related to climate variability and climate change; and confronting climate change. Although the framework is specified for adaptation, one of the points also actually involves management of risks. For the barriers to ICT adoption, the study of Cucciniello et. al (2015) is used as basis.

The following definitions were used as guide to achieve the purpose of the study (see Table 3).

Table 3: Definitions of Concepts

Concepts	Definition	Source
Monitoring of Climate Change Impacts	Understanding local climate and anticipation of local impacts	Karanasios, 2011
Disaster Management	Timely and effective disaster management and response	
Climate Change Adaptation	Enhancing the capacity to cope with current and future climate stresses	
Addressing the drivers of vulnerability	*"..concerned with the underlying factors that make people and communities vulnerable to the impacts of climate change, rather than being concerned with those impacts themselves."*	World Bank, 2012b, p. 6
Building the response capacity of local and regional systems and communities	*"..helping communities[3] acquire the resources they need to respond to the impacts of climate change."*	
Reducing and managing risks related to climate variability and climate change	*"..providing information and facilities to help communities change lifestyle and economic behaviours in ways that make them more sustainable in new climate conditions."*	World Bank, 2012b, p. 7
Confronting Climate Change	*"..addressing the physical impacts of climate change such as rising sea levels and the spread of malarial mosquitoes into newly favourable regions."*	
Inter-institutional dynamics	Inter-institutional networks or the lack thereof do/does not encourage ICT adoption	Cucciniello et. al, 2015
Legal factors	Strict legal requirements	
Political factors	Political attitude of relevant actors against innovations	
Economic factors	Budget Constraints	
Social factors	No public pressure to drive ICT adoption	

[3] Within the context of Metro Manila LGUs, Barangays are considered as local systems because they are the sub-administrative units of cities/municipalities in the Philippines (UNPAN, 2004)

Demographic factors	Small demographic context does not encourage innovation	
Technological factors	Lack of infrastructures to support ICT; Low public ICT readiness; Threats to information security; Technological complexity	
Organizational factors	Bureaucracy and organizational structures/arrangements prevent innovation	
Individual factors	Lack of ICT readiness among individuals in the system	

3.3 Research strategy

This study employed two main strategies: survey and a case study. The use of survey allows for the measurement of the variables while the case study provides the link among them. The survey was used to measure all the variables among the LGUs in Metro Manila. Surveys enable better generalization and validity of the findings as it allows for efficient collection of large-scale data findings (Van Thiel, 2014). The survey questions were designed using the aforementioned indicators and values. The use of survey to measure ICT diffusion has already been utilized by other studies such as when the Organization for Economic Co-operation or OECD (2015) measured ICT usage by businesses, and when Azam (2014) looked into the correlation between ICT diffusion and the performance of small and medium enterprises. With respect to measuring the level of achieving climate change adaptation and risk management objectives, perceived performance was used. While the use of perceived performance may result to biased responses, it is already being applied by many researchers (Carlos & Rodrigues, 2016). Moreover, self-reported measures for research purposes are not expected to produce bias (Coleman & Borman, 1999). The study of the United Nations Conference on Trade and Development or UNCTAD (2011) on *"Measuring the Impacts of Information and Communication Technology for Development"* provided that surveys can be used to directly ask respondents on the impact of ICTs. It further stated that perception questions using survey could provide causal information on the impacts of ICTs which this study attempts to explore. While the use of survey provides breadth, it is supplemented by a case study to add depth to the findings (Van Thiel, 2014). This study involved a single case that was aimed at providing a more detailed description on how ICTs are actually being used. The final output of this study, therefore, is a snapshot or an overview of ICT diffusion within the local climate e-governance in Metro Manila using the survey results and in this regard, also a narrative into how the ICTs are specifically being utilized using the single case study findings.

3.4 Data Collection and Sampling

3.4.1 Survey

A survey was used to collect data for this study. Both online and physical questionnaires were used depending on what the respondents, from the city/municipal governments, preferred. Most of the survey questions are close-ended and the response options are according to certain values corresponding to the indicators as provided in Table 2. For the different types of ICTs, the following categories were used: a) Wireless Broadband Technologies (Wi-Fi, WiMax); b) Wireless Sensor Networks (intelligent sensor nodes for monitoring environmental cues); c) Mobile Technology; d) GIS Applications; e) Social Media (Facebook, Twitter); f) Other Web-based applications g) Other Early Warning System Technologies. These were from the reviewed literature but were also mainly derived from Karanasio's (2011) study. Note that for this study, ICTs refer to both hardware (ICT devices) and software (ICT-enabled programs). For issues and barriers to ICT diffusion, the following values were used: 1) inter-institutional dynamics; 2) legal factors; 3) political factors; 4) economic factors; 5) social factors; 6) demographic factors; 7) technological factors; 8) organizational factors; 9) individual factors; and 10) technological factors (Cucciniello et. al, 2015).

To support the findings for this study, four other questions were asked. First is a close-ended question on hazard exposure which could take the values of the different types of climate change-related hazards according to Wang et. al (2009) namely: flood, storm surges, drought, tropical cyclone, tornado, heatwave or others. This provides for further contextualization of the study. The second one is a question on the perceived impact of ICT over the different adaptation entry points. This was asked to further establish connection between ICT and achievement of adaptation and risk management objectives. It also takes the form of low, medium or high. The other two were open-ended questions on the respondents' recommendations to further strengthen ICT-use for local climate e-governance and on their comments about this study. The former was asked in order to get ideas for recommendation as well as to validate the findings regarding issues and barriers to ICT diffusion while the latter was for future research recommendations.

The values for other indicators such as quality of use, perceived performance, and extent of hindrance, as mentioned, were measured using a low-medium-high scale. Table 4 provides for the definition of the scale for all indicators that are measured using a low-medium-high scale.

Table 4: Definitions of Values (Low, Medium, High)

Indicator	***Low***	***Medium***	***High***
Quality of use	task will be achieved effectively and efficiently even without the use of ICTs	task will be achieved, but not effectively and efficiently, without the use of ICTs	task will be achieved only with the use of ICTs
Perceived performance	objective is not being achieved	objective is being barely achieved	objective is being achieved effectively and efficiently
Perceived ICT impact	objective will be achieved effectively and efficiently even without the use of ICTs	objective will be achieved, but not effectively and efficiently, without the use of ICTs	objective will be achieved only with the use of ICTs
Extent of hindrance	negatively affects ICT adoption but not a major reason for prevention	prevents adoption of few ICTs	prevents adoption of many ICTs

For quality of use, the scale is defined according to how much the use of the respective ICTs result to effective and efficient achievement of the local climate e-governance tasks. The assumption is that the more crucial an ICT is in achieving the local climate e-governance tasks, the more likely it is being used extensively for those purposes. For extent of hindrance, it is defined using how much the respective types of barriers affect the adoption of ICTs. For perceived performance, it is measured according to how much the climate change adaptation and risk management objectives are achieved while for perceived ICT impact, the scale is based on how crucial ICT is to achieving the objectives effectively and efficiently. They were specified to serve as guiding criteria for answering the survey questions in order to minimize subjectivity and perception differences in the interpretation of the scale. Hence, they were also included in the survey questionnaires.

3.4.2 Case Study

The single case study comprised interview/s, analysis of relevant online web pages such as their website and social media, and use of secondary data and other relevant literature. The interview/s were performed among knowledgeable officers of the target city - Marikina city, in terms of their locality's climate change action programs, projects and activities. The interview questions are semi-structured and are also based on the variables and indicators but evidently, they are open-ended. Again, as the purpose is to supplement depth to the findings, the case study was used to extract detailed qualitative information on the different variables and to further the case between the relationship of ICT diffusion and the achievement of climate change adaptation and risk management objectives.

Note: Due to certain limitations, the data collection was delegated by the researcher to another person. Nevertheless, the researcher was in regular communication with the person who gathered the data during the data collection period to ensure that appropriate and adequate data and infromation were acquired .

See Annex 1 for the survey form and the interview guide questions for the case study

3.4.3 Sampling

3.4.3a Survey Sampling

The units of analyses for this study are the cities/municipalities in Metro Manila (see Figure 5), specifically the following 17 LGUs (PSA, 2018):

- Manila
- Mandaluyong
- Marikina *(Case Study)*
- Pasig
- Quezon City
- San Juan
- Caloocan
- Malabon
- Navotas
- Valenzuela
- Las Piñas
- Makati
- Muntinlupa
- Parañaque
- Pasay City
- Taguig
- Pateros (Municipality)

Note that this study aims to generalize at the organizational level and as such, the number of LGUs in Metro Manila was the main basis for the survey sample: 17 LGUs. Also, since data analysis for the survey results involves only the use of descriptive statistics, there is no specific formula or strict guidelines with respect to sample size (Israel, 1992). Nevertheless, this study followed sampling recommendations from relevant literature.

Traditional multi-organization studies use a single respondent to represent each organization under study but this research made use of at least three respondents per organization, or in this case, per LGU to take into account perception differences and to allow for better generalization of the survey responses (Balloun et. al, 2011). Hence, the target minimum number of respondents for this study is 51[4]. The sampling method used for the survey was snowball sampling. Snowball sampling is a type of convenience sampling method that is usually applied when it is difficult to acquire respondents with target characteristics (Naderifar et. al, 2017) which in this study's case, those with most adequate knowledge on the ICT-use of the respective LGUs' local climate action. This was done simply by asking the LGUs to refer or select respondents for the survey. The idea behind the usage of snowball sampling for this study was that the members of the different LGUs are in the best position to refer respondents with the characteristics desired for this study (Atkinson & Flint, 2001). The reason for having the aforementioned criteria for the selection of respondents was for higher propensity of getting the most accurate information from the survey responses. Initially, the preferred respondents were from the LGUs' respective City Environment and Natural Resources Office (CENRO), Disaster Risk Reduction and Management Office (DRRMO), Planning Office (PO), ICT Office or the Office of the Mayor but essentially, the final respondents still depended on whoever the LGUs deemed fit to answer the survey.

3.4.3b Case Study Sampling

The sampling method for the selection of key informants for interviews was also snowball sampling. Snowball sampling was used in the case study for the same reasons as to why it was applied in the survey. The key informants must be those who have the most adequate knowledge about Marikina's ICT-use for climate action and these are best determined by members of the Marikina LGU. Hence, snowball sampling was used. The snowballing of interviews stopped until all relevant departments were covered. This was done for data triangulation as it allows collection of data and information from different sources, that is, the different departments (Guion et. al, 2002). At least one (1) key informant per department was interviewed.

The sampling methodology, particularly the selection of Metro Manila (survey) and Marikina (case study) as areas for this study, is further explained under external validity in the next section. See Annex 2 for the list of interviewees.

3.5 Validity and Reliability

3.5.1 Validity

3.5.1a External Validity

Generally, external validity looks into the extent of generalizeability of the findings (Calder et. al, 1982). Although probability sampling is usually done for high external validity, this study only involves a small number of research units and since it covers all cities and one municipality in Metro Manila, its results can be generalized for the region (Van Thiel, 2014). Moreover, while it only covers Metro Manila, the findings could still be suggestive for other cities/municipalities outside the region. Given that Metro Manila is a highly vulnerable region and at the same time it is the economic and political center of the Philippines, it is highly possible that the LGUs in the region have the best practices in terms of ICT use for

[4] 3 *(minimum number of respondents per LGU)* x17 *(number of LGUs)*

local climate e-governance. The findings, therefore, could set a baseline information for the Philippines on the matter.

Figure 5: Metro Manila *(Encircled is Marikina's location)*;
Source: Porio, 2013

Van Thiel (2014) provides that in selecting case studies, selection of a particular case may be because it would "*constitute an extreme example of the phenomenon of interest*" (Van Thiel, 2014, p. 89). As such, for this study, Marikina (see Figure 6) was selected because of higher propensity of getting good examples on how ICTs are leveraged in local climate e-governance due to Marikina's high climate risk vulnerability and relatively good e-governance practices.

Marikina, based on the 2015 census, has a population density of 20,945 persons per square kilometer which is just almost a percent higher than the population density of the whole Metro Manila (PSA, 2016). Geographically, it is a highly prone area to flooding as it serves as a catch basin to other cities and towns in Metro Manila (Santos, 2017). This is in addition to the fact that a river, the Marikina river, is located inside the city that usually overflows during the wet season. All of its sixteen (16) barangays experience severe flooding. Moreover, 85% of the city's total area is exposed various flood depths where 58% of which is within the upper spectrum corresponding to over half of the city's population. As such, it is among the cities in Metro Manila most vulnerable to climate change risks and hazards (CDRI, 2010). Nonetheless, it is among the best LGUs in the country with good disaster risk reduction and management practices (Santos, 2017).

In terms of e-governance practices, Marikina is among the bests in the Philippines. Their website, for example, is one of the most cited and awarded in terms of quality, content and interactivity (Magno, 2010). With respect to disaster management, an interactive viewer on risk-related information through an application called OSA Map was developed in Marikina as part of a larger assessment project (UN-APCICT, 2011). Marikina is also among the seven LGUs that bagged the 5th E-government Awards for exemplifying excellence in ICT for Good Governance (NICP, n.d.).

Figure 6: Map of Marikina
Source: one-map website
(https://onemap.marikina.gov.ph/)

3.5.1b Internal Validity

Van Thiel (2014) provides that internal validity refers to the soundness and effectiveness of measuring the variables. It specifically looks into the validity of how the variables are operationalized and if the presupposed relationships of the variables were adequately established. Starting with the measurement of ICT diffusion, the indicators used are based on two diffusion models – the Adoption-Diffusion (AD) Model and the Use-Diffusion Model (UD). On one hand, the UD model focuses on the act of ICT adoption itself while the AD model, on the other hand, focuses on extent of use (Sahadev & Islam, n.d). The same principles are applied for the barriers to ICT adoption. The idea behind the usage of the AD and UD model is to look into both the quantitative – types of ICTs/Barriers and qualitative – quality of use/hindrance, aspects of ICT adoption and the barriers. For measuring impact of ICT, as per UN (2011), self-reported data or perceived impact is used as the indicator. With regard to the values for the level of diffusion/hindrance, the types of ICTs used and barriers respectively provides for the quantitative measurement - the more types of ICTs/Barriers, the higher the level of diffusion/hindrance. The qualitative measure is through extent of use/hindrance which could be low, medium or high according to the definitions provided in Table 4. These definitions are adopted for consistency. These were applied as well for the values for perceived performance and perceived ICT impact. With respect to causality, this study does not attempt to make absolute and quantitative correlations or relationships but rather descriptive and suggestive ones through descriptive statistics and a qualitative analysis of the different variables.

3.5.2 Reliability

Reliability is a function of accuracy and consistency (Van Thiel, 2014). Accuracy involves the appropriateness of measurement instruments that are used. For this study, the instruments used were survey, interviews, relevant web pages and literature. It attempts to generalize for Metro Manila LGUs thus, a survey was used. It also allows measurement of different variables through subjective indicators that are backed up by literature and theoretical bases. In order to provide depth to the findings, case study was used through interviews and analysis of relevant web pages and literature. This allowed for the measurement of variables through qualitative analyses. In terms of consistency, the methodology is expected to be repeatable. As pointed out by Van Thiel (2014), however, in social sciences research, people learn from past mistakes. Thus, the findings could be different even when same methodologies are used. Nonetheless, the methodology for this study was documented and the concepts used are well defined for easy replicability. The meaning of the concepts and the responses, specifically the scales, are defined in the survey questions improving the consistency of the results.

3.6 Data Analysis Methods

Descriptive statistics for the survey and process tracing analysis for the case study were the two methods used in this study. Descriptive statistics was simply used to summarize and describe collected data (Mordkoff, 2016). The summary of the collected data was used to discuss and describe, in general, the level of ICT diffusion in local climate e-governance in Metro Manila. This was supplemented by the findings from the case study using process-tracing analysis. "*Process-tracing is a research method for tracing causal mechanisms using detailed, within-case empirical analysis of how a causal process plays out in an actual case*" (Beach, 2017, p. 1). The interviews, analyses of relevant web pages, and the use of secondary data and other relevant literature were done to describe how the possible relationships from the descriptive statistics actually carry out. In this case, it would show, for instance, how the use of ICTs actually lead to better achievement of the climate change adaptation and management of risks objectives or how the barriers actually hamper ICT adoption. Excel and Atlas Ti were the tools used for the descriptive statistics and process tracing analysis respectively. In sum, the quantitative analysis -descriptive statistics, was for providing values to the variables while the qualitative analysis - process tracing analysis, was for linking the variables.

Chapter 4: Research Findings

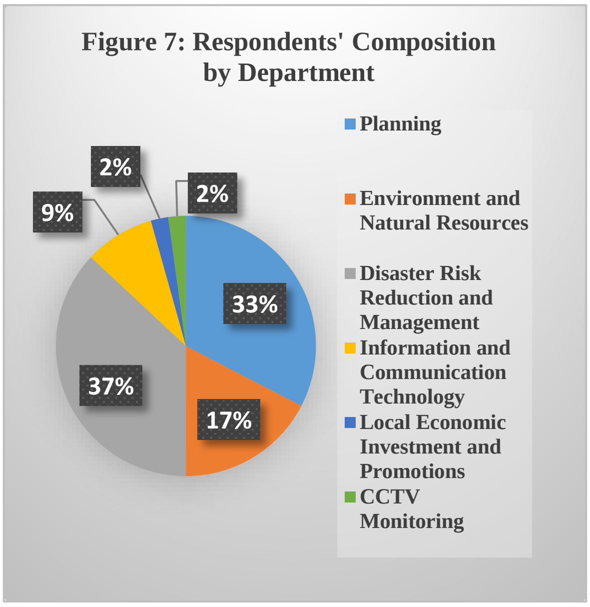
This chapter begins with the presentation of the survey respondents' profile and LGUs' hazard exposure. It then proceeds with the main findings which are outlined according to the research objective:

i. ICT-usage- the different types of ICTs used for local climate e-governance and to what extent they are being used
ii. ICT Diffusion Processes - the processes that link ICTs to the achievement of climate change adaptation and risk management objectives (case study results)
iii. Achievement of Climate Change Adaptation and Risk Management Objectives - to what extent do the LGUs achieve climate change adaptation and risk management objectives and how do ICTs play a role
iv. Issues, and Barriers to ICT Diffusion - factors that affect ICT Diffusion

4.1 Profile of the Respondents

Table 5: Number of Respondents per LGU

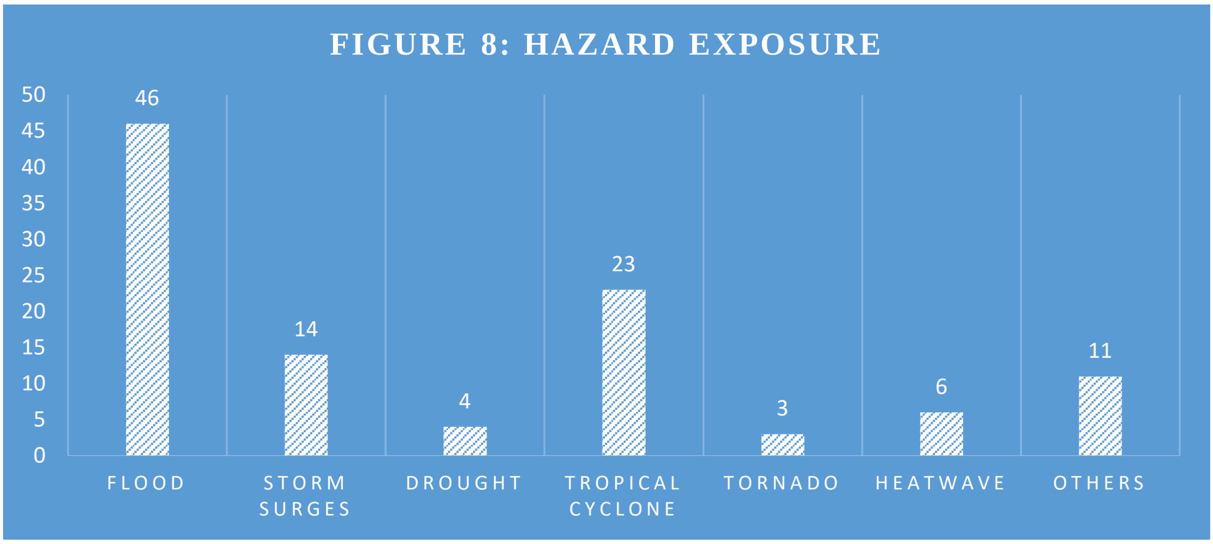
City/Municipality	Number of Respondents
Manila	1
Mandaluyong	1
Marikina	3
Pasig	3
Quezon City	3
San Juan	3
Caloocan	3
Malabon	3
Navotas	3
Valenzuela	3
Las Piñas	3
Makati	3
Muntinlupa	3
Parañaque	3
Pasay City	3
Taguig	3
Pateros	2
Total (Number of Respondents):	**46**
Total LGUs covered:	**17**



A total of 46 survey responses were collected, covering all of the 17 LGUs in Metro Manila (see Table 5). A 90% response rate based on the minimum target of at least 3 respondents per LGU. Most of the LGUs were represented by three (3) respondents except for Pateros (2), Mandaluyong (1) and Manila (1). Majority of the respondents are from their respective LGUs' Disaster Risk Reduction and Management (37%), and Planning (33%) departments while the rest are from the Environmental and Natural Resources (17%), Information and Communication Technology (9%), Local Economic Investment and Promotions (2%) and CCTV Monitoring departments (see Figure 7).

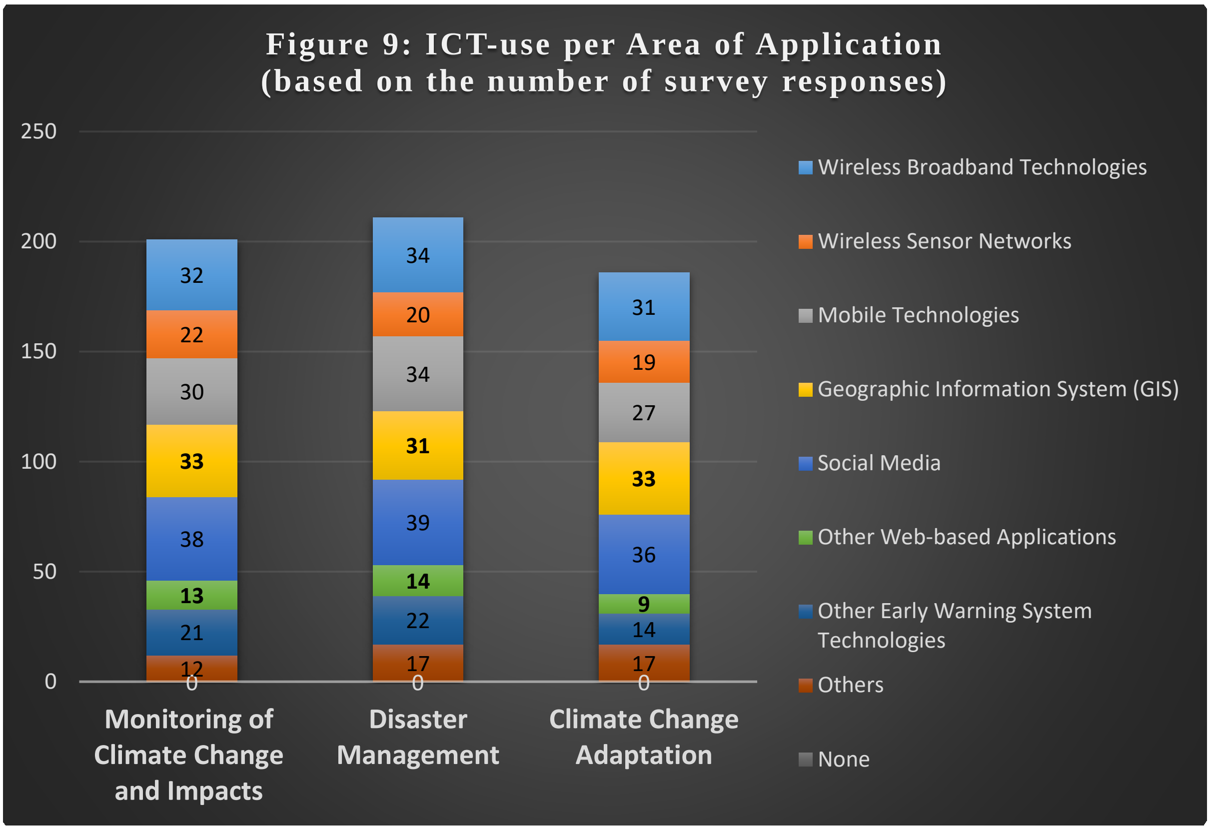
For the case study, a total of six (6) key informants from the City Planning and Development Office (CPDO), Management Information Systems and Call Center (MISCC), Engineering Office, City Environment Management Office (CEMO) and the DRRMO of Marikina city were interviewed (see Annex 2).

4.2 Hazard Exposure



All of the respondents (46) provided that their respective LGUs are prone to flooding. Half of them (23) also said that they are vulnerable to tropical cyclones (see Figure 8). Only a few respondents indicated that they are vulnerable to storm surges (14), Heatwave (6), Drought (4) and Tornado (3). 11 respondents added that they are also vulnerable to other hazards such as earthquake (6), Liquefication (4), Landslide (2), Fire (1) and human-induced hazards (1). For Marikina, as mentioned, the main climate change-related hazard that they are highly exposed to is also flooding. What these suggest is that the local climate e-governance of LGUs in Metro Manila is mainly directed towards reducing the impacts of flooding or sometimes, tropical cyclones.

4.3 ICT-usage



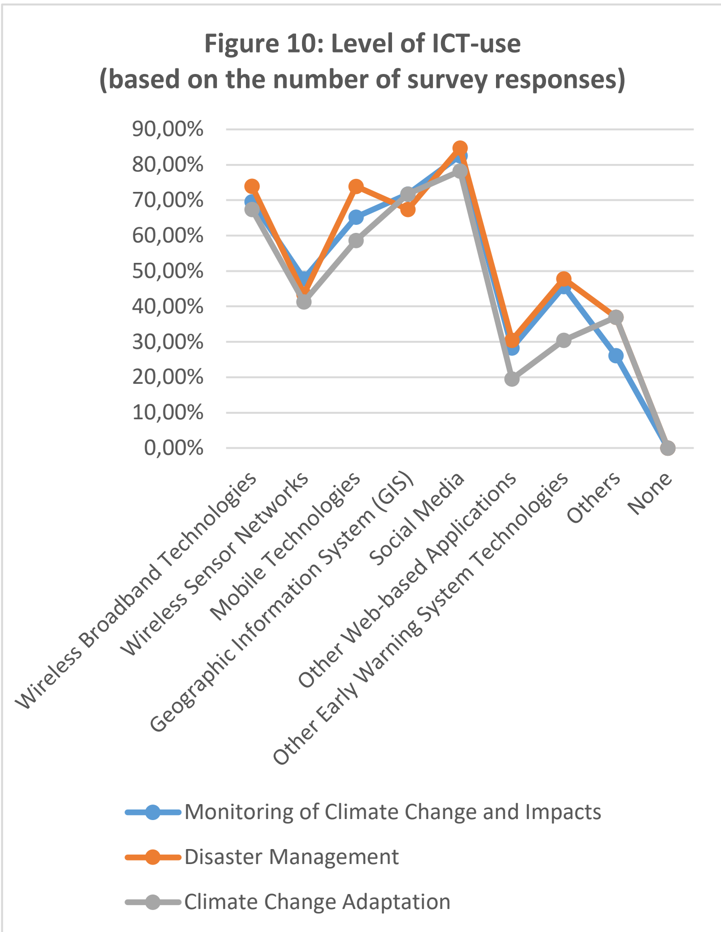


Figure 9 shows that the overall level of ICT-use per area of application - monitoring of climate change and impacts; disaster management; and climate change adaptation, based on the number of survey responses, among Metro Manila LGUs are almost identical. Moreover, the figure shows that the level of use for each type of ICT among all three areas are also almost the same. The identical trend among the different areas are better shown in Figure 10 reflecting the percentage of respondents who provided that their LGUs use the different types of ICTs per application area. Hence, what these suggest is that generally, in terms of local climate e-governance, the most useful ICT is **Social Media (78%-83%)** followed by **Wireless Broadband Technologies (67%-73%), GIS (67%-72%);** and **Mobile Technologies (58%-74%).**

Social Media. According to Alampay and Delos Santos (2016), the use of social media among LGUs in Metro Manila started around 2008 and peaked from 2012 onwards. Their study also concluded that social media use has already diffused in the DRRM operations of Metro Manila LGUs. Out of the 16 LGUs they monitored, all of them have facebook accounts while 15 have twitter accounts. Figure 9 suggests that social media has also diffused with respect to monitoring of climate change and impacts and climate change adaptation.

One of the early adopters of social media is actually Marikina. It started out as a personal account of an employee but because it eventually exceeded the 5,000 limit of friends, a page for Marikina was created (Alampay et. al, 2018). Ms. Lisa Cruz of the engineering department also shared that the employees' use of social media back then when it was not yet adopted for official use was done in secret suggesting that the use of social media in the workplace was an unacceptable practice in Marikina LGU. The City Administrator (CA), however, eventually thought to just utilize social media for the benefit of the LGU since its use among the members of the LGU seemed unavoidable.

"...the CA saw that the employees could not stop using facebook so he thought, instead of using it for something (personal use), why not just use it for the benefit of the LGU? He gave a reason to facebook's usage."

Generally, social media is used for disseminating information that focuses on disaster preparedness, ranging from updates on typhoons, water levels, flooding, earthquakes, traffic and vehicular accidents, and power and water utility interruptions (Alampay & Delos Santos, 2016). As such, social media activities among Metro Manila LGUs increase when hazard occurrences are at its peak. In terms of how the social media accounts are managed, Alampay et. al (2018) said that each LGUs are in a stage where they develop and adopt their own respective management practices. This shows that at present, there are no general rules that applies to social media use among LGUs in the Philippines.

Wireless Broadband Technologies. Internet connectivity in the Philippines is relatively inferior in terms of overall performance. A report by the DICT shows that compared to neighboring ASEAN countries such as Indonesia, Malaysia, Singapore and Thailand, internet performance in the Philippines is still weak in terms of affordability, availability and speed (DICT, 2017). Siar (2005), on her assessment of local e-governance in the Philippines, also attributes the slow progress of e-governance in the Philippines to the poor quality of internet connectivity in the country. As such, despite the high diffusion of broadband technologies in among Metro Manila LGUs, the quality of connection is most likely poor. Even in Marikina, many of the interviewees said that slow and sometimes disappearing internet connection is a regular occurence. Since internet connection in Marikina is centralized, if their broadband system goes down, the whole LGU becomes offline. In such cases, since online access is crucial to many of the LGU's tasks, the employees and officials are forced to use their personal mobile data which are not reimbursed by the LGU. When asked about reimbursement regarding this matter, Ms. Jackie Lou Espinosa of the DRRMO said:

"Not anymore. It's just a small contribution to your work and the department because if you don't, you will just make things more difficult for you as an ICT personnel..."

Aside from a centralized broadband system in Marikina, pocket wireless wifis are also used by field officers which allows them to communicate and transmit data to the main office even when on the ground. This further reflects the importance of internet connectivity for local climate e-governance

GIS. Many LGUs in the Philippines have already been using GIS for mapping to support decision-making (Tongco, 2011). The Housing and Land Use Regulatory Board (HLURB), a national agency in the Philippines, even created a guideline for GIS use of LGUs in 2007 called the 'GIS cookbook which describes how to create GIS-based land-use plans. A report by Aban (2016) also found that GIS, along with other ICT-enabled services, is already being used at different levels of local government in the Philippines. GIS softwares used include ArcGIS as well as other free and open source softwares such as QGIS.

Marikina also uses GIS, specifically ArcGIS, to a great extent. They have already created many thematic maps and these maps are actually available online through a website that Marikina designed called 'One-Map'. The maps of Marikina are integrated into the plans of the LGU, especially to their Comprehensive Land-Use Plan (CLUP) which is mandated by the Local Government Code of the Philippines under Section 20, RA 7160. It states that *"the local government units shall, in conformity with existing laws, continue to prepare their respective land use plans enacted through zoning ordinances which shall be the primary and dominant bases for the future use of land resources…"* (Salazar-Quitalig & Orale, 2016, p. 44). According to Ms. Nelisa Palomar of Marikina's CPDO, it was after 'Ondoy', a typhoon that resulted to heavy flooding in Metro Manila, especially Marikina, in 2009, that Marikina, along with other LGUs, really enhanced their DRRM capacity which included the production of many hazard maps.

Mobile Technologies. The literature on the use of mobile technologies for local e-governance is limited but based on the survey, two noteworthy mobile-based applications were specified by some of the respondents: 'Batingaw' and 'Makatizen App'. On one hand, Batingaw is created by the National Disaster Risk Reduction and Management Council (NDRRMC) of the Philippines (*Batingaw, n.d.)*. The term 'Batingaw' means "siren or alarm" which somehow encapsulates the main objective of the application which is to help the public prepare for emergencies and disasters by providing them access to relevant information through government and ngo websites, disaster or emergency related twitter feeds, and different hazards and safety tips. Digital tools such as siren, flashlights, compass, strobe, e-library, FM/AM radio are also available in the application (Waidyanatha, 2015). The application is available for free download at the google playstore making it accessible to smartphone users. On the other hand, another mobile-based application is used by Makati city called the 'Makatizen App'. It is not specifically designed for climate action purposes but it offers different types of information about the Makati City government which may include news, updates and announcements about impending disasters and climate change-related programs projects and activities (*SOCA*, 2018). Makatizen app is also available for free download at the google playstore (*Makatizen App.* n.d).

For Marikina, LGU personnel and officials use mobile technologies to communicate amongst themselves and with the public. Mobile devices such as cellphones allow them, for instance, to reach people from other departments especially in Marikina where offices are not necessarily closely positioned to one another. Some offices such as the DRRMO also uses mobile phones as one of the channels for the public to reach them in cases of emergency. Besides as a channel for communication, Marikina also makes use of mobile technologies through mobile-based applications. CEMO, for example, can access data from the air quality monitoring devices around Marikina from a cellphone. Moreover, CCTVs or Closed-Circuit Televisions of

Marikina have counterpart mobile-based applications that enable DRRM officers to monitor the footages even when they are not in the command center.

Figure 11: ICT-use for Monitoring Climate Change and Impacts (based on survey responses per LGU)

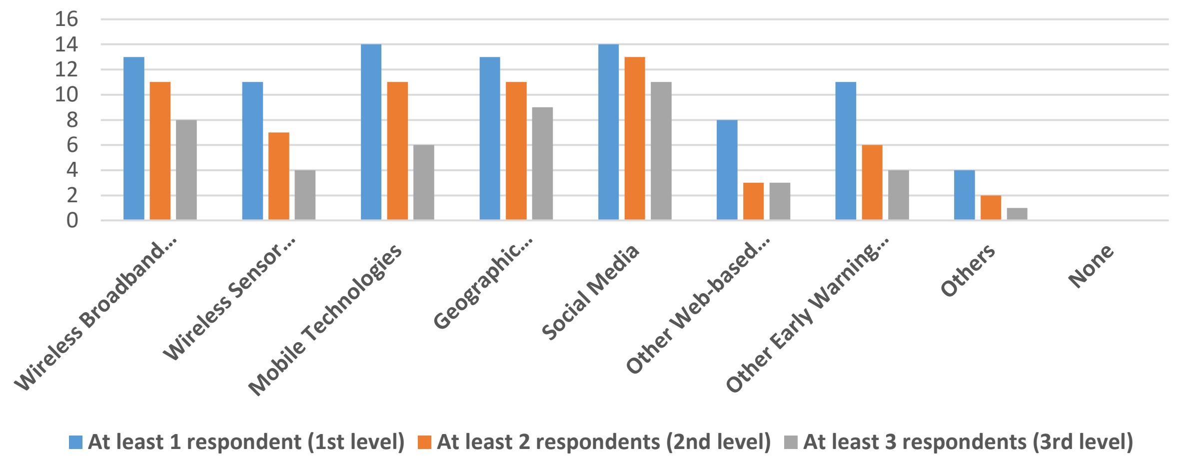


Figure 12: ICT-use for Disaster Management (based on survey responses per LGU)

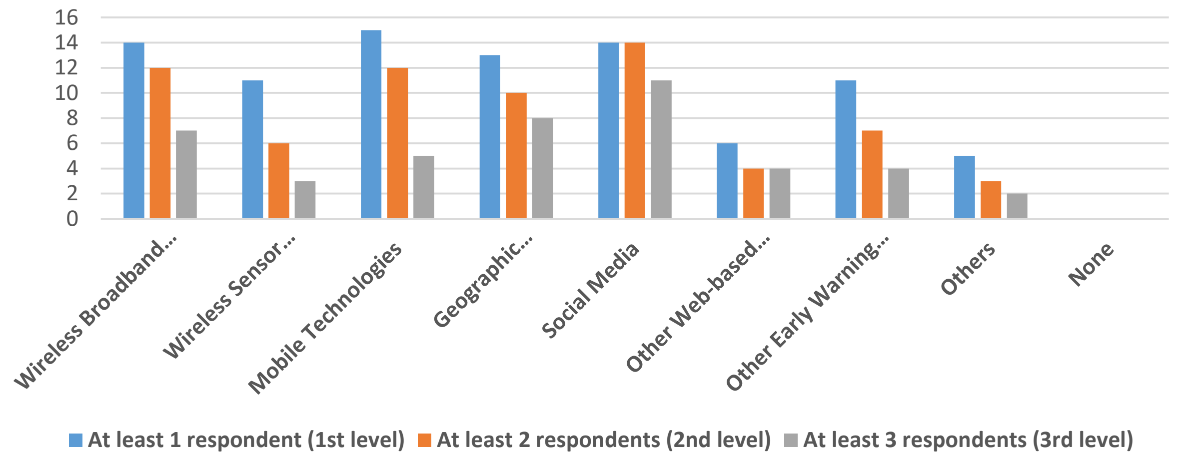
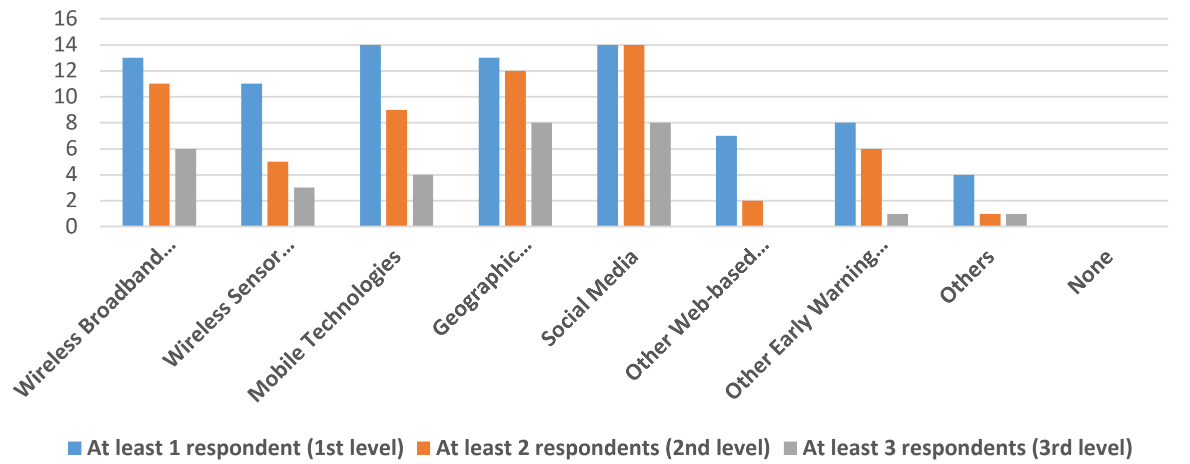


Figure 13: ICT-use for Climate Change Adaptation (based on survey responses per LGU)



While figures 9 and 10 look into ICT-use according to the number of respondents who provided that their LGUs use the different ICTs indicated in the survey, figures 11, 12 and 13 generalize ICT-use at the LGU level. Simply put, they show the number of LGUs in Metro Manila that use the different ICTs for monitoring climate change and impacts (see Figure 11), disaster management (see Figure 12), and climate change adaptation (see Figure 13). To take into account perception differences, there are three levels of generalizations per LGU which are based on the minimum number of respondents: at least 1 (1st level), 2 (2nd level) and 3 (3rd level) respondents, who provided that their respective LGUs use the different types of ICTs. For instance, for the 1st level, if at least one respondent said that their LGU uses social media for disaster management, the response is generalized for the whole LGU. This rule applies as well for the next two levels. If at least 2 or 3 respondents provided that their LGU uses a particular ICT for a local climate e-governance task, then their responses are accepted to be true for their LGU. This was done to see the extent of variation in terms of perception differences with respect to ICT-use for local climate e-governance. Note that less than three responses were collected for Pateros (2), Manila (1) and Manadaluyong (1).

Generally, figures 11, 12 and 13 present the same kind of trend as figures 8 and 9 where social media, GIS, mobile technologies and wireless broadband technologies are the most used ICTs for local climate e-governance. In terms of extent in variations among the different levels of generalizations, the differences are apparent. This suggests that there is high perception differences when it comes to which ICTs are used for local climate e-governance. Relatively, however, the extent of variation among the different levels of generalization for social media and GIS are not as drastic as in other ICT types. This provides a stronger case for the use of social media and GIS for local climate e-governance.

Aside from the above-mentioned ICTs, around 19%-30% of the survey respondents said that they also use other web-based applications. Many of these applications are locally operated such as NOAH and MDSI:

Nationwide Operational Assessment of Hazards (NOAH) - http://noah.up.edu.ph/#/

Figure 14: NOAH
Sources: *NOAH, n.d.* & *The Center, n.d.*

NOAH is a center based at the University of the Philippines that "*conducts research, development and extension services on natural hazards, disaster risk reduction and climate change actions*" (*The Center*, n.d.). The results of their work are transformed into free and accessible tools, such as the above web-based application (see Figure 14) that can assist LGUs, community leaders, policy makers, planners, and families prevent and mitigate disasters. Some features of their web-based application according to their website (noah.up.edu.ph) include measurement of linear distance and area of polygon on map, and provision of risk and hazard-related data and information such as data, rain data, river inundation, doppler and satellite information, and weather outlook; real-time information from rain gauges, weather stations and tide levels; flood hazards maps and landslide-related information; storm surge hazards maps and historical data; impact assessment of an area; rainfall record in mm/hr for places experiencing rainfall etc.

Met-Hydro Decision Support Infosys (MDSI) - https://v2.meteopilipinas.gov.ph/

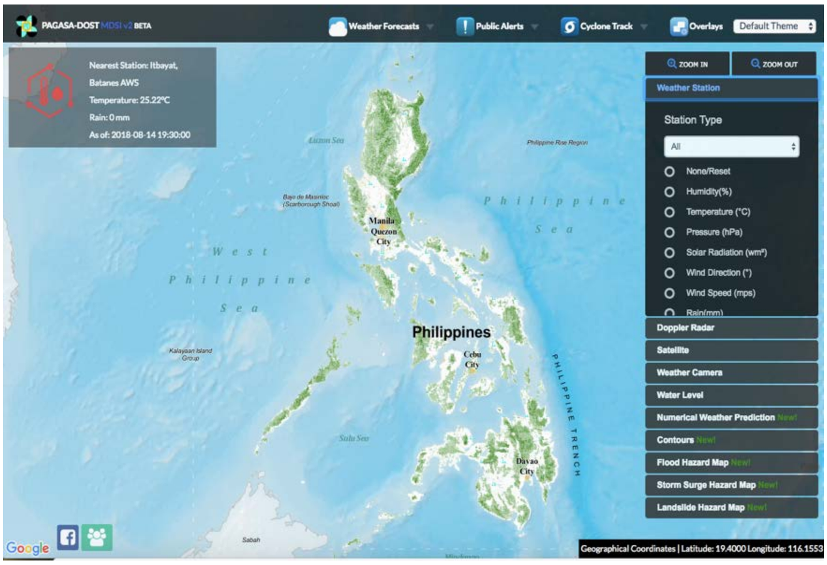


Figure 15: MDSI
Source: *PAGAASA-DOSTMDSIv2BETA*. n.d.

MDSI (see Figure 15) is operated by the Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA), an attached agency of the Department of Science and Technology (DOST) in the Philippines. It is mainly tasked *"to provide protection against natural calamities and utilize scientific knowledge as an effective instrument to insure the safety, well-being and economic security of all the people, and for the promotion of national progress."* (*About us*, n.d.). Like NOAH, the MDSI also provides hazard-related information produced mainly from PAGASA's radar dopplers, automatic rain gauges (ARG) and automatic weather stations (AWS) that are deployed all over the country allowing the measurements of barometric pressure, atmospheric pressure, air temperature, relative humidity, wind speed and direction from remote areas using meteorological sensors (*PAGASA Met-Hydro Decision Support Infosys, n.d) d*. These data can be viewed and overlaid in the map through the MDSI along with other data from water level stations, radar stations, flood forecasting and warning system, satellite images, and weather cameras. Mobile technologies are used to report the data gathered from the different stations. The application also provides a toolset for weather forecasts, public alerts, and cyclone track timeline as well as hazard maps for flood, storm surge and landslide.

Some of the LGUs also make use of internationally-run web-based applications that provide, in varying extents, same data and information as the above-mentioned such as Windy, Himawari-8 Real-time Web, tide-forecast and COMS RI.

Around 30%-48% of the respondents also provided examples of other ICTs they use as part of their early warning system such as automated/manual sirens, automated/manual rain gauges, automated weather stations, water level gauges, water level measuring sensors, flood sensor devices, flood level gauges, and flood simulators. Another ICT specified by some of the respondents that their LGU uses for climate governance is CCTV. For Marikina, their early warning system involves the use of CCTV, manual and automated sirens, water level gauge and social media.

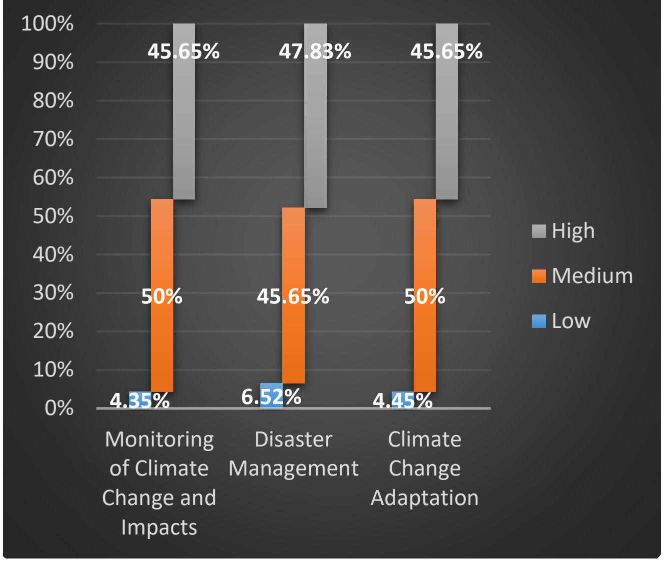


Figure 16: Quality of ICT-use

With respect to quality of ICT-use, the trend is also almost identical for the three application areas where about half (45%-50%) of the respondents attribute ICT-use to effective and efficient achievement of climate e-governance tasks. This means, according to this study's parameters, medium extent of ICT-use (see Figure 16). Most of the remaining half, around 45%-48%, believe that the climate e-governance tasks can only be achieved using ICTs, suggesting high quality of ICT-use while only a few respondents, 4%-7% said that ICTs are not that important in achieving the climate governance tasks which suggests low quality of ICT-use.

4.4 ICT Diffusion Processes

This section makes use of Marikina's case to provide for the different processes that enable the achievement of climate change adaptation and risk management objectives using ICTs. These processes emerged through a process tracing analysis using the findings from the interviews with Marikina LGU members and analysis of Marikina's managed web-pages. Three main processes were identified:1) Facilitating execution of tasks; 2) Collecting data/information; and 3) Processing and analyzing data/information

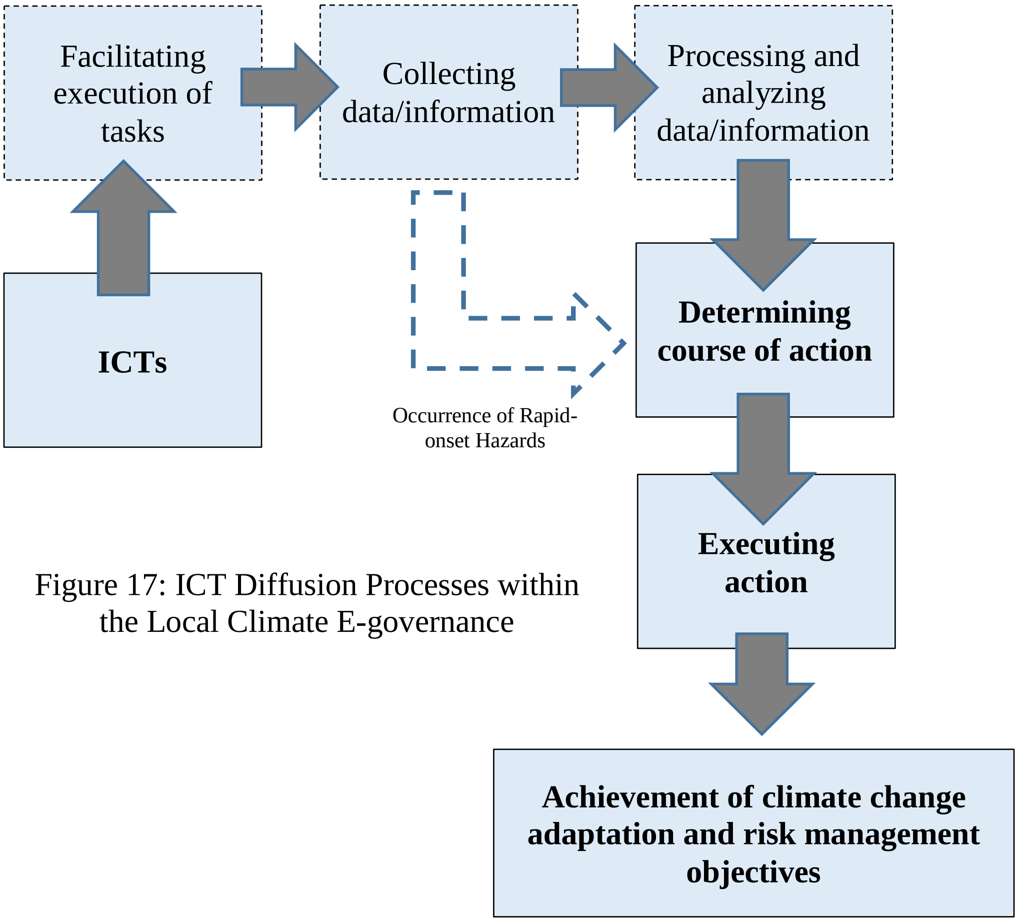


Figure 17: ICT Diffusion Processes within the Local Climate E-governance

Figure 17 provides a visual representation of how the use of ICTs in local climate e-governance lead to the achievement of climate change adaptation and risk management objectives through the three identified ICT diffusion processes. The identified processes in the middle, inside the boxes with dashed outlines, are those where ICTs play a major role. Given the nature of ICTs, the processes primary involve the flow of data/information within the local climate e-governance. As reflected in Figure 17, the role of ICTs stops or becomes very minimal after 'processing and analyzing data/information' then two more processes are involved before the actual achievement of climate change and risk management objectives. Although ICTs may not be directly involved in these final two processes, they do not occur without the first three processes where ICTs play a major role. It is also important to note, as also reflected in Figure 17, that during rapid-onset hazards, 'determining course of action' comes right after 'collecting data/information'. All these will be explained in detail below using Marikina's case.

4.4.1 Facilitating execution of tasks

This process is about how ICTs enable an environment that allow for the facilitation of executing day-to-day and other important tasks including those related to climate action. In Marikina's case, this is mainly manifested through the capacity of ICTs to provide internet connectivity, and two-way communication channels.

Internet Connectivity. Many climate governance tasks require internet connectivity which is made available using wireless broadband technologies, specifically through wifi. Marikina city makes use of environment or weather related information from NOAH's web-based application as well as from the social media pages of relevant government agencies such as PAGASA and the Department of Envrionment and Natural Resources (DENR) to decide on future actions especially at times of impending hazards. Access to these web applications and pages are only possible through internet connection. The air quality monitoring stations owned by the DENR deployed in Marikina also make use of internet connection to transmit data. The data that DENR collects from these stations are analyzed, processed and posted on their social media accounts and website which Marikina city uses as reference to determine whether they need to implement air quality related interventions or not. Marikina city's field officers are also equipped with pocket wifis which are mainly used to access online communication channels that enable fast transmission of data/information from the field to the main office. This allows for immediate analysis of the data/information as well as for quick decision-making. Internet connectivity is also especially crucial with respect to Marikina city's disaster management operations. The DRRMO views the CCTV footages using web and mobile applications allowing them to monitor the water level of marikina river realtime. As such, they are able to determine whether the water in marikina river reaches a level that require immediate attention. The CCTV footages are also streamed live in Marikina city's website and social media accounts allowing the residents to know and prepare before a flood would occur. This whole operation, from realtime monitoring to streaming of the CCTV footages require internet connectivity. Because of the importance of internet connectivity to the operations of DRRMO, Ms. Jackie Lou Espinosa shared that they are actually trying to upgrade their wifi system as they need faster internet connection. Although the present internet set-up of Marikina LGU is centralized, the internet upgrade that Ms. Jackie Lou Espinosa was referring to would only apply for DRRMO. She said that their department, the DRRMO, gets their own separate funding for the procurement of their own supplies and needs such as internet connectivity. This reflects that the institutional set-up of the Philippine Government recognizes the extra needs to support disaster-related operations. At present, the whole Marikina LGU is engaged with an internet provider called 'Tri-ph' and the DRRMO is planning to get the services of another provider called 'Converge' who, according to Ms.

Jackie Lou Espinosa, offers a much faster internet service of at least 25 megabytes per second (mbps).

"We are engaged with Tri-ph but since our command center was created, they have been our provider but I'm not sure if it (contract with Tri-ph) has already been renewed but we are planning to replace them because our needs demand faster wifi service right? Especially for a large department like us, that is why we are trying to discuss with converge who offers fiber (internet service) that allot at least 25 mbps... it would help us more compared to our present provider."

Two-way communication channels. The use of two-way communication channels are also evidently crucial in the conduct of many tasks within the LGU and these channels are mainly provided for by ICTs. Two-way communication occurs primarily in two ways - internal and external. Internal communication involves communication between members of the LGU while external communication is between the LGU and the public or other institutions such as the national government and other LGUs.

In Marikina, internal two-way communication occurs, for instance, when field officers transmit data/information from the field to the people in the main office. Field officers mainly use radio as their main channel for communicating with people in the main office but they also make use of calling, texting or chatting through cellphones or tablets. All departments are equipped with two-way radio devices, and many members of the LGU are also equipped with walkie-talkies; a type of portable two-way radio device - from field personnel and project engineers up to the Mayor.

Mr. Oliver Villamena of CEMO makes a comparison between field officers who use messenger, for example, and those who do not use any mode of communication at all which reflects the importance of two-way communication channels. He said:

"...that is what is good about it, unlike others who leave the office in the morning who do not use messenger. They will only be able to come back and report, for example, at around noon, so many hours have already passed. Unlike those who are dispatched [and use messenger], they are able to send pictures from the field right away. Those pictures can be immediately evaluated by our chief who could then decide on what to do next...."

Coordination among different departments are also facilitated by two-way communication channels especially in Marikina's case where the department offices are not necessarily close to one another. This is mostly done through the use of telephones, online chatting applications such as facebook messenger, texting and e-mail. Mr. Adriano from the MISCC even said that they have a facebook group where they can call the attention of other departments to address specific requests. He added that aside from facebook, they also use a software called 'compliance slip' that allows them to send and track requests to other departments. This software is used by all departments in Marikina. Through the compliance slip, the different departments within the LGU can send receive requests from each other. They can also track the status of these requests. This software fosters accountability and promotes timeliness in terms of accomplishing deliverables. Another example of internal communication in action is during typhoon occurences when the Mayor send directives via text or messenger to the CA which are then cascaded to the different departments.

With respect to external communication, this usually involves communication between the LGU and the public, or between LGU and other institutions. On one hand, in terms of the latter, this is exemplified in various ways. For one, nearby LGUs are able to inform Marikina through text or facebook whenever they experience heavy rainfall. Ms. Nelisa Palomar said that because of ICTs, there is better coordination among LGUs. She shared that after typhoon Ondoy, a network of LGUs in Metro Manila was formed where member LGUs alert and coordinate with each other whenever a hazard occurs. Their main mode of communication is through text or facebook. This is important since Marikina city, because of geographical circumstances, is a catch basin for its nearby cities and towns. This kind of coordination allows Marikina to implement appropriate measures before flooding from nearby areas, for example get into their own city.

Marikina also uses ICTs to coordinate or receive data from the national government. Large-scale and more advanced ICTs for hazard monitoring and data collection are owned and operated by the national government agencies such as the NDRRMC, PAGASA and DENR. As such, Marikina relies on the data/information sent to them by these agencies. For Marikina's DRRMO, for instance, they rely on PAGASA's weather forecasts sent through email, fax or even through a viber group, a mobile-based messaging application, for the whole Metro Manila Disaster Risk Reduction and Management Council in which the Marikina LGU is represented. As mentioned, the DENR also sends daily email to Marikina CEMO regarding air quality data and information from their monitoring stations. In the same way, other institutions such as KOICA[5] and JICA[6], who owns water level sensors, and the Metro Manila Development Authority (MMDA), who operates the Effective Flood Control Operating System (EFCOS), send Marikina city weather and hazard related data that are crucial to the local climate action activities of the LGUs.

External communication with the public, on the other hand, usually happens using social media. The residents of Marikina usually message the LGU through facebook messenger. Many times it is coursed through the public, closed-group, of Marikina named "Marikina News." (see Figure 18). It currently has over 300,000[7] members which is over 66% of the city's population[8]. While it may not be validated whether all members are actual residents of Marikina, the number is still suggestive of the facebook groups's reach.

Ms. Lisa Cruz said that residents usually post their concerns or requests there or sometimes, she said, that the residents message them directly through facebook messenger.

"...All of Marikina resident's requests are posted here in Marikina news. Anyone [from the LGU] who will see the requests [that concern our department] would forward them to me which I will then forward to the city engineer."

[5] Korea International Cooperation Agency
[6] Japan International Cooperation Agency
[7] Checked at around 9:00 PM, August 18, 2018, Netherlands
[8] Based on the 2015 census (PSA, 2016)

Figure 18: Marikina News Facebook Group
Source: Marikina News Facebook Group (https://www.facebook.com/groups/966365156757316/)

There are actually other venues for the public to reach Marikina such as calling them through their telephone lines but Ms. Lisa Cruz said that that rarely occurs as most of the time, they are reached through social media or email. Aside from Marikina news, there are also other facebook pages that the public can message to communicate with the LGU such as the 'Marikina PIO (@MarikinaPIO)' which is the main facebook page of Marikina handled by their Public Information Office (PIO) with over 220,000 followers[9]. Whenever the page receives a message from the public, the information is endorsed to the concerned departments or offices. Another popular facebook page of Marikina is the 'Marikina City Rescue 161 (@MarikinaRescue161)' which is the official page of the LGU for disseminating disaster related information in Marikina. It has almost 52,000 followers[10] and is also utilized by the DRRMO as a channel for the public to reach them especially at times of disasters when residents need assistance or rescuing.

Marikina also makes use of a Data Tracking System (DTS) which is somehow the counterpart of the 'compliance slip' software for public communication. It allows residents with any kind of transaction with the Marikina LGU to track the status or check updates of their requests, concerns or inquiries. This is done through a tracking number. Ms. Lisa Cruz explains how this works through an example:

...for example, you search for a name, 'Juan Dela Cruz', if someone is trying to follow-up on a document he requested, it will be shown here. For example, here (shows DTS software),

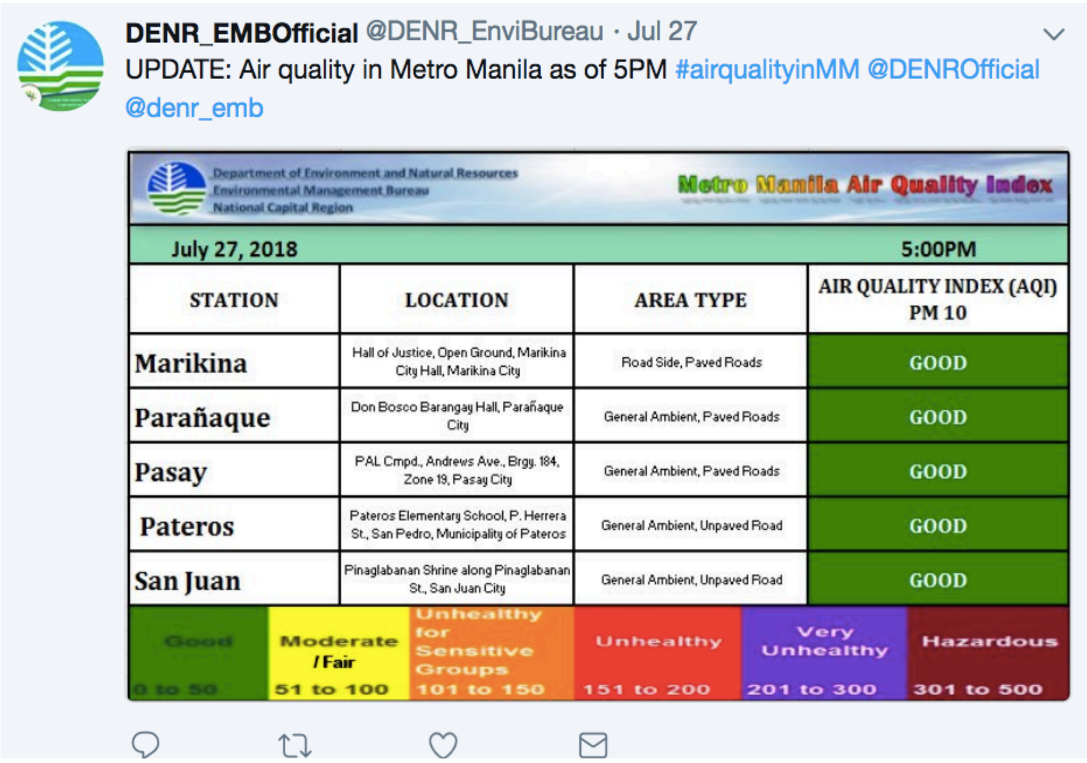
[9] Checked around 8:40 PM of August 17, 2018, Netherlands
[10] Checked around 10:34 PM of August 17, 2018, Netherlands

this is his number, you can see,, it is actually disapproved. So anyone with a request would know. If you are a computer literate, you can access (DTS). (shows tracking number) This is what we call the tracking number, this what we give to the applicants..."

4.4.2 Collecting Data/Information

When internet connection and communication channels are already in place, with respect to climate e-governance, ICTs play its next major role through collection of data and information. In Marikina's case, this is possible because of the monitoring devices, access to relevant information online, and public communication.

Among the departments interviewed, CEMO and DRRMO are the main handlers of the monitoring devices deployed in Marikina. For CEMO, the main monitoring device they use are air quality monitoring stations. However, as mentioned, these stations are actually owned by the DENR. Nevertheless, the CEMO gets daily data and information from DENR extracted from the monitoring stations. If further data is needed, Mr. Oliver Villamena said that they could just easily send a request to DENR. There are are two realtime and two manual air quality monitoring stations. On one hand, the realtime stations produce realtime data that can be produced right away from extraction. The manual monitoring stations, on the other hand, have filters that must be replaced every 6 days then you have to wait for 24 hours to extract the data from the machines. What these stations monitor are PM[11]10 and PM2.5. Data from these are posted by DENR on their social media accounts such as twitter. Below is a sample tweet update from DENR's twitter account, specifically from their Environmental Management Bureau (EMB). As shown, air quality for other areas where the monitoring stations are deployed are also displayed (see Figure 19). What is indicated is already processed data, meaning to say that the DENR had already analyzed the data and interpreted the quality, whether they are good, moderate, unhealthy for sensitive groups, unhealthy, very unhealthy and hazardous based on a certain air quality index.



STATION	LOCATION	AREA TYPE	AIR QUALITY INDEX (AQI) PM 10
Marikina	Hall of Justice, Open Ground, Marikina City Hall, Marikina City	Road Side, Paved Roads	GOOD
Parañaque	Don Bosco Barangay Hall, Parañaque City	General Ambient, Paved Roads	GOOD
Pasay	PAL Cmpd., Andrews Ave., Brgy. 184, Zone 19, Pasay City	General Ambient, Paved Roads	GOOD
Pateros	Pateros Elementary School, P. Herrera St., San Pedro, Municipality of Pateros	General Ambient, Unpaved Road	GOOD
San Juan	Pinaglabanan Shrine along Pinaglabanan St., San Juan City	General Ambient, Unpaved Road	GOOD

Figure 19 - Sample Air Quality Tweet from DENR; Source: DENR EMB Twitter Account

[11] Particulate Matter

According to Mr. Oliver Villamena, aside from what is posted by the DENR, data from the monitoring stations can also be accesed through certain websites, although they were not specified. He also shared that they are planning to implement a clean air action plan around October of 2018 that will include a project involving air quality monitoring machines that will be attached to cars to be driven around Marikina, covering the 16 barangays. This will improve the coverage of air quality monitoring in Marikina.

Figure 20: Rain Gauge in Marikina River
Source: Marikina LGU

Another monitoring device extensively used in Marikina is the CCTV. In terms of climate e-governance, CCTVs are used to monitor flood and water level situations. CCTVs are mainly located along entry and exit points, major intersections and within flood-prone areas in Marikina. According to Ms. Jackie Lou Espinosa, the CCTVs are linked to the server in their command center and the footages of the CCTV can be viewed live online through Marikina's website or through their facebook page. One of the CCTVs is especially used to monitor the water level in Marikina river where a gauge is located (see Figure 20). This allows both the DRRMO and the public to be aware when the water level of Marikina river reaches alarming heights. Marikina implements evacuation protocols in this regard. When the water reaches 15, 16 and 18 meters, 1st, 2nd and 3rd alarms are triggered. For 1st alarm, the sirens are aired for a minute. This signifies that the residents should stay alert and prepare for possible evacuation. For the 2nd alarm, the sirens are aired for 2 minutes which indicates that the residents are already advised to evacuate while for the 3rd and final alarm, the sirens are aired for 5 minutes and the residents are forced to evacuate. The sirens in Marikina are still manually operated but they can be triggered remotely from the command center. It as such that the officers in DRRMO must always stay alert and monitor the CCTV footages even when they are not in the command center. Ms. Jackie Lou Espinosa said that this can be done using mobile applications where they just need to input the Internet Protocol (IP) Address used by their CCTVs then they will be able to view the footages.

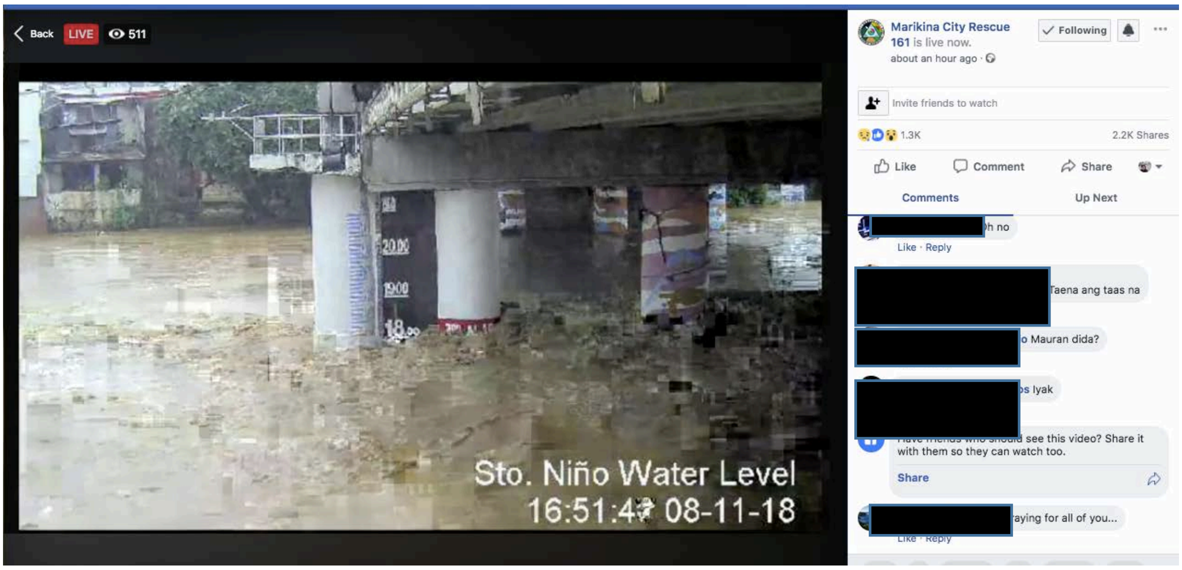


Figure 21: Marikina River Water Level Monitoring CCTV Live Stream
Source: Marikina City Rescue Facebook Page

Again, the CCTV footages are streamed live in Marikina's website and facebook pages. Figure 21 shows a screenshot of the live CCTV footage of Marikina River Water level monitoring. As shown, the water level at that time reached 18 meters which triggered the 3rd alarm. In situations like that, where there is an occurrence of rapid-onset hazards such as flooding, as reflected in Figure 16, the data/information collected do not go through the analysis or processing stage. In this instance, actions are already pre-determined once data/information are collected from the ground.

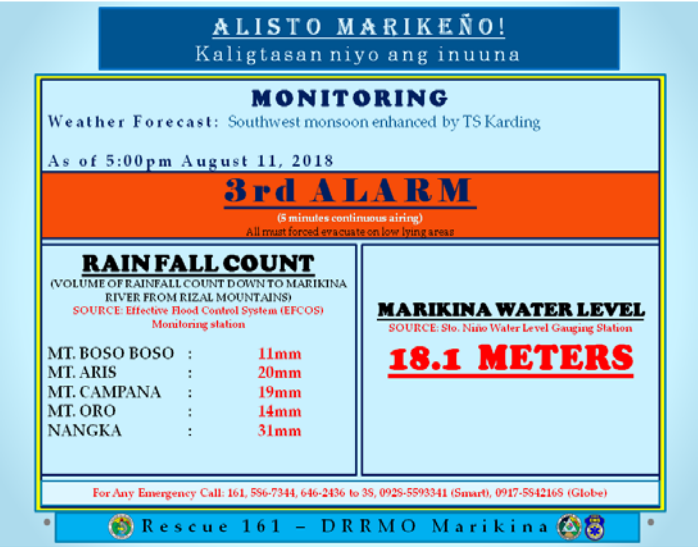
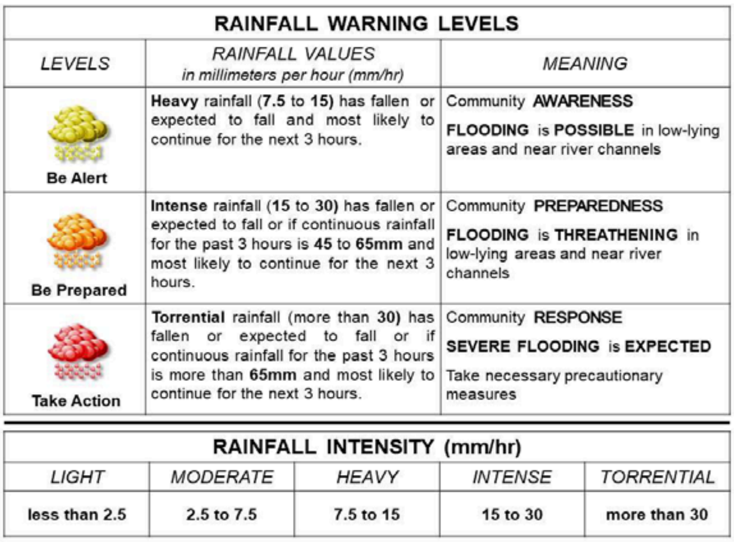


Figure 22: Marikina's Facebook Warning announcement
Source: Marikina City Rescue Facebook Page

Marikina also releases warnings on social media such as shown in figure 22. It shows the level of alarm, what it signifies, volume of rainfall count at selected flood-prone areas in Marikina and water level itself. It also shows emergency contact numbers of the LGU. As indicated in figure 22, the data for the rainfall count comes from the MMDA, *"a special development and administrative region and certain basic services affecting or involving Metro Manila as metro-wide services more efficiently and effectively planned, supervised and coordinated by a development authority as created therein, without prejudice to the autonomy of the affected local gvernment units."* (*Republic Act 7924*. n.d.). The MMDA operates EFCOS or the Effective Flood Control Operation System, an equipment funded by JICA for monitoring rainfall volume and to analyze whether a flooding will be imminent. For Marikina, the EFCOS monitors five upstreams, as shown in Figure 22 - Mt. Boso boso, Mt. Aris, Mt. Campana, Mt. Oro and Nangka (Tipan, 2016). Ms. Citas DeVera said that the fastest that the MMDA could transmit data from the EFCOS to their command center is hourly during weather distrubances. She shared that during a heavy rainfall, they actually tried to ask at a faster rate but they were still sent the data hourly. When asked whether they would prefer to get data quicker, she said that it could help them better. To help the public interpret the rainfall data, they also constantly share the rainfall warning guide regularly posted by PAGASA (see Figure 23).



RAINFALL WARNING LEVELS		
LEVELS	*RAINFALL VALUES in millimeters per hour (mm/hr)*	*MEANING*
Be Alert	**Heavy** rainfall (**7.5 to 15**) has fallen or expected to fall and most likely to continue for the next 3 hours.	Community **AWARENESS** **FLOODING** is **POSSIBLE** in low-lying areas and near river channels
Be Prepared	**Intense** rainfall (**15 to 30**) has fallen or expected to fall or if continuous rainfall for the past 3 hours is **45** to **65mm** and most likely to continue for the next 3 hours.	Community **PREPAREDNESS** **FLOODING** is **THREATHENING** in low-lying areas and near river channels
Take Action	**Torrential** rainfall (more than **30**) has fallen or expected to fall or if continuous rainfall for the past 3 hours is more than **65mm** and most likely to continue for the next 3 hours.	Community **RESPONSE** **SEVERE FLOODING** is **EXPECTED** Take necessary precautionary measures

RAINFALL INTENSITY (mm/hr)				
LIGHT	*MODERATE*	*HEAVY*	*INTENSE*	*TORRENTIAL*
less than 2.5	2.5 to 7.5	7.5 to 15	15 to 30	more than 30

Figure 23: Rainfall Warning Guide shared by Marikina City from PAGASA's Facebook Account
Source: Marikina City Rescue Facebook Page

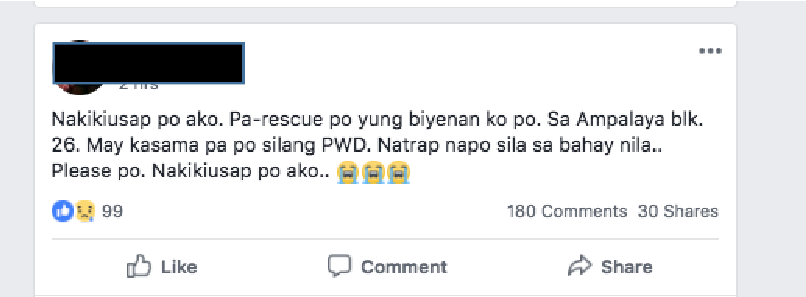
Marikina LGU is also able to collect climate change related data and information from the residents themselves through their grievances, concerns and messages, in general, addressed to the LGU through social media, telephone lines, and e-mail. Again, the most popular option among residents to reach the LGU is social media. Looking into the 'Marikina News' facebook close-group provides an overview on the different kinds of information collected from the residents. This was done by using the name of the departments as keywords as well as other relevant terms to search over the content of the posts of the group. These keywords are also based on what was shared by the interviewees from Marikina LGU about the usual concerns and grievances of the residents. Keywords used are 'CEMO', 'Rescue', 'Evacuation', 'CCTV', and 'Engineering'. As shown in the examples below, concerns of the residents allow the Marikina LGU to monitor happenings or things that need to be addressed around Marikina such as broken drainages, local policy violations, rescue needs, evacuation conditions, broken cctvs, and open manholes.

Keyword: CEMO

"Calling CEMO, maybe you can visit this area around lilac street, the drainage needs fixing. Thanks!"

"ATTENTION: CEMO
Please attend to this matter, it's really inconvenient and I understand that there is an ordinance against burning"

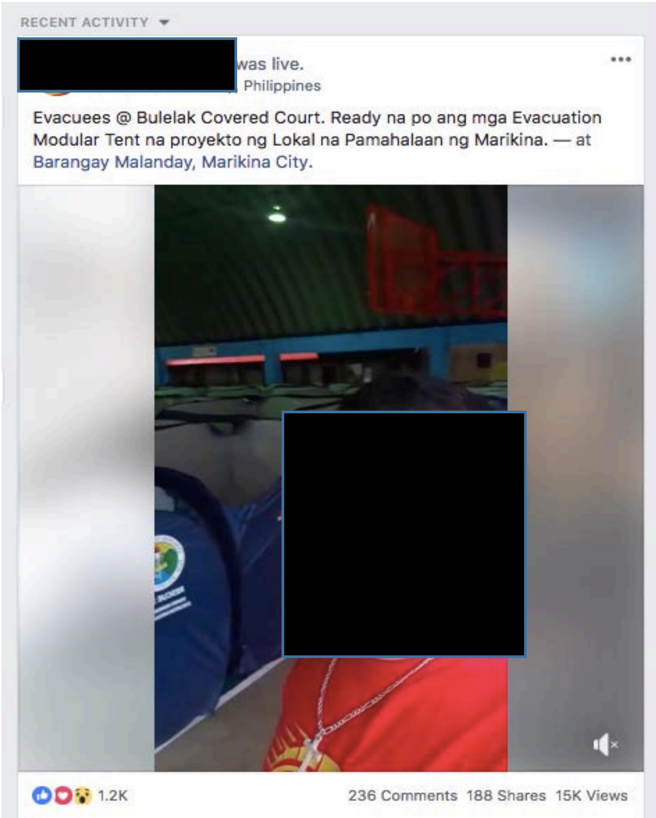
Keyword: Rescue



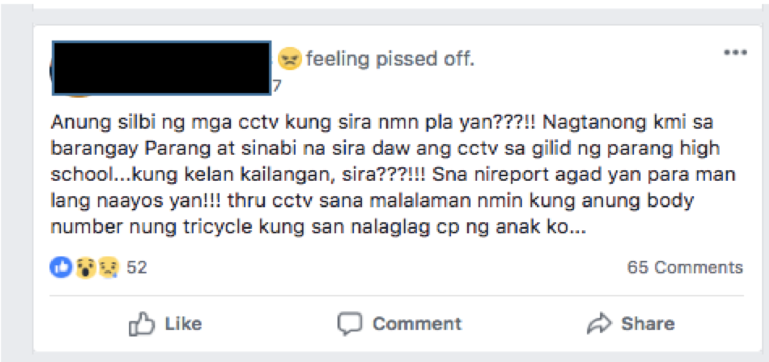
"I am begging you, please rescue my mother-in-law. She's at Ampalaay block 26. She's with a PWD. They are trapped inside their house. Please. I'm begging..."

Keyword: Evacuation

"Evacuees @Bulelak Covered Court. The Evacuation Modular Tent, a project by the local government of Marikina, is ready..."



Keyword: CCTV

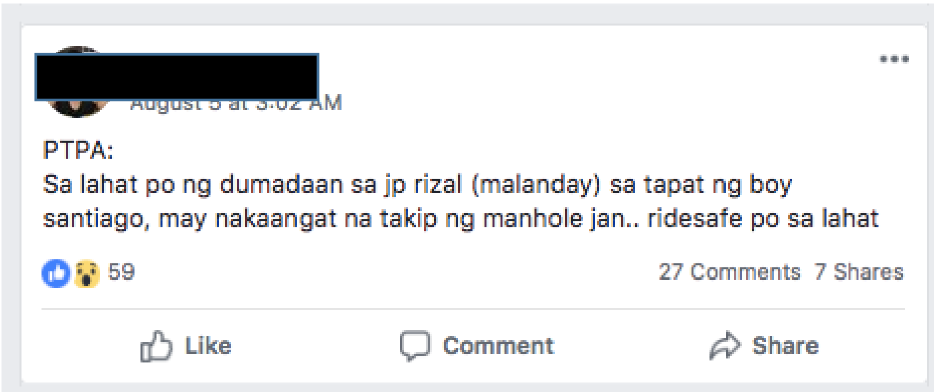


"What's the use of CCTV if it's broken? We asked Barangay Parang and they told us that the CCTV beside parang high school is broken...why is it broken when it is mostly needed???!!! This couldhave been reported immediately to be repaired right away.

Through CCTV, we could have known the body number of the tricycle where my kid dropped his cp."

Keyword: Engineering

"PTPA (Permission to Post Admin). Respect Please. Because it is inconvenient to go to the engineering department. Many children's feet are frequently get stuck here like my own kid including even my wife. Maybe you could schedule a repair for this sidewalk! E. Santos street concepcion uno, boss Ryan Salvador, please take care of this for us."



"PTPA: To all those who pass by JP Rizal (Malanday) in front of boy santiago there is a lifted manhole cover.. please ride safely everyone."

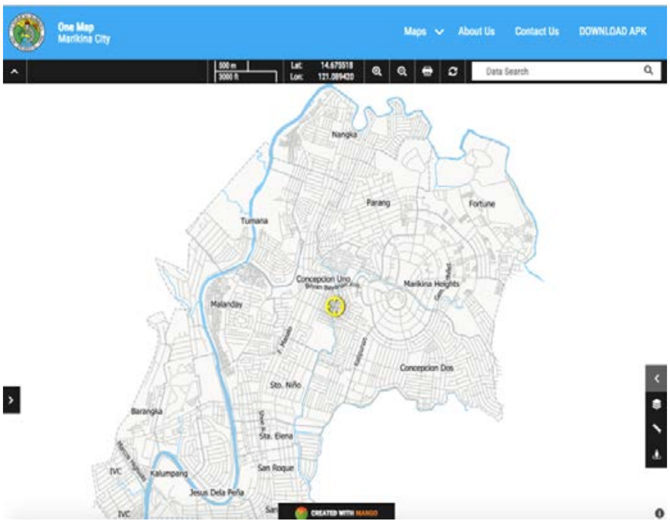
In general, what can be observed in Marikina is that the main ICTs used for collecting data and information that could aid local climate action are monitoring devices such as the air quality monitoring stations and the CCTVs, online web-pages of national government agencies such as PAGASA and DENR that provide weather and hazard-related information, and social media through the residents' concerns and grievances. It may also be observed that these ICTs support each other. For instance, CCTV footage of the Marikina river water level is streamed live in Marikina city's facebook page which allows the residents to view it as well. This also allows the DRRM officers to monitor water level in Marikina river it even when they are not in the command center. Data from the monitoring stations owned by the national government such as the DENR are also posted on their website which Marikina makes use of. Sometimes these data are also emailed or sent via web to Marikina.

4.4.3 Processing and Analyzing Data/Information

After data and information are collected, they are analyzed and processed in order to guide decision-making. The most evident use of ICTs for processing and analyzing data and information for local climate action in Marikina is making maps such as hazard and risk maps. The MISCC is the main department in-charge of map-making. According to Mr. Richard Adriano, the main bases for the maps are historical data and the main software used is ArcGIS. What happens, for instance, is when a flooding occurs, the engineering department conducts a survey around Marikina to determine the level of flooding among different areas then the data are given to the MISCC to overlay the data to their base map. Aside from the survey, they also get data from satellite images. They also sometimes get maps from external sources such as from the Marine and Geosciences Bureau (MGB), a national government agency, and the Greater Metro Manila Area (GMMA) Project, a World Bank Project. Different infrastructure types are also plotted in their maps. For instance, if new buildings are established in Marikina, because these buildings go through the LGU for permit, once approved, they plot them on their maps right away. Note that what MISCC uses is a thematic map where they have a base map and they overlay data to the maps according to different themes or data types. To facilitate map-creation in MISCC, they also designed an online program called 'One-map' (see Figure 24). This software allows for centralized creation and revision of their maps. For example, if someone from the department is adding or revising the data of their thematic maps, others who are accessing one-map can monitor the changes being done. One-map is also available for public online viewing. As such, anyone can see and even download the different maps that Marikina has produced. At present, there are currently four categories of thematic maps that can be viewed in one-map: Environment, Hazards, Landuse and Settlement. The following are plotted per map category:

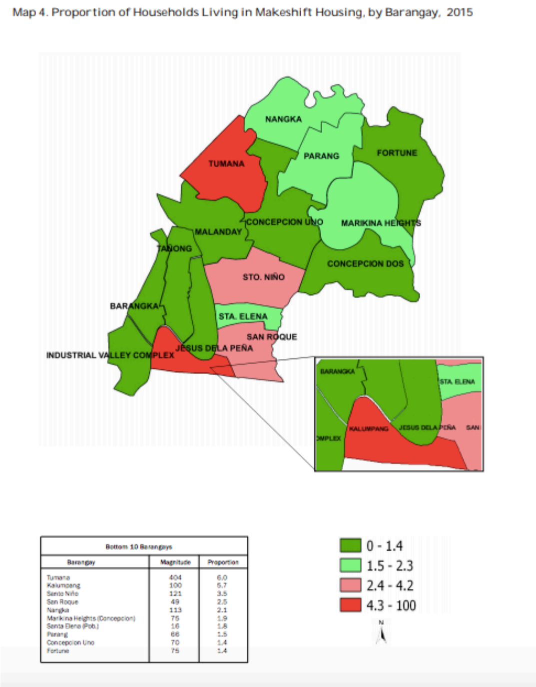
- <u>Environment:</u> Solid Waste Management Facilities; and Materials Recovery Facilities
- <u>Hazards:</u> Earthquake Induced Landslide; Liquefication; Raind Induced Landslide; Flooded Areas Ondoy and Ground Shaking (Magnitude 7.2)
- <u>Landuse:</u> existing landuse and zoning for residential, commercial, industrial institutional, cultural heritage, parks-open space-recreational, cemeteries, APD, roads, rivers and zoning
- <u>Settlement:</u> Evacuation and Settlements

Figure 24: One-Map
Source: One-Map Website (https://onemap.marikina.gov.ph/)



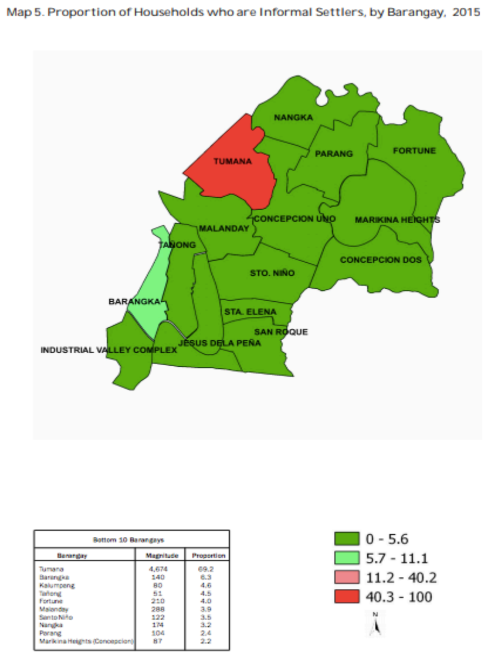
Aside from these, as mentioned, different infrastructures can also be located on their map such as government offices, hospitals, health centers, police stations, fire stations, public schools, private schools, churches, heritage sites, cemeteries, transportation terminals, cctv live feeds location, bikelanes, transport routes, street drives, barangay boundaries, buildings, roads and rivers. Distances and areas within Marikina can also be measured using one-map. It also connects to google map if you want a streetview of a location in the map.

Marikina also conducted a type of mapping that includes social and other vulnerability factors through the community-based monitoring survey (CBMS). CBMS is a survey that tries to capture the different facets of poverty through different indicators that define the following: a) health; b) nutrition; c) housing; d) water and sanitation; e) basic education; f) income; g) employment and h) peace and order (Reyes et. al, 2017). Some maps produced from CBMS that could aid significantly in LGU's climate action activities include proportion of households living in makeshift housing (see Figure 25), households who are informal settlers (see Figure 26), households without access to safe water supply (see Figure 27), households with income below the poverty threshold (see Figure 87) etc. The last CBMS conducted was in 2015.



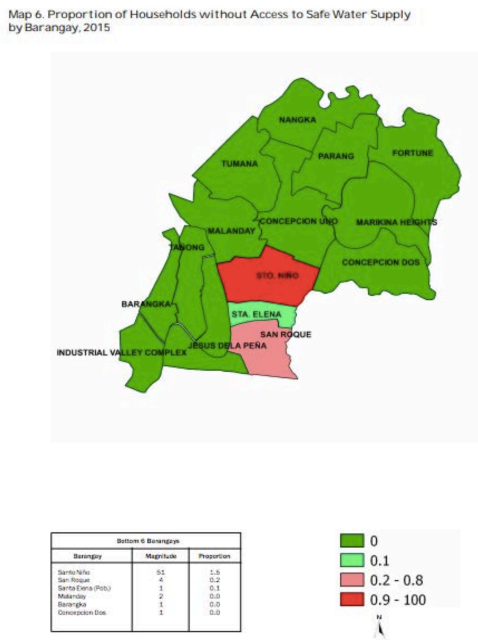
Bottom 10 Barangays		
Barangay	Magnitude	Proportion
Tumana	404	6.0
Kalumpang	100	5.7
Santo Niño	121	3.5
San Roque	49	2.5
Nangka	113	2.1
Marikina Heights (Concepcion)	75	1.9
Santa Elena (Pob.)	16	1.8
Parang	66	1.5
Concepcion Uno	70	1.4
Fortune	75	1.4

Figure 25: CBMS-Makeshift Housing
Source: Reyes et. al, 2017



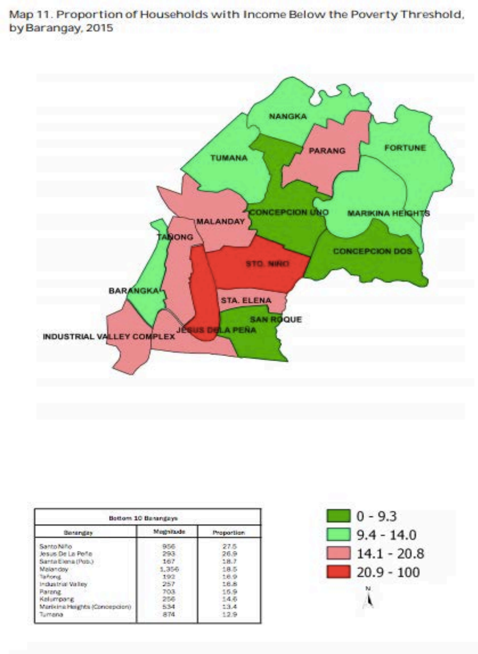
Bottom 10 Barangays		
Barangay	Magnitude	Proportion
Tumana	4,674	69.2
Barangka	140	6.3
Kalumpang	80	4.6
Tañong	51	4.5
Fortune	210	4.0
Malanday	288	3.9
Santo Niño	122	3.5
Nangka	174	3.2
Parang	104	2.4
Marikina Heights (Concepcion)	87	2.2

Figure 26: CBMS-Informal Settlers
Source: Reyes et. al, 2017



Bottom 6 Barangays		
Barangay	Magnitude	Proportion
Santo Niño	51	1.5
San Roque	4	0.2
Santa Elena (Pob.)	1	0.1
Malanday	2	0.0
Barangka	1	0.0
Concepcion Dos	1	0.0

Figure 27: CBMS-Safe water supply
Source: Reyes et. al, 2017



Bottom 10 Barangays		
Barangay	Magnitude	Proportion
Santo Niño	956	27.5
Jesus De La Peña	293	26.9
Santa Elena (Pob.)	167	18.7
Malanday	1,356	18.5
Tañong	192	16.9
Industrial Valley	257	16.8
Parang	703	15.9
Kalumpang	256	14.6
Marikina Heights (Concepcion)	534	13.4
Tumana	874	12.9

Figure 28: CBMS-Poverty Threshold
Source: Reyes et. al, 2017

All the data are processed from the mapping are integrated into Marikina's CLUP as well as other as other plans that involve creation of programs, projects and activities. Mr. Oliver Villamena even shared about a project that was a result of the CBMS when asked what they do after the mapping was done.

"A program should be implemented. For example, when we conducted a survey on toilet facilities in Marikina, what we did next was to provide free toilet bowls among settlement areas. You should create projects for it..."

Processing of data can also take the form of validation. For instance, when the LGU receives a complaint or grievance from the public from social media, they visit the area where there is a complaint to determine whether it is valid or not. The field officers usually take pictures of the area if the complaint involves structural concerns which are sent to the main office for evaluation. It is then that a course of action is determined and then executed. During heavy rainfall, the DRRMO also analyzes data from the EFCOS. They are able to calculate a probability if the rainfall would lead to heavy flooding. Through this analysis, they are able to also determine whether they will need to advise the residents to already evacuate even when water levels in Marikina river has not reached an alarming level yet.

The role of ICTs becomes very minimal after analysis and processing of data and information, at least in Marikina's case. Courses of action, for example, are decided upon council meetings and the actions themselves usually do not involve the use of ICTs. For instance, when a resident complaints about a clogged drainage, ICTs are involved from when the resident communicated with the LGU for his/her concern, to its processing and validation but the actual declogging does not involve ICTs. Nevertheless, the final actions are not reached without the first few processes where ICTs play major roles.

4.5 Achievement of Climate Change Adaptation and Risk Management Objectives

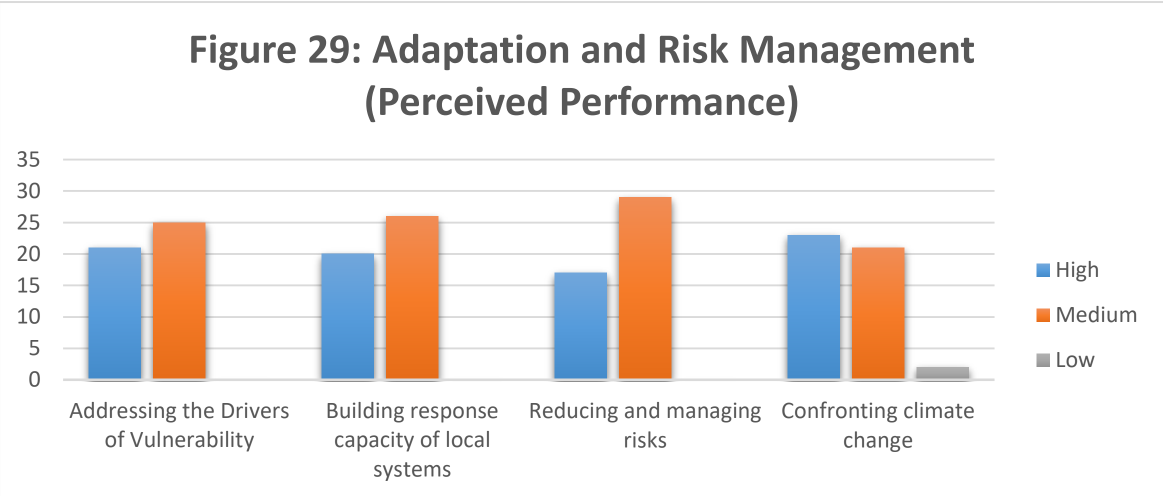


Figure 29 shows how the respondents rate their respective LGUs with respect to achieving the four adaptation entry points - addressing the drivers of vulnerability, building response capacity of local systems, reducing and managing risks and confronting climate change. What the figure suggests is that majority of the respondents feel that their LGUs, based on this study's parameters, are barely addressing drivers of vulnerability (54.35%), building response capacity of local systems (56.52%) and reducing and managing risks (63.04%). It is a different story, however, when it comes to confronting climate change where more (50%) of the respondents said that their LGUs are able to achieve this objective effectively and efficiently.

For Marikina city, perhaps the most useful ICT, which is also reflected in the survey, that help achieve the different adaptation and risk management objectives is social media. In terms of addressing drivers of vulnerability, for instance, social media serves as an avenue for them to reach the LGU. Ms. Citas DeVera even said that concerns from vulnerable groups are prioritized. As an example, she used a case of an elderly who needed an ambulance. This was coordinated using social media and was then addressed. It is also very helpful when it comes to reducing and managing risks since many safety tips and other disaster or climate change related information are posted on social media such as weather advisories, class suspensions, information on environment related ordinances and programs. Many actions that allow for better confrontation of climate change impacts come from the public's concerns that are coursed through social media such as drainage declogging, rescue needs, broken cctvs and roads.

Another very useful outcome of ICT-use that helps in local climate action is the CBMS and other thematic maps produced. These maps provide area-specific information within Marikina which then leads to formulation of progams, project and activities that will cater to the specific needs for different areas in the city. Since these maps are also available for public viewing through one-map, this allows Marikina residents to be aware which risks and hazards they are highly susceptible to. Moreover, government facilities and offices are plotted as well in the map which helps the residents locate where they can go for basic services such as healthcare or evacuation. As such, drivers of vulnerability are better addressed, response capacity of local systems are enhanced, and generally, climate change is better confronted.

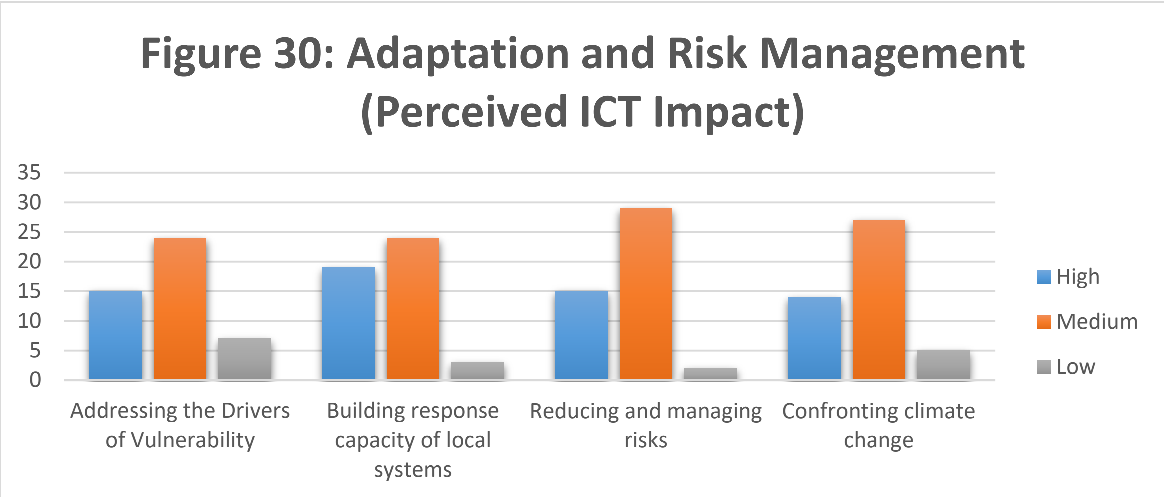
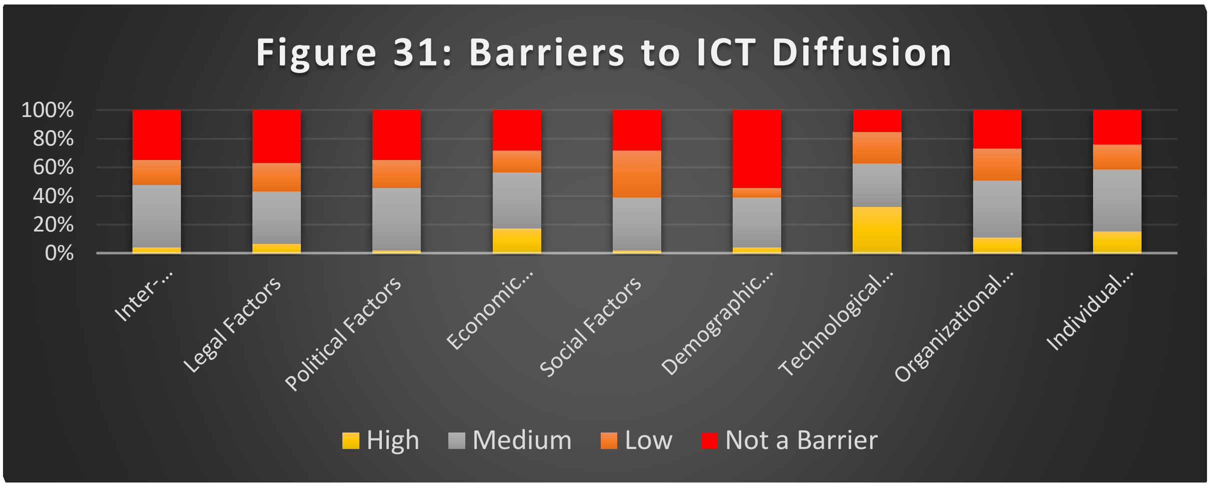


Figure 30 shows the perceived impact of ICTs with respect to achieving the said adaptation entry points. For all objectives, 'medium' is the most selected response: reducing and managing risks (63.04%); confronting climate change (58.70%); building response capacity of local systems (52.17%) and addressing drivers of vulnerability (52.17%). This suggests that the use of ICTs is not necessarily crucial to achieve the adaptation and risk management objectives but it helps primarily with regard to their effective and efficient accomplishment. The process tracing analysis could provide insight on why this is the case. According to the analysis, ICTs play a major role only in the first three processess: facilitating execution of tasks, collecting data/information and processing and analyzing data/information, and not in the determination and execution of the actual course of climate change action. This could be among the reasons why more of the respondents perceive that ICTs are only tools for effective and efficient accomplishment of climate change adaptation and risk management objectives but not necessarily vital in order to do so.

4.6 Issues, and Barriers to ICT Diffusion



Regardless of extent of hindrance, almost all factors were considered by most respondents as a barrier where technological factors (84.78%), and individual factors (76.09%) are the most selected (see Figure 31). By taking into account extent of hindrance, technological factors, individual factors as well as economic factors are most highly rated barriers to ICT diffusion. This suggests that most hindering barriers to ICT diffusion are lack of infrastrures for ICT support, low public ICT readiness, threats to information security, technological complexity, lack of ICT readiness among individuals in the system (within the LGUs) and budget constraints.

Technological factor as the main barrier to ICT diffusion is also reflected in the recommendations provided by the respondents to strengthen ICT-use for local climate e-governance, specifically within the aspect of technological complexity. This means that there is a need to better equip LGU personnel and officers with skills and knowledge to operate complex ICTs. Examples of some comments by the respondents in this regard include the following:

"The LGU is in great need of ICT officers and specialist. As of the moment, DRR-CCA is about to be mainstreamed here in the city, The DRRM office has no technical personnel such as GIS specialist because of lack of budget for personnel services. Although budget of ICT equipment is being prioritized on the DRRM fund, we still need to wait for the office ratification to hire people. The office greatly relies on consultants(EMI and UP Planades) and other offices such as City Planning Office (Land Use and Zoning) and Information Technology and Development Office"
- Guillan Tibule, Special Operation Support Staff, DRRMO, Quezon City

"Issue policies mandating a team of IT skilled employees with envi[ronmental] and urban planning technical employes to work on the ICT program for CC[Climate Change]"
- Melinda Daroy, Project Development Officer III, CPDO, Marikina City

"Capacity-building/Technical Trainings or workshops regarding the use of ICTs"
- Rachel Ann Mellarpis, CENRO Staff, CENRO, Valenzuela City

"I think there is a need to strengthen the mainstreaming of the usage of ICT in terms of local climate governance. With that said, there should be more equipment and training made

available to the offices and personnel concerned, like our local DRRMO and the other member offices of the Protective Services sub-cluster..."
- Cyril Marfil, Administrative Officer II, CPDO, Muntinlupa City

The case of Marikina suggests that the underlying factors that hinder ICT adoption involve inter-institutional dynamics and budget constraints. In terms of inter-institutional dynamics, many of weather and climate related monitoring ICTs are owned and operated at the national level. As such, the quality as well as the timeliness of data received by the LGU relies upon the effiency of concerned national government agencies. For example, when asked about how often does the DENR provide raw data to Marikina's CEMO, Mr. Oliver Villamena said:

"As long as you request for it but unlike in the past, the previous regional director (of DENR) provided quarterly but now, they only send us data upon request. If we do not request for a year (for example), they will not give us any data."

The response of Mr. Oliver Villamena suggests that changes in leadership affects as well the dynamics between national-local governments with respect to data sharing. Although the LGU also wants to purchase their own equipment and facilities, many of these are beyond the financial capacity of the LGU. Budget constraints overlap with issues on legal restrictions. Citas DeVera, for example, said that they are being held back by the funding restrictions under RA 10121 or the 'Philippine Disaster Risk Reduction and Management Act of 2010'. Under this law, the DRRMO gets 5% allocation from the LGU's total budget which is called the Local Disaster Risk Reduction and Management Fund (LDRRMF). 30% of this fund should be set aside as Quick Response Fund (QRF) or funds that can be used only when the locality is under a state of calamity where relief and recovery programs and activities are necessary. The remaining 70% can be used for pre-disaster preparedness activities. Acquisition of internet services, however, is not considered by the law as a pre-disaster activity. As such, they get funding for this from the general fund which is what is used for paying for general utilities which is smaller than what they could have obtained from the LDRRMF.

"Our budget is divided into two, we have the general fund and the disaster fund. For the general fund, that is what we use to pay for our utilities such as the lights, electricity, internet, and telephones. Whatever amount the budget officer gives us, we have to make do...you know, under RA 10121, there are many restrictions..."

Budget constraints also could lead to technological issues. The aforementioned issue on lack of ICT specialists, for instance, could actually be attributed to budget constraints. Ms. Lisa Cruz actually said that good ICT professionals are not encouraged to work for the government since they can get better jobs with better pay in the private sector. Another technological issue that stems from budget constraints is lack of ICT infrastructure. For instance, with respect to internet connectivity, Mr. Oliver Villamena shared they are not able to improve the quality of their connection because in order to do so, they will have to install another antenna which the LGU cannot afford. When asked about improving their internet connectivity, Mr. Oliver Villamena said:

"Because in order to address that (slow internet connection), we need to buy, for example, an antenna because we are somehow all connected to one antenna. There are things like that although it is possible (to improve quality of internet connection) but it is going to be expensive.."

Chapter 5: Discussion/Conclusions and Recommendations

5.1 ICT Diffusion

It is important to note that this study relies on perception data which means that measurement of the variables rely on the respondents' knowledge on the questions asked. For questions on ICT diffusion, for instance, it is possible that there are ICTs that some respondents perceive as not being used for climate action but actually are. Differences in perception for the survey responses are taken into account in the previous chapter through figures 11, 12 and 13. These figures suggest that there is high extent of variation in the responses in terms of which ICTs the respondents deem to be useful for climate e-governance. Nonetheless, the responses still provided, at the very least, a suggestive overview on which ICTs do Metro Manila LGUs mostly use for climate e-governance. It is also important to emphasize that the main hazard exposure of Metro Manila LGUs is flooding. As such, the ICTs that they use, and how they use them are more likely for reducing flooding impacts.

The findings suggests that the most diffused ICTs for local climate e-governance are social media, wireless broadband technologies, GIS and mobile technologies within local climate e-governance in Metro Manila. Quality of use for the ICTs are medium to high which means that some LGUs use these ICTs only for better performance of local climate action tasks while some relies on the ICTs to actually get the tasks done. Note that these are true for the three climate change application areas for ICTs identified by Karanasios (2011) namely monitoring of climate change and its impacts, disaster management and climate change adaptation. This validates the interrelatedness of the three areas as indicated by Karanasios' framework. Other ICTs used by many LGUs in Metro Manila include web-based applications such as NOAH and MSDI as well as mobile application such as Batingaw. Among the ICT types, wireless sensor networks were not used as much. This may be because, as the case study revealed, many sensor and other monitoring networks are usually operated at the national level.

The use of the aforementioned ICTs are in line with how Pants and Heeks' (2011) linked the use of ICTs for the development of adaptive capacity in line with climate action. They explained that the capacity to adapt to climate change involves the usage of relevant data, information and knowledge. As such, access to these data, information and knowledge, as well as the ability to assimilate, create and utilize them, helps build adaptive capacity of a system. All the ICTs identified to be highly diffused in terms of local climate e-governance among Metro Manila LGUs in this study are used primarily for this purpose. As per the case of Marikina, social media allows for collection of climate relevant data and information mainly through public grievances. As discussed in the previous chapter, these grievances could range from broken drainages, local policy violations, rescue needs, evacuation conditions, broken cctvs, and open manholes. Social media also allows for facilitation of data and information sharing among different institutions. For instance, national agencies such as DENR and PAGASA upload climate relevant information on their respective social media accounts that the LGUs could access. Other relevant data can also be collected, as discussed in the previous chapter, through mobile-based and web-based applications. All these are accessible online which is where wireless broadband technologies come in. GIS plays its role in terms of assimilation, creation and utilization of data and information. Collected climate related raw data from the ground are transformed into maps using GIS that are consequently used to aid local climate action planning.

Pants and Heeks (2011) also provided that ICTs could enable integration of local and external data and knowledge. Moreover, they said that adaptive capacities must be recognised both collectively and individually. In the context of local climate e-governance, these points look into the sharing dynamics with respect to data and knowledge between the LGUs and its stakeholders. In the case of Marikina, this was manifested through ICT's capacity to serve as communication channels. Social media, for instance, is used both to share and receive climate related data and information. Marikina also makes use of one-map, a web-based application that presents different thematic maps such as hazard and risk maps of Marikina, which is available for public viewing online. They also make use of mobile technologies (e,g, SMS and viber) and other web-based applications (e.g. email) to coordinate and share knowledge and information with other institutions such as other LGUs or national agencies. All these provide for the integration of local and external climate related knowledge and information that ultimately leads to the strengthening of both collective and individual capacities in Marikina.

5.2 Role of ICTs

Using Marikina's case, this study identified three processes that lead to the achievement of adaptation and risk management objectives where ICTs play major roles - facilitating execution of tasks, collection data/information and processing/analyzing data/information. ICTs faciliate execution of tasks mainly through internet connectivity and channels for two-way communication. Wireless broadband technologies provide for internet connectivity while radio, social media, and mobile technologies provide for the two-way communication channels. With respect to collection of data and information, monitoring stations such as for air quality and CCTVs, relevant online web-pages and social media are the most useful ICTs. Data and information collected are then analyzed and processed where GIS plays a major role and then eventually, the analyzed and processed data/information could help determine and execute courses of action.

The results of the process tracing analysis may be compared with Eakin et. al's (2014) analytical model of ICTs in adaptation which identifies fivc domains where ICTs could contribute to the formulation of adaptation strategies namely: 1) ICTs for informing decisions; 2) ICTs in coordination; 3) ICTs for building capacities ; 4) ICTs for evaluating outcomes and 5) ICTs in learning and feedback. In terms of informed decision-making, this is very evident through how climate related data and information are facilitated among the three identified processes which are eventually utilized for determining and executing courses of climate actions. For ICTs in Coordination, this is exemplified through how ICTs enable external communication under the process of facilitating execution of tasks. Through social media and mobile technologies, for instance, Marikina is able to communicate and coordinate with external entities such as the public and other insitutions in relation to climate action activities. Next, for building capacities, the use of GIS and other softwares such as one-map, compliance slip and DTS strengthens the overall insitutional capacity of Marikina LGU. This is also evident in all three identified processes from the process tracing analysis.

For the last two domains: ICTs for evaluating outcomes and ICTs in learning and feedback, the process tracing analysis did not specifically yield a process that involves the said domains. This suggests that ICTs are not yet maximized by Marikina with respect to evaluating outcomes and for learning/feedback schemes. However, in a way, the two domains could still fall under collecting data/information and processing and analyzing data/information. Air quality information from DENR, for instance, could reflect if local regulations and ordinances on air quality are being effective. Public grievances coursed through social media or mobile technologies can also provide information and insights on evaluating outcomes and on feedbacks about climate change related actions.

In terms of achievement of the adaptation and risk management objectives: 1) addressing the drivers of vulnerability; 2) building the response capacity of local and regional systems and communities; 3) reducing and managing risks related to climate variability and climate change; and 4) confronting climate change, the findings suggest that ICTs are not necessarily crucial. This may be because, as reflected in the process tracing analysis, ICTs do not play a major in the actual execution of climate action programs, projects and activities, at least with the present state of ICT diffusion. They, however, as per the survey results, make the acomplishment of these objectives more effective and efficient which, as the findings of the process tracing analysis suggests, may be due to the capacity of ICTs to help facilitate executions of tasks, collect data/information and process/analyze data/information.

The survey results also show that LGUs in Metro Manila feel that they are only barely addressing drivers of vulnerability, building local response capacity and reducing/managing risks through lifestyle and behavioural changes but in terms of confronting climate change, more of the respondents feel that they are effective and efficient. This self-rated low performance is also reflected in a report by the Adaptation Knowledge Platform (AKP, 2012) which provided that many LGUs in the Philippines do not actually have the technical capacity to undertake climate change adaptation interventions. More specifically, the report found that LGUs are weak in three areas: 1) assessing a situation and creating a vision and mandate; 2) formulating policy and strategy and 3) monitoring and evaluation. Furthermore, the report recommended that LGUs should have access to more data and information such as climate projections, multi-temporal and multi-spatial hazards, biophysical and social vulnerabilities and future climate impacts. Given its nature, ICTs could actually contribute significantly to the said issues and recommendations from the report. As such, what these suggest is that at present, the state of ICT diffusion in local climate e-governance among Metro Manila LGUs is still inadequate when it comes to performing climate change adaptation and risk management measures. This means that Metro Manila LGUs may need to adopt, use and maximize more types of ICTs on top of those that are already highly diffused for local climate e-governance namely, as this study found: social media, GIS, mobile technologies and wireless broadband technologies.

5.3 Issues/Barriers to ICT Adoption and Recommendations

The survey results show that technological factors hinder the adoption of ICTs the most with respect to local climate e-governance among Metro Manila LGUs, specifically the lack of ICT specialists and capacity of ICT personnel. Hence, what could be done is to either implement capacity-building activities related to ICT among LGUs or to come up with incentive schemes to attract good ICT professionals or both. The case of Marikina, however, revealed that issues concerning inter-institutional dynamics, budget constraints and legal restrictions may be the underlying barriers to ICT adoption including the lack of ICT specialists. On one hand, in terms of institutional dynamics, the more advanced ICTs such as AWS, ARG and air quality monitoring stations are operated by national agencies. Hence, Marikina do not reap the benefits of collecting and analyzing firsthand climate-related data as the LGU depends on the processed data or transmitted raw data from national agencies such as PAGASA and DENR. On other hand, budget constraints and legal restrictions are interrelated. In general, the budget for procuring ICTs that could aid in climate e-governance is not enough. This is affected by legal restrictions under available funding from the national government such as LDRRMF under RA 10121, as discussed in the previous chapter. As shown in the case study, for instance, the acquisition of wireless broadband technologies cannot be considered as a disaster management expenditure. The report of AKP (2012) also supports this finding. Aside from RA 10121, the report found that LGUs are having a hard time accessing funds for climate change adaptation at the national level under RA 7160 or the *"Local Government Code of 1991"* and RA 9729 or the *"Climate Change Act of 2009"*. Under these national laws, there are many funding opportunities for climate action for LGUs; however, as the report found, they are being underutilized. Other than having limited resources for ICT procurment, the budget constraints lead to other issues for ICT diffusion. The lack of ICT specialists, for example, could be due to low budget allocation for the salaries of ICT specialists in LGUs, as shared by one of the key informants for the Marikina case study. This serves as a disincentive for good ICT specialists to work for the LGUs when they can work elsewhere, such as in the private sector where compensation is much better. In the case of Marikina, budget constraints also lead to low level of infrastructure capacity to adopt ICTs. For instance, as one case study key informant shared, to upgrade Marikina's internet connectivity, they would need to install an antenna that costs beyond the LGU's financial capacity. Because of the substandard quality of internet service in Marikina, the members of LGU even have to resort to using their own personal mobile data which are not funded or reimbursed by the LGU.

Generally, the findings suggest that ICT-use is not yet integrated within the climate change action framework both at the national and local level. This is apparent in the varying levels of ICT-use among LGUs as well as in the Marikina case study where the adoption of ICTs seem to be merely based on convenience and preference of the LGU and its members. It is also evident in the high perception differences among the survey responses in terms of which ICTs are used for climate e-governance. One of the case study key informants even explicitly said that there are still no rules and regulations regarding ICT use for local climate action. ICTs are also not mentioned in the National Climate Change Action Plan (Climate Change Commission, n.d.) of the Philippines. This actually results to a gap between the capacity and the responsibility of LGUs with respect to climate e-governance. This is also supported by AKP (2012) where they found that LGUs lack the capacity to fulfill its mandate under RA 9729 which states that LGUs are supposed to be *the frontline agencies in the formulation, planning and implementation of climate change action plans in their respective areas…*" (LGA, 2014).

What the findings indicate is that the present institutional set-up restrict ICT diffusion for climate e-governance which could hamper the capacity of LGUs to serve as frontline agencies for climate action. As such, to really maximize ICT-use for local climate action, there is a need to integrate ICTs within the climate change action framework both at the national and local level. If the LGUs are actually able to operate their own monitoring stations, they will have faster access to relevant climate-related data and also, they will be able to get their hands on raw data that they could analyze and use for their own respective local needs. By integrating ICTs into the climate change action framework, the distribution of ICTs may be synchronized within the dynamics of the national and the LGUs in terms of climate action. Doing so could also result to integration of ICTs into other climate change related policies such as RA 10121. Such policies, especially those that have funding implicationsm should recognize ICTs as integral to climate action. This will allow LGUs to access more funds and resources, such as the 70% under the LDRRMF, to acquire ICTs that can be used for local climate e-governance.

The government should also invest more in improving infrastructures and facilities to support ICT diffusion in e-governance such as in terms of internet connectivity in the country. Many ICTs are enabled by internet connectivity. The poor quality of internet service in the Philippines further hampers ICT diffusion and level of e-governance in the country as provided by Siar (2005).

5.4 For Further Research

Given that the studies done on ICT-use for local climate e-governance has been limited, this study attempted to be descriptive and explanatory at the same time. As a result, while an overview of ICT diffusion was produced, there are many aspects that are left for further research. First of, there may be other ICTs not taken into consideration in this study. Moreover, the actual impact of each ICT-types could be further studied. This could reveal other applications of these ICTs that this study could have overlooked. The link of ICTs and achieving the adaptation and risk management objectives can also be studied in greater detail. More aspects can be looked into such as using different indicators per objective. The framework of Ospina and Heeks (2010b) can be used, for instance, for addressing drivers of vulnerability: socio-political, livelihoods and finance, health, habitat, food and water. For building response capacity of local systems, the resilience sub-properties that Ospina and Heeks (2010a) talked about can be used as indicators as well. The same research can also be in other areas in the Philippines for comparison. This could also reveal if there is digital divide among LGUs in different regions.

In terms of methodology, many aspects could be further improved as this study worked within a certain time frame and constraints. The survey, for example, is better administered if guided. Some concepts may have been broad or theoretical and thus, could have been misunderstood by the respondents. More secondary data from the LGUs would also lead to better validity of the findings. This will enable better triangulation of data and validate the survey responses. The use of inferential statistics to establish the link between ICTs and achievement of adaptation and risk management objectives may also be explored.

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ANNEX 1: Research Instruments

Survey
Greetings! I am Xavier Venn Asuncion, a student at the Institute for Housing and Urban Development Studies (IHS), Erasmus University Rotterdam under the Master in Urban Management and Development degree program. I am currently conducting my thesis which aims to determine the extent of ICT diffusion in local climate governance in Metro Manila.

In this connection, I would like to request a few minutes of your time to answer this survey which will only take approximately ten minutes. Rest assured that all information gathered from this survey will be exclusively used for this study and all personal details will be kept confidential. Should you have any questions regarding this survey, please don't hesitate to contact me through e-mail at mackyasuncion35@gmail.com or 488863xa@student.eur.nl.

Thank you.

Profile

Name:	**Designation** *(please spell out)*:
	Department *(please spell out)*:
City/Municipality:	**E-mail Address:**

Hazard Exposure

1) Which among the following climate change hazards is your city/municipality vulnerable to? *(you may choose more than one option)*

- ☐ Flood
- ☐ Storm Surges
- ☐ Drought
- ☐ Tropical Cyclone
- ☐ Tornado
- ☐ Heatwave
- ☐ Others

ICT Diffusion in Local Climate e-Governance

For this section, use the following criteria to answer questions on extent of use involving low, medium, high scale:

Low = task will be achieved effectively and efficiently even without the use of ICTs

***Medium* =** task will be achieved, but not effectively and efficiently, without the use of ICTs

High = task will be achieved only with the use of ICTs

Monitoring of Climate Change Impacts

2a) What are the types of ICTs your LGU uses for understanding local climate and anticipation of local impacts? *(you may choose more than one option)*

- ☐ Wireless Broadband Technologies (Wi-Fi, WiMax)
- ☐ Wireless Sensor Networks (intelligent sensor nodes for monitoring environmental cues such as temperature, light intensity, water levels, local meteorological data and pollutant level)
- ☐ Mobile Technologies
- ☐ Geographic Information System (GIS)
- ☐ Social Media
- ☐ Other Web-based Applications such as ____
- ☐ Other Early Warning System Technologies such as _______________________________
- ☐ Others
- ☐ None

2b) For your LGU, how crucial is the use of ICTs in understanding local climate and anticipation of local impacts? If your LGU does not use any ICTs in this regard, provide a hypothetical answer.

- Low
- Medium
- High

Disaster Management

2c) What are the types of ICTs your LGU uses for timely and effective disaster management and response? *(you may choose more than one option)*

- Wireless Broadband Technologies (Wi-Fi, WiMax)
- Wireless Sensor Networks (intelligent sensor nodes for monitoring environmental cues such as temperature, light intensity, water levels, local meteorological data and pollutant level)
- Mobile Technologies
- GIS
- Social Media
- Other Web-based Applications such as ____
- Other Early Warning System Technologies such as ________________________________
- Others
- None

2d) For your LGU, how crucial is the use of ICTs for timely and effective disaster management and response? If your LGU does not use any ICTs in this regard, provide a hypothetical answer?

- Low
- Medium
- High

Climate Change Adaptation

2e) What are the types of ICTs your LGU uses for enhancing the capacity of your locality to cope with current and future climate stresses? *(you may choose more than one option)*

- Wireless Broadband Technologies (Wi-Fi, WiMax)
- Wireless Sensor Networks (intelligent sensor nodes for monitoring environmental cues such as temperature, light intensity, water levels, local meteorological data and pollutant level)
- Mobile Technologies
- GIS
- Social Media
- Other Web-based Applications such as ____
- Other Early Warning System Technologies such as ________________________________
- Others
- None

2f) For your LGU, how crucial is the use of ICTs for enhancing the capacity of your locality to cope with current and future climate stresses? If your LGU does not use any ICTs in this regard, provide a hypothetical answer?

- Low
- Medium
- High

Achievement of Climate Change Adaptation and Risk Management Objectives

For this section, use the following criteria to answer questions on performance involving low, medium, high scale:

Low = objective is not being achieved

Medium = objective is being barely achieved

High = objective is being achieved effectively and efficiently

Rate your performance on the following tasks:

3a) Addressing the drivers of vulnerability or the underlying factors that make people and communities vulnerable to the impacts of climate change - not concerned with those impacts themselves (e.g. Micro-credit schemes; immunization programmes).

- ☐ Low
- ☐ Medium
- ☐ High

3b) Building the response capacity of local and regional systems and communities by helping communities acquire the resources they need to respond to the impacts of climate change (e.g. Improving information and communications infrastructure; training in GIS technology).

- ☐ Low
- ☐ Medium
- ☐ High

3c) Reducing and managing risks related to climate variability and climate change by providing information and facilities to help communities change lifestyle and economic behaviours in ways that make them more sustainable in new climate conditions (e.g. Introduction of drought-resistant crops; emergency response systems).

- ☐ Low
- ☐ Medium
- ☐ High

3d) Confronting Climate Change by addressing the physical impacts of climate change such as rising sea levels and the spread of malarial mosquitoes into newly favourable regions (e.g. reducing potential for glacial lake outburst flood; building sea walls).

- ☐ Low
- ☐ Medium
- ☐ High

For this section, use the following criteria to answer questions on ICT impact involving low, medium, high scale:

Low = objective can be achieved effectively and efficiently even without the use of ICTs

Medium = objective can be achieved, but not effectively and efficiently, without the use of ICTs

High = objective can be achieved only with the use of ICTs

How much do you think the use of ICTs help you achieve the following tasks:

3e) Addressing the drivers of vulnerability or the underlying factors that make people and communities vulnerable to the impacts of climate change - not concerned with those impacts themselves (e.g. Micro-credit schemes; immunization programmes).

- ☐ Low
- ☐ Medium
- ☐ High

3f) Building the response capacity of local and regional systems and communities by helping communities acquire the resources they need to respond to the impacts of climate change (e.g. Improving information and communications infrastructure; training in GIS technology).

- ☐ Low
- ☐ Medium
- ☐ High

3g) Reducing and managing risks related to climate variability and climate change by providing information and facilities to help communities change lifestyle and economic behaviours in ways that make them more sustainable in new climate conditions (e.g. Introduction of drought-resistant crops; emergency response systems).

- ☐ Low
- ☐ Medium
- ☐ High

3h) Confronting Climate Change by addressing the physical impacts of climate change such as rising sea levels and the spread of malarial mosquitoes into newly favourable regions (e.g. reducing potential for glacial lake outburst flood; building sea walls).

- ☐ Low
- ☐ Medium
- ☐ High

Barriers to ICT Adoption

For this section, use the following criteria to answer questions on extent of hindrance involving low, medium, high scale:

Low = negatively affects ICT adoption but not a major reason for prevention

Medium = prevents adoption of few ICTs

High = prevents adoption of many ICTs

4a) Which of the factors prevent your LGU from adopting ICTs *(you may choose more than one option)* and how much do these factors affect ICT adoption (choose within the low, medium, high scale)?

- ☐ Inter-institutional dynamics: Inter-institutional networks or the lack thereof do/does not encourage ICT adoption.

  How much does it affect ICT adoption? __ Low __ Medium __ High

- ☐ Legal factors: Strict legal requirements

  How much does it affect ICT adoption? __ Low __ Medium __ High

- ☐ Political factors : Political attitude of relevant actors against innovations

  How much does it affect ICT adoption? __ Low __ Medium __ High

- ☐ Economic factors: Budget constraints

  How much does it affect ICT adoption? __ Low __ Medium __ High

- ☐ Social factors: No public pressure to drive ICT adoption

  How much does it affect ICT adoption? __ Low __ Medium __ High

- ☐ Demographic factors: Small demographic context does not encourage innovation

  How much does it affect ICT adoption? __ Low __ Medium __ High

- ☐ Technological factors: Lack of infrastructures to support ICT; Low public ICT readiness; Threats to information security; Technological complexity

  How much does it affect ICT adoption? __ Low __ Medium __ High

- ☐ Organizational factors: Bureaucracy and organizational structures/arrangements prevent innovation

  How much does it affect ICT adoption? __ Low __ Medium __ High

Individual factors: Lack of ICT readiness among individuals in the system How much does it affect ICT adoption? __ Low __ Medium __ High
5) What are your recommendations to strengthen ICT use for local climate governance in your LGU?
6) Do you have any comments, or suggestions regarding this survey or study?

Link for the online version: http://bit.do/ICTDiffusionSurvey

Main Questionnaire for Case Study Interview

Profile	
Name:	**Designation:**
City/Municipality:	**E-mail Address:**
Vulnerability Profile	
1) What are the types of climate change related hazards and risks that your locality face?	
ICT Diffusion in Local Climate Governance	
Monitoring of Climate Change Impacts 2) What types of ICTs do you use for understanding local climate and anticipation of local impacts? How exactly are they used? Do you think the use of ICTs is crucial to do this task? Why? *Disaster Management* 3) What types of ICTs do you use for timely and effective disaster management and response? How exactly are they used? Do you think the use of ICTs is crucial to do this task? Why? *Climate Change Adaptation* 4) What types of ICTs do you use for enhancing the capacity of your locality to cope with current and future climate stresses? How exactly are they used? Do you think the use of ICTs is crucial to do this task? Why?	
Achievement of Climate Change Adaptation and Risk Management Objectives	
5) How do you address drivers of vulnerability or the underlying factors that make people and communities vulnerable to the impacts of climate change within your locality? Do you think the use of ICTs is crucial to do this task? Why?	

6) How do you build the response capacity of local and regional systems and communities? How do you help communities acquire the resources they need to respond to the impacts of climate change? Do you think the use of ICTs is crucial to do this task? Why? 7) How do you reduce and manage risks related to climate variability and climate change? How do you provide information and facilities to help communities change lifestyle and economic behaviours in ways that make them more sustainable in new climate conditions? Do you think the use of ICTs is crucial to do this task? Why? 8) How do you confront climate change? How do you address the physical impacts of climate change? Do you think the use of ICTs is crucial to do this task? Why?
Barriers to ICT Adoption
9) What factors affect ICT adoption in your LGU? How exactly do these factors affect ICT adoption? 10) What are your recommendations to strengthen ICT use for local climate governance in your LGU?

ANNEX 2: Case Study Interviewees

Interviewee	Department	Designation
Nelisa Palomar	Marikina City Planning and Development Office	Housing and Homesite Regulation V
Richard Adriano	Management Information Systems and Call Center	Computer Operator III
Liza Cruz	Marikina City Engineering Office	IT in-charge
Oliver Villamena	City Environment Management Office	Administrative Officer IV
Jackie Lou Espinosa	Disaster Risk Reduction and Management Office	ICT support
Citas Vida May DeVera	Disaster Risk Reduction and Management Office	Research and planning supervisor in charge

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