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Planning for Climate Resilient *Barangays* in the Philippines: The Case of *Barangay* Tumana in Marikina City, Metro Manila

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Abstract

The Philippines is among the countries most threatened by climate change. This combined with other human and developmental factors compounds the challenge that *barangays*, the smallest political and administrative units in the country, face: to build and scale-up local resilience. This paper presents the case of *Barangay* Tumana in Marikina City, Philippines, the second most populated *barangay* in the city and the most devastated when Typhoon *Ondoy* (international name: Ketsana) hit the country in 2009.

The study examines key hazards and elements of the communities in *Barangay* Tumana that contribute to its susceptibility to climate-related impacts, using the definition of the United Nations Framework Convention on Climate Change (UNFCCC) to frame the process of analysis. In particular, it characterizes the biophysical/environmental risks and socioeconomic/demographic vulnerabilities of the communities (exposure and sensitivity elements) in *Barangay* Tumana that can be addressed through planning in order to further community resilience and enhance long-term quality of life (Ensor, and Berger, 2009). These risks and vulnerabilities are established through various quantitative and qualitative methods of data gathering and analysis, including questionnaire surveys, key informant interviews, Geographic Information System (GIS) analysis, reviews of key local documents and related literature, and a multi-stakeholder validation and consultation. Policy options to build *barangay* resilience in the context of climate change are then recommended.

1. Introduction

The Philippines is one of the countries most at risk from the impacts of climate change. It ranks fifth on the Global Climate Risk Index 2017 in terms of extreme weather events (Kreft, Eckstein, and Melchior, 2016). This exacerbates the developmental challenges faced by the nation and thus necessitates sound and urgent measures to build and maximize local resilience.

Marikina City has long been plagued by numerous environmental hazards, especially flooding. The swelling of the Marikina River is an old problem: incidents of large-scale flooding have been documented as far back as 1937, when Marikina was still a largely agricultural town. A huge flood in 1988 saw the Marikina River rise to 19 meters. From the early 90s to the first decade of 2000, the city faced intermittent flooding with floods reaching as high as 18 meters.

Tropical Storm Ketsana (locally known as *Ondoy*) brought about flashfloods that inundated 80% of metropolitan Manila on September 26, 2009. The waters of the Marikina River reached a record high of 22.8 meters and severely affected Marikina City. Tropical Storm Meari (locally named *Falcon*) brought heavy rains to the country in June 2011, and the Marikina River again reached a critical level. In November of the same year, Typhoon Nesat (locally named *Pedring)* dumped heavy rains comparable to Typhoon *Ondoy*. Water levels reached as high as 20.1 meters, submerging several *barangays* in the process. In August 2012, the monsoon rains or *habagat* caused the river to swell to 20.6 meters, just a few meters below the record level set by Typhoon *Ondoy*. The rains affected the rest of metropolitan Manila, with some areas submerged in flood waters up to 3 meters high.

The destruction caused by these flood incidents was driven by topographic and anthropogenic factors, and resulted in the displacement of hundreds of households, particularly in the informal settlement areas by the riverbanks in Marikina (Delos Reyes, and Espina, 2016). These informal settlements are "residential areas where 1) inhabitants have no security of tenure vis-à-vis the land or dwellings they inhabit, with modalities ranging from squatting to informal rental housing, 2) the neighbourhoods usually lack, or are cut off from, basic services and city infrastructure and 3) the housing may not comply with current planning and building regulations, and is often situated in geographically and environmentally hazardous areas" (UN-Habitat, 2015).

Extreme weather events in the region are projected to increase in the coming years (PAGASA, 2011) and, if left unaddressed, will lead to greater impacts. Cities, especially those that have been repeatedly affected by typhoons and monsoon rains, are thus encouraged to conduct socioeconomic profiling of disaster risk areas to determine their level of exposure and to inform planning and disaster response operations (ADB, 2013).

The paper is a case study of the *Barangay* Tumana. This is the second most populated *barangay* in Marikina City, with 41,809 residents as of 2010 (PSA 2016), and the most severely affected by the onslaught of Typhoon *Ondoy* and the recent monsoon rains.

2. Study Context

2.1. Research Questions

The project aims to answer the main research question: *What are the exposure and sensitivity factors of the communities in Barangay Tumana that contribute to its vulnerability to climate-related hazards?* In particular, the study seeks to determine the biophysical/environmental risks and socioeconomic/demographic vulnerabilities of the geographic site and its communities, and how these can be addressed through *barangay* planning in order to improve resilience.

2.2. Objectives

To answer the questions above, the research intends to accomplish the following objectives:

a. To determine climate-related exposure and risks faced by *Barangay* Tumana;
b. To characterize and analyze *Barangay* Tumana's *sensitivity* to climate-related risks, particularly its socioeconomic and demographic profile; and
c. To formulate policy and strategy options to improve *barangay* resilience.

2.3. Research Methodology

The study uses various methods of data gathering and analysis. Among them are the following:

a. *Administration of Survey.* A survey was conducted from November to December 2013 in the *barangay* with 384 households. The sample size was determined through stratified random sampling, applying Slovin's Formula[1] to the total number of households;
b. *Geographic Information System (GIS) Processing and Analysis.* GIS was used to process primary and secondary data. Results are presented graphically as maps;
c. *Interviews.* Interviews and consultation meetings were likewise conducted for assessment and triangulation of data.

2.4. Scope of the Research

a. *Spatial Coverage:* Analysis of the socioeconomic profile and exposure data of Marikina City is focused on Tumana, a *barangay* with high flood risk.
b. *Time Frame:* The study examines the events that happened during Typhoon *Ondoy* in September 2009, Typhoon *Falcon* in June 2011, and the Monsoon Rains/ *Habagat* in August 2012. Environmental/biophysical and climate-

[1] Slovin's formula is used to calculate the sample size (n) given the population size (N) and a margin of error (e). It is computed as $n = N / (1 + Ne^2)$ (Ariola, 2016)

related exposures are analyzed and projected for the medium term (year 2020) and for the long term (year 2050). The survey focusing on the socioeconomic condition of the population was conducted from November to December 2013.

c. *Target Population:* The study focuses on the population affected by flooding during Typhoon *Ondoy* in 2009 and *Habagat* in August 2012. The unit of analysis is a household.

d. *Planning and Policy Focus:* The study focuses on the assessment of exposure and sensitivity of the site to inform planning and policy options for the following areas:

- *Database formulation and local government decision making*.

Knowledge of the exposed elements and their sensitivity is a basic requirement for disaster and resilience-related decisions. Knowing the what, who, where, and why's of the *barangay's* vulnerability shall influence the soundness of the decisions of the local government. The study exposes the significance of this database and conducts preliminary stocktaking that can guide immediate decisions. It can also serve as a template for future assessments and strategies, and as a model for other sites.

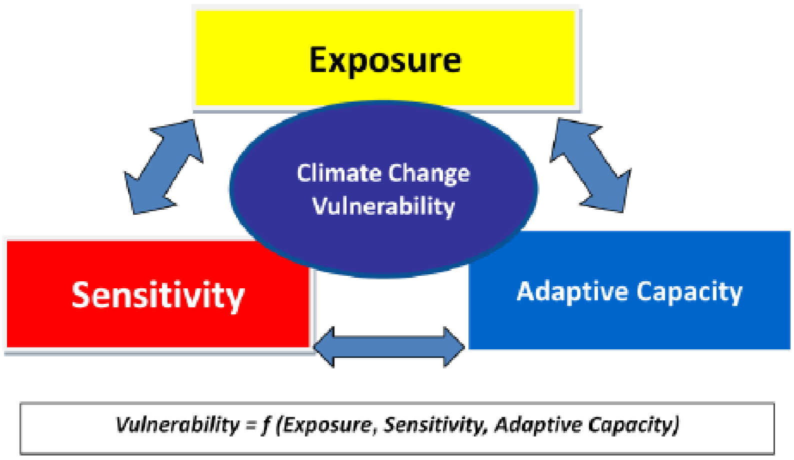
- *Development planning and barangay resilience*.

Vulnerability information (e.g. high-risk areas, area with the most number of residents exposed, households most sensitive to impacts) reveals the areas or sectors where resources are most necessary. This is crucial for the identification of plans, programs and projects that need to be prioritized by the *barangay* in order to foster development and simultaneously increase its resilience to disasters. The study includes this information and derives recommendations that are deemed useful for the formulation of development plans (e.g. physical, economic and social plans and programs) of the *barangay*, and for city planning (e.g. land use plans and development plans).

3. Framework of Analysis

The definition of the United Nations Framework Convention on Climate Change (UNFCCC) on climate change vulnerability (**Figure 3.1.**) is used to frame the analysis. The *exposure*, *sensitivity and adaptive capacity level* of the households in Tumana, Marikina are assessed in this study. These are determined using existing government data, available research, personal accounts, and other official studies on relevant indicators and factors.

Figure 3.1. Vulnerability Framework by the United Nations Framework Convention on Climate Change (IPCC 2014)



- *Exposure* is what is at risk from climate change (e.g. population, resources, property), the change in climate itself, and its implications (e.g. sea level rise, temperature, precipitation, extreme events, etc.).
- *Sensitivity* is the degree to which a system is affected by the biophysical impact of climate change. It also considers the socioeconomic context
- *Adaptive capacity* is the ability of a system to adjust to climate change (including climate variability and extremes) and limit potential damage, to take advantage of opportunities, or to cope with the consequences.

The general analysis of the *exposure* criterion consists of examining what is at risk in the locality and identifying climate-induced hazards and stresses. *Sensitivity* analysis is done by examining and characterizing the socioeconomic profile of the community affected by climate change impacts. *Adaptive capacity* is also determined by examining the socioeconomic conditions, as well as institutional capacity, availability of resources, and disaster-preparedness among others.

Figure 3.2. Analytical Framework of the Study

Analysis of Exposure and Characterization of Socio-Economic Profile	
Exposure	**(Socio-Economic Profile) Sensitivity**
Exposed Units: Spatial and Geographic Context Climate Change-Related Drivers of Impact	Socio-Economic Conditions

4. **Results and Discussion**

The following results are presented according to the UNFCCC Framework. The first part highlights the exposure information, while the second part examines the socioeconomic, or *sensitivity*, aspect of *Barangay* Tumana.

4.1. Exposure Information

4.1.1. Spatial and Geographic Context: What is at Risk?

Tumana is one of the 16 *barangays* that constitute Marikina City. It is part of the Second District of Marikina and is situated in the northwest portion of the city. It is bounded by *Barangay* Nangka on the northeastern side, by *Barangay* Concepcion Uno on the eastern side, and *Barangay* Malanday in the south. Tumana has a land area of approximately 181.97 hectares (Marikina City 2010b) and a total population of 41,809 as of 2010 (PSA 2016). The *barangay* has been identified as one of the low-lying *barangays* with flood risk.

Spatial data was processed through Geographic Information System (GIS) and confirmed through consultations. These analyses are presented below.

Figure 4.1.1.1. Marikina City *Barangay* Map

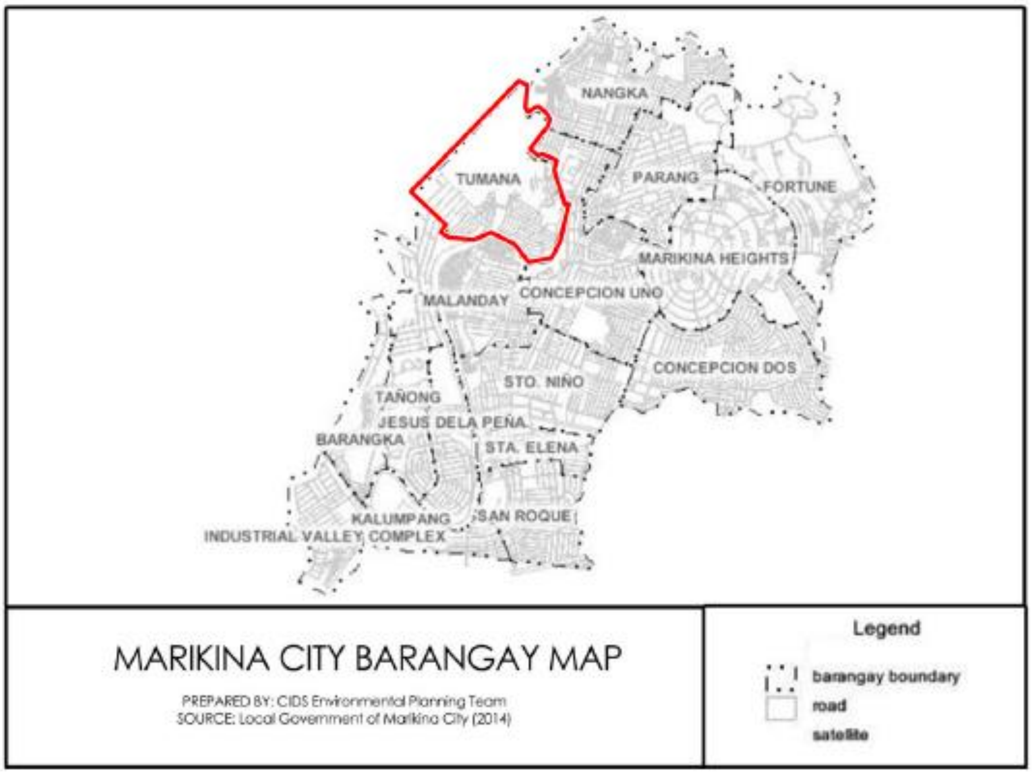


Figure 4.1.1.2. Tumana *Barangay* Boundary Map

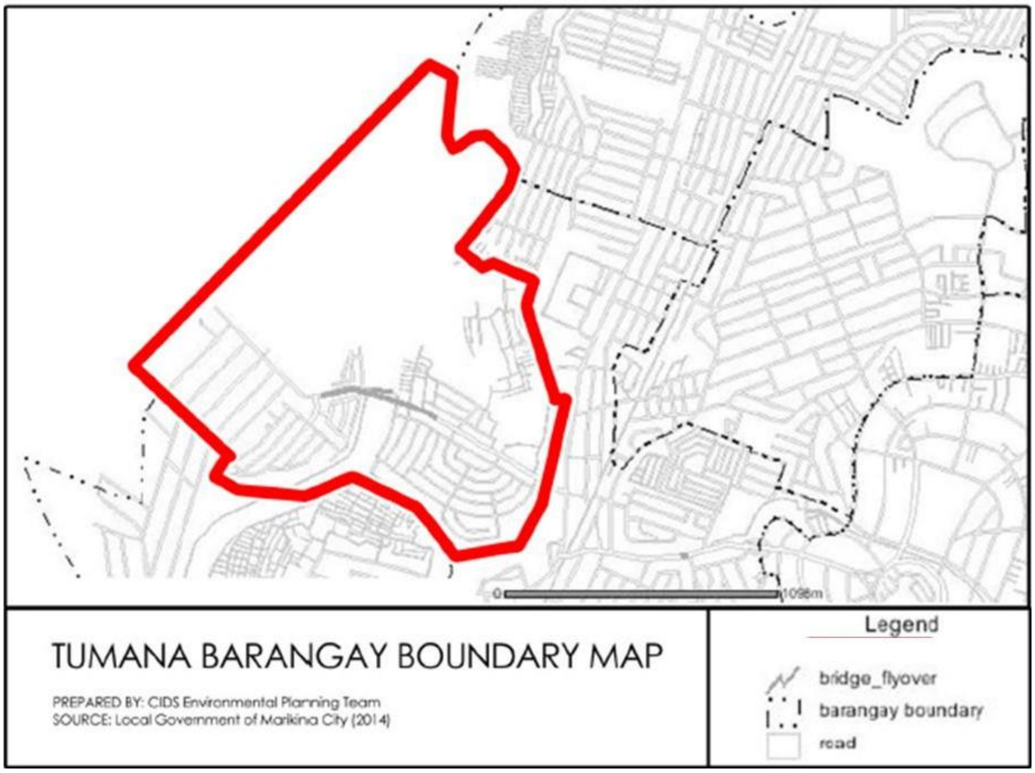


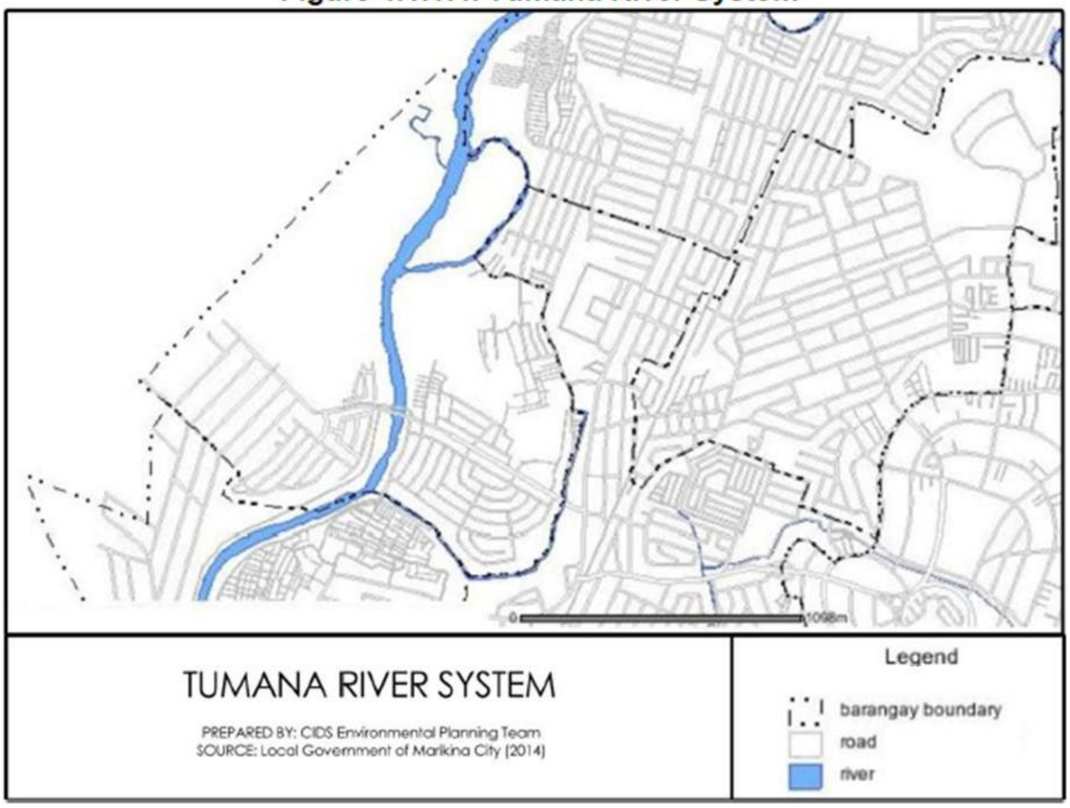
Figure 4.1.1.3. Satellite Map of *Barangay* Tumana

The lowest areas of the *barangay*, and therefore the first areas to be flooded at 16 meters above sea level, are those by the creek side of Angel Santos and Amplaya, the portion of Palay Street near the creek, the streets of Pipino, Singkamas, Mais (at Tumana Proper), Iwahig and Ilaw (at Doña Petra).

Higher ground is found along the streets of Upo, Okra, Patola, and portions of Palay and Farmers II in the central part of Tumana Proper. Certain portions of Doña Petra are the same level as the Central Level of Tumana Proper.

Adding to Tumana's susceptibility to flooding is the river system traversing the *barangay* as shown in **Figure 4.1.1.4**.

Figure 4.1.1.4. Tumana River System



The eastern side of the *barangay* is subjected to intermittent flooding brought about by the overflowing of the Marikina during the rainy season, as illustrated in **Figure 4.1.1.5**. This is particularly noteworthy – this area is home to clusters of families in approximately 8,000 households (Marikina City 2010a), who live in shanties on the outskirts of the river and its surrounding *esteros*.

During the 2013 monsoons, data from the local government show that the eastern *barangay* was subjected to greater than 2 meters of flood inundation **(Figure 4.1.1.6)**.

Figure 4.1.1.5. Frequently Flooded Areas in Tumana due to Overflowing of Marikina River

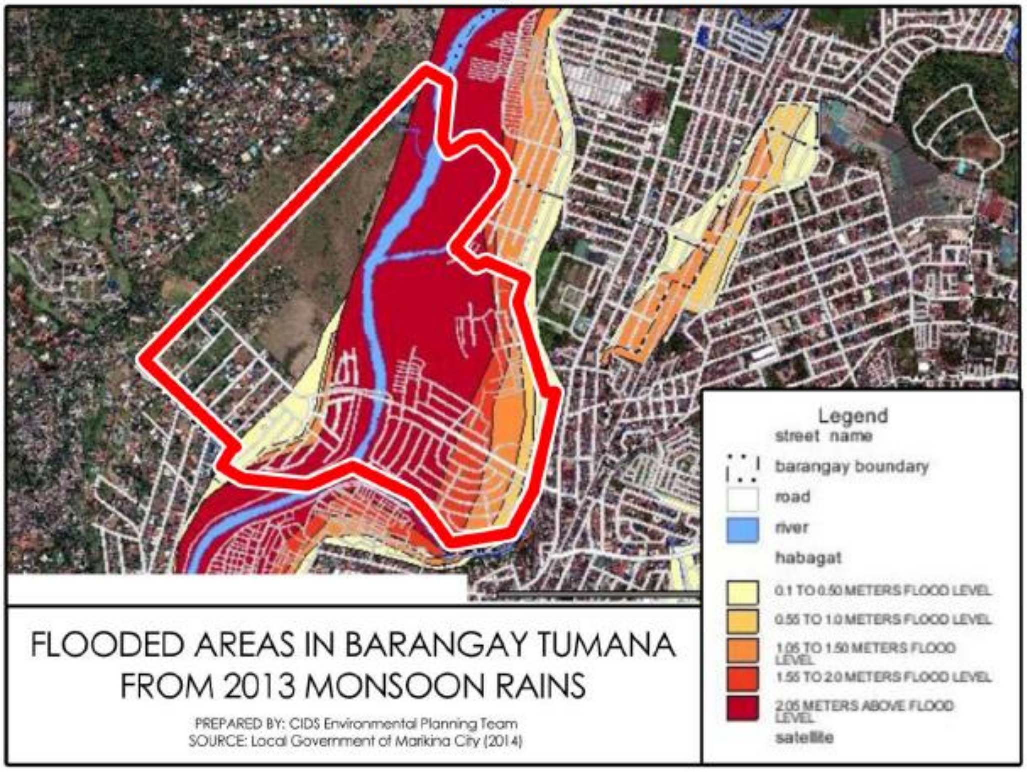
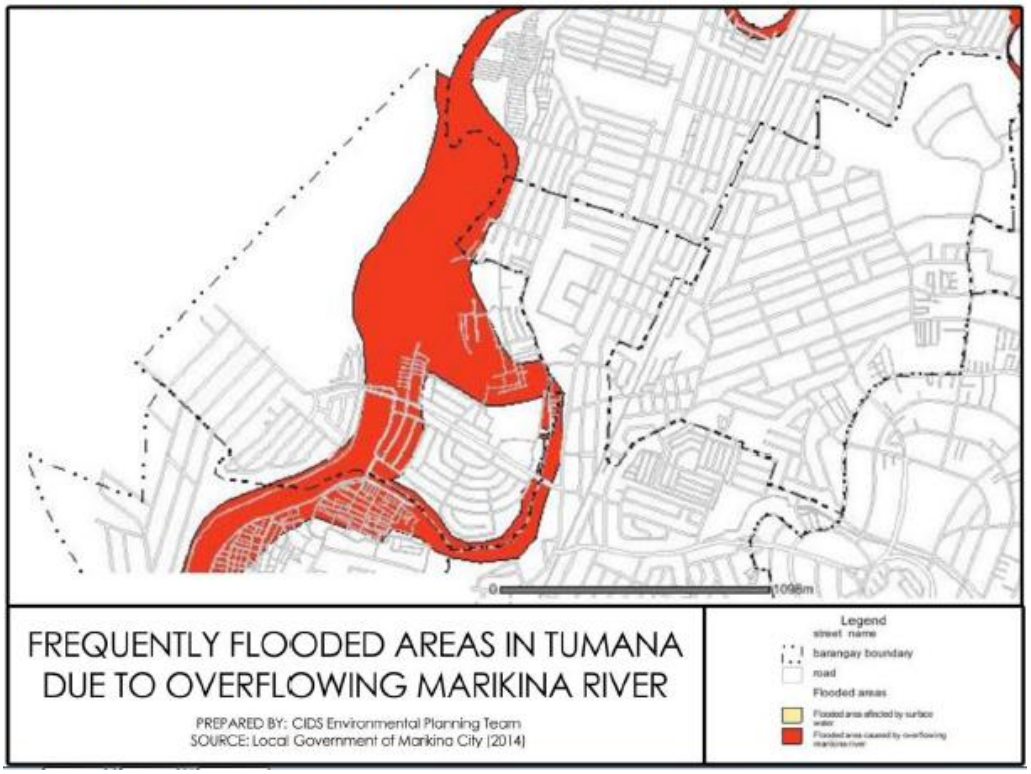
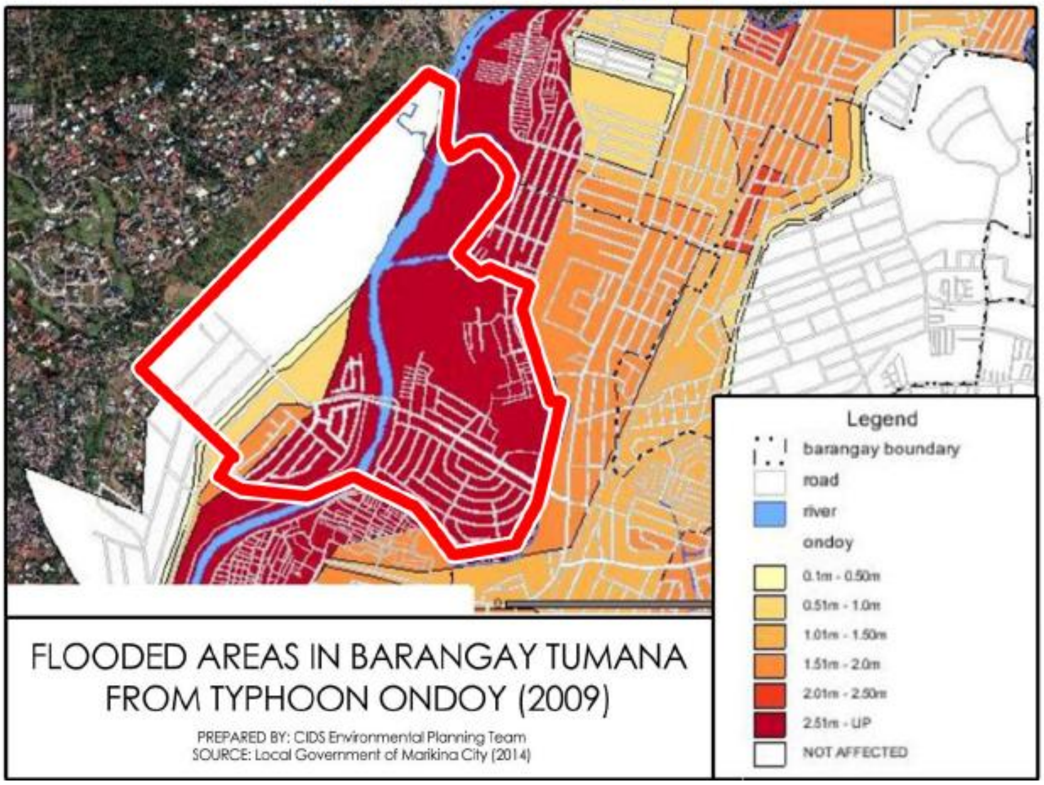


Figure 4.1.1.6. Flooded Areas in *Barangay* Tumana from 2013 Monsoon Rains



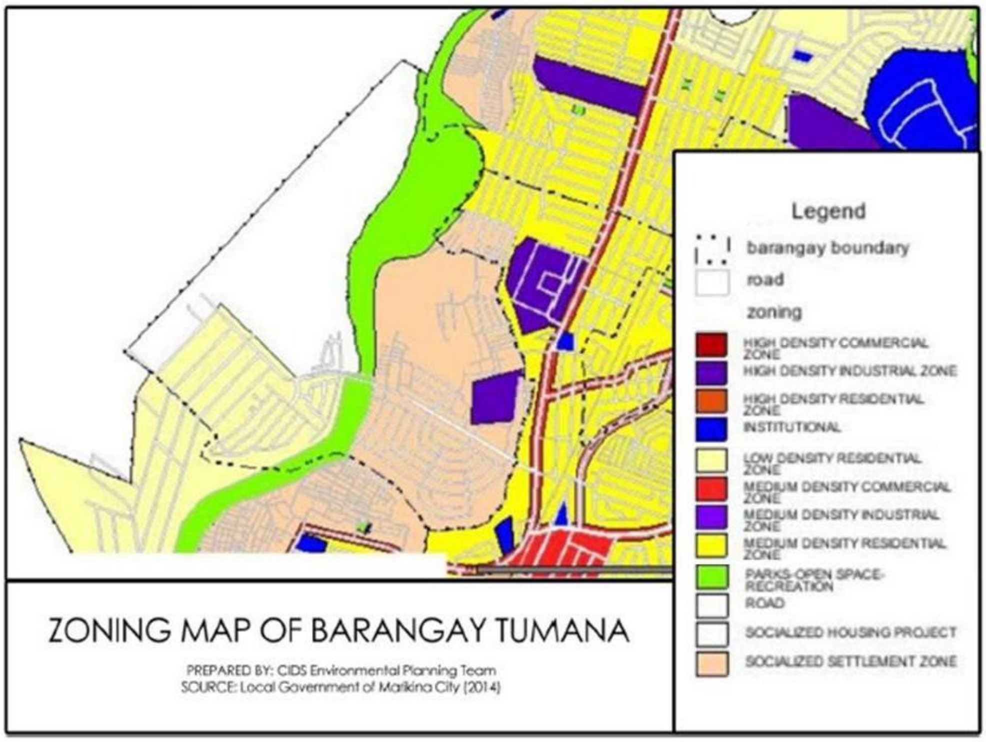
During the onslaught of Typhoon *Ondoy* in 2009*,* the whole area on the eastern portion of the Marikina River was inundated by floodwater of more than 2.5 meters.

Figure 4.1.1.7. Flooded Areas in *Barangay* Tumana from 2009 Typhoon Ketsana/ *Ondoy*



According to the zoning map of Marikina City (**Figure 4.1.1.8**), *Barangay* Tumana is assigned five main land uses. The land uses affected by intermittent flooding are the designated Socialized Settlement Zone, Low Density Residential Zone, High Density Industrial Zone, and Parks/Open Space/ Recreation Zone. The residents in these zones, except those in the upscale Loyola Grand Villas in the western part of the *barangay*, are considered informal settlers.

Figure 4.1.1.8. Zoning Map of *Barangay* Tumana



4.1.2. Climate Change Projections

Data from the Philippine Atmospheric Geophysical and Astronomical Services Administration (PAGASA) under the Department of Science and Technology (DOST) reveal the medium- and long-term climate projections for Tumana, Marikina, which will greatly affect the population and units operating within the *barangay*. The projected climate change scenarios in *average emission scenarios* are shown as bases for the indicative macro-level climate assessment. These scenarios are then used to deduce changes in climate parameters: precipitation, temperature, and extreme events.

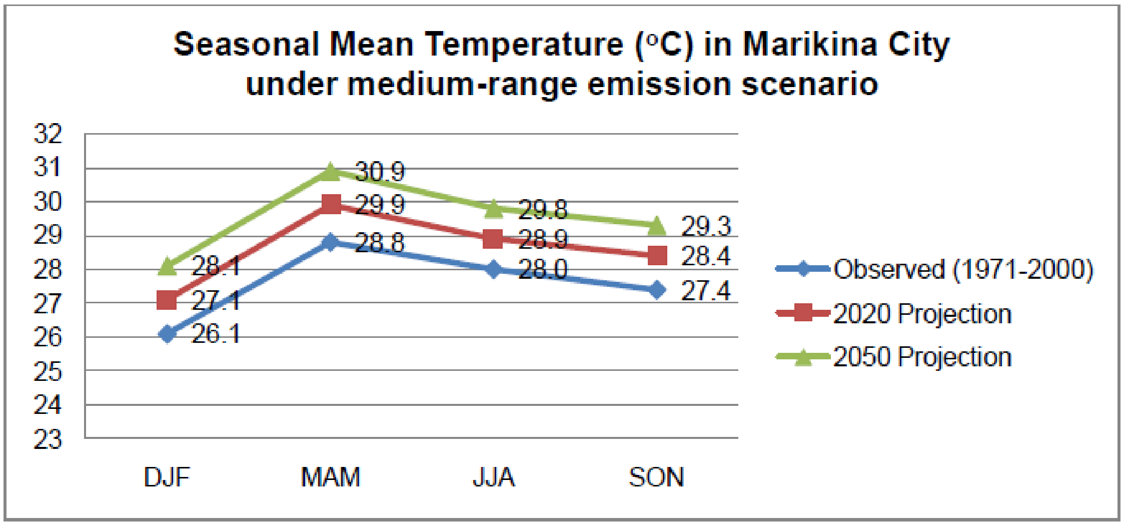
a. Projected Changes in Average Temperature in Marikina City

The projections made by PAGASA illustrate significant warming in the Philippines by the middle of the century. Average annual mean temperature is projected to increase by 0.9°C-1.1°C by 2020 and by 1.7°C-3.0°C by 2050. Higher temperatures are generally expected in all regions of the country by 2050, with the rates doubling from 2020 levels. Adopting these projections, the estimated changes in Seasonal Mean Temperature in Marikina City in 2020 and 2050 under the medium-range emission scenario are shown in **Figures 4.1.2.1** and **4.1.2.2**.

Figure 4.1.2.1. Projected Changes in Seasonal Mean Temperature in Marikina City in 2020 and 2050

SEASON	OBSERVED (°C)	PROJECTED CHANGE (°C)		PROJECTED MEAN TEMPERATURE (°C)	
	(1971-2000)	(2006-2035)	(2036-2065)	(2006-2035)	(2036-2065)
Dec-Jan-Feb (DJF)	26.1	1.0	2.0	27.1	28.1
Mar-Apr-May (MAM)	28.8	1.1	2.1	29.9	30.9
Jun-Jul-Aug (JJA)	28.0	0.9	1.8	28.9	29.8
Sep-Oct-Nov (SON)	27.4	1.0	1.9	28.4	29.3

Figure 4.1.2.2. Graphical Representation of the Projected Changes in Average Temperature (in °C) in Marikina City



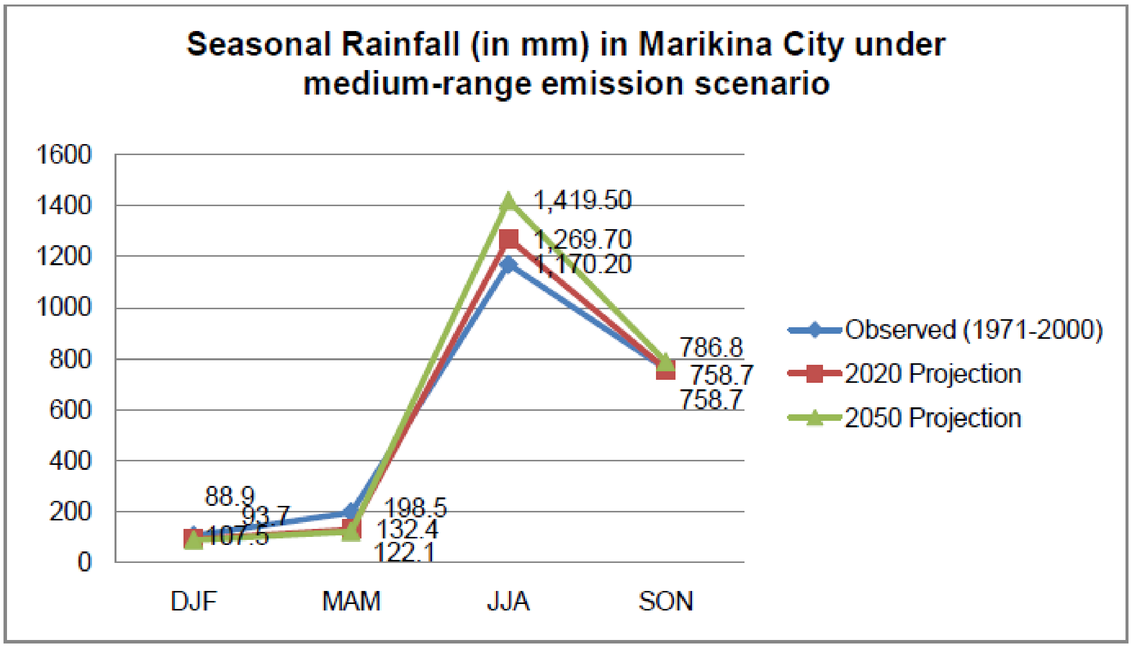
b. Projected Changes in Seasonal Rainfall in Marikina City

PAGASA projects a change in annual precipitation of -0.5% to 17.4% in 2020 and -2.4% to 16.4% in 2050. Increases in rainfall are particularly evident in most areas of Luzon and Visayas, while Mindanao is projected to undergo a drying trend. Average annual rainfall increases over most parts of Luzon. Change in the Visayas is estimated at 2% to 17% by 2020 and 1% to 16% by 2050. Projected changes in seasonal rainfall in Marikina in 2020 and 2050 under the medium-range emission scenario are presented in **Figures 4.1.2.3** and **4.1.2.4**.

Figure 4.1.2.3. Projected Changes in Seasonal Rainfall in Marikina City in 2020 and 2050

SEASON	OBSERVED (mm)	PROJECTED CHANGE (%)		PROJECTED RAINFALL AMOUNT (mm)	
	(1971-2000)	(2006-2035)	(2036-2065)	(2006-2035)	(2036-2065)
Dec-Jan-Feb (DJF)	107.5	-12.8	-17.3	93.7	88.9
Mar-Apr-May (MAM)	198.5	-33.3	-38.5	132.4	122.1
Jun-Jul-Aug (JJA)	1,170.2	8.5	21.3	1,269.7	1,419.5
Sep-Oct-Nov (SON)	758.7	0	3.7	758.7	786.8

Figure 4.1.2.4. Graphical Representation of the Projected Changes in Seasonal Rainfall in Marikina City



c. Projections on Extreme Climate Events in Marikina City

Hot days are expected to increase by 81% and 185% from observed conditions by 2020 and 2050, respectively, while dry days are seen to decline by 16-17% in those years. Days with precipitation are also projected to increase by 44% in 2020 and by 89% in 2050.

Figure 4.1.2.5. Climate Projections on Extreme Climate Events in Marikina City

No. of Days w/ Tmax > 35°C			No. of Dry Days			No. of Days w/ Rainfall >200mm		
OBS (1971-2000)	2006-2035	2036-2065	OBS (1971-2000)	2006-2035	2036-2065	OBS (1971-2000)	2006-2035	2036-2065
1,095	1,984	3,126	7,476	6,302	6,220	9	13	17

d. Summary and Implications of Climate Projections in Marikina City

Figure 4.1.2.6. Summary of Climate Projections in Marikina City

Changes in Means and Extreme Events	Projected Increase(+)/ Decrease(-) by 2020
Average Temperature	+1.0 °C DJF +1.1 °C MAM +0.9 °C JJA +1.0 °C SON
Average Rainfall	-12.8% DJF -33.3% MAM +8.5% JJA -0.0% SON
No. of days with rainfall > 200mm	+ 4 days (44.4%)
No. of days w/ Tmax > 35°C	+ 889 days (81.2%)

Marikina City is expected to have a 1°C incremental change in temperature by 2020. This implies that upcoming storms will be more intense, with longer dry spells between them. Precipitation will become more sporadic. Increasing temperatures, changing rainfall patterns, sea level rise, and extreme weather events form the backdrop upon which the Philippines, particularly Tumana in Marikina City, endeavors to pursue its development goals. Such factors affect key geographic and spatial contexts where at-risk population and systems operate. The ability of a unit to address such impacts affects the facility by which sustainable development and resiliency are pursued.

4.2. Sensitivity Information

4.2.1. Socioeconomic Profile of the Informal Settler Families in Tumana, Marikina

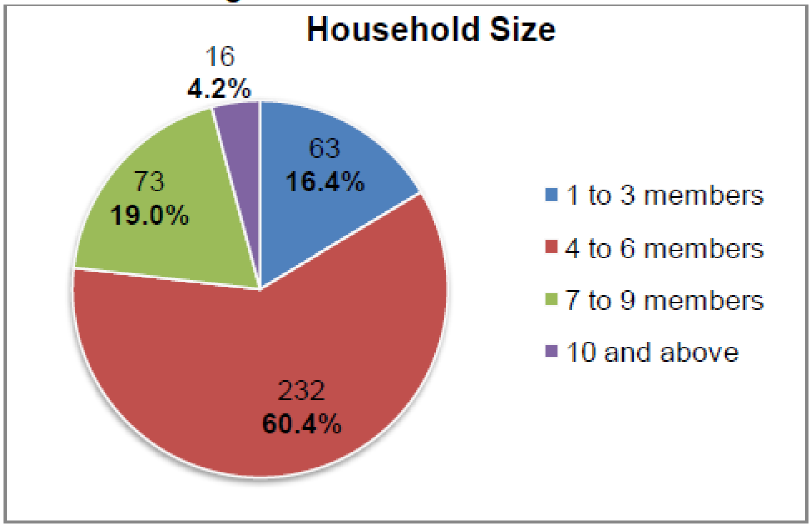
The following data on the Socioeconomic Profile of Informal Settler Families in *Barangay* Tumana was generated from a survey conducted in 384 households from November to December in 2013. They form part of the *sensitivity* data and some *adaptive capacity* data for analysis.

a. Household Size

The household sizes were stratified into the following number of people per household: 1 to 3; 4 to 6; 7 to 9; and 10 and above.

The majority (60.4%) of the households reported having four to six members, and only 4.2% have ten or more members. The average number of people per household is five.

Figure 4.2.1.1. Household Size



b. Sex Distribution

Of about 2,045 surveyed household members, the gender distribution is nearly equal, with the males numbering 1,036 (50.7%), and the females 1,009 (49.7%).

Table 4.2.1.1. Sex Distribution

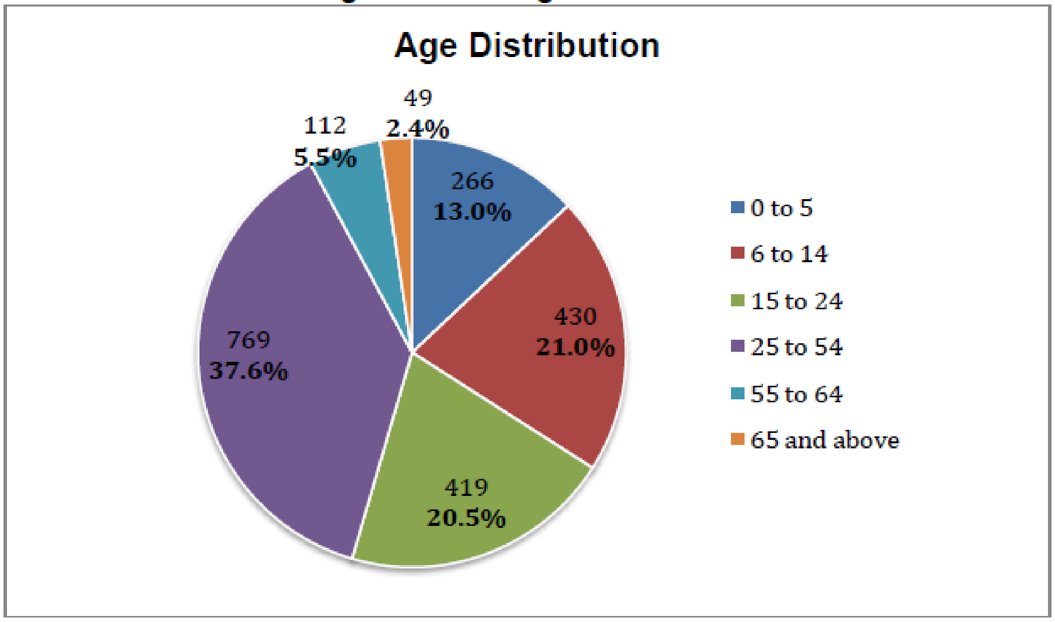
Sex	Total Population	%	Statistics Per Household			
			Average	Standard Deviation	Minimum	Maximum
Male	1,036	50.7	2.70	1.47	0.0	9.0
Female	1,009	49.3	2.63	1.36	0.0	8.0

Data gathered also reveals that there are more females (79%) taking on the role of household heads than males (21%).

c. Age Distribution

Residents aged 25 to 54 make up the largest population (37.6%) in the *barangay*. They are followed by those aged 6 to 14 years of age (21.0%), and those aged 15 to 24 (20.5%). The group aged 55 and above only comprises 2.4% of the population.

Figure 4.2.1.2. Age Distribution



With residents aged 0 to 14 and 65 and above considered dependents, dependency rate in the area is about 47%.

d. Educational Attainment

Out of the households surveyed, 32.03% have at least one high school graduate. 26.04% have at least one member who attended college, and only 19.27% have a college graduate.

As for the educational attainment of household heads, 17.45% attended college but only 4.69% graduated. 38.02% finished high school, while 17.97% attended high school but did not graduate. Around 4.95% finished vocational schooling and a very small percentage (1.04%) have a Ph.D./Master's Degree.

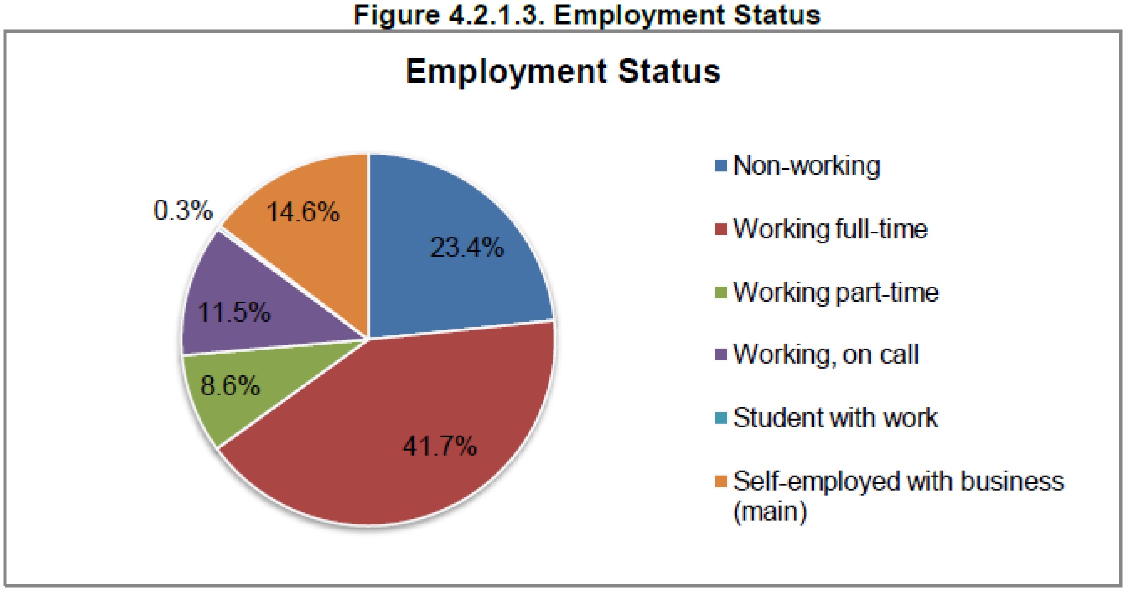
Table 4.2.1.2. Educational Attainment

Educational Attainment	Highest Educational Attainment in a Household		Highest Educational Attainment of Household Head	
	Count	%	Count	%
No Formal Education	0	0.00	3	0.78
Elementary Undergraduate	0	0.00	25	6.51
Elementary Graduate	6	1.56	51	13.28
High School Undergraduate	32	8.33	69	17.97
High School Graduate	123	32.03	146	38.02
College Undergraduate	100	26.04	49	12.76
College graduate	74	19.27	18	4.69
Vocational	40	10.42	19	4.95
Doctorate/Masteral Degree	9	2.34	4	1.04

e. Employment Status

About 63% of the surveyed population is in the labor force (i.e. ages 15-64). Of the population, 41.7% reported having full-time jobs and 14.6% are self-employed. Those working part time and on-call make up 8.6% and 11.5%, respectively. The non-working population is 23.4%.

Figure 4.2.1.3. Employment Status



f. Engagement in Business

Only a third of the households are engaged in businesses. Most (43.27%) are employed in Retail/Wholesale, while a third (32.69%) are vendors (neighborhood variety stores, recyclables collectors, and the like). Around 11.24% are engaged in home/small scale industries, 8.65% in personal services, and 2.88% in transport.

Table 4.2.1.3. Household Engagement in Businesses

Business	Household Count	%
With Business	113	29.43
Home/Small Scale Industry	12	11.54
Personal Services	9	8.65
Retail/Wholesale	45	43.27
Service Contracting	1	0.96
Transport	3	2.88
Others (Vendor, Neighborhood Variety Store, Recyclables Collection)	34	32.69
Without Business	271	70.57

g. Income and Savings

As of 2009, the average annual income and expenditure of families in Metro Manila amounted to PHP 356,000 and PHP 309,000, respectively (PSA, n.d.). This translates to an average monthly income of PHP 29,667 and expenditure of PHP 25,750.

Survey results show that household heads' earnings average PHP 9,307.12, and the monthly household income average is PHP 15,838.33 – 46.61% below the regional average.

Table 4.2.1.4. Average Monthly Income (in PhP)

Unit	Average	Standard Deviation	Minimum	Maximum
Household Heads	9,307.12	7,799.55	1,000	108,000
Household	15,838.33	12,817.86	1,500	108,000

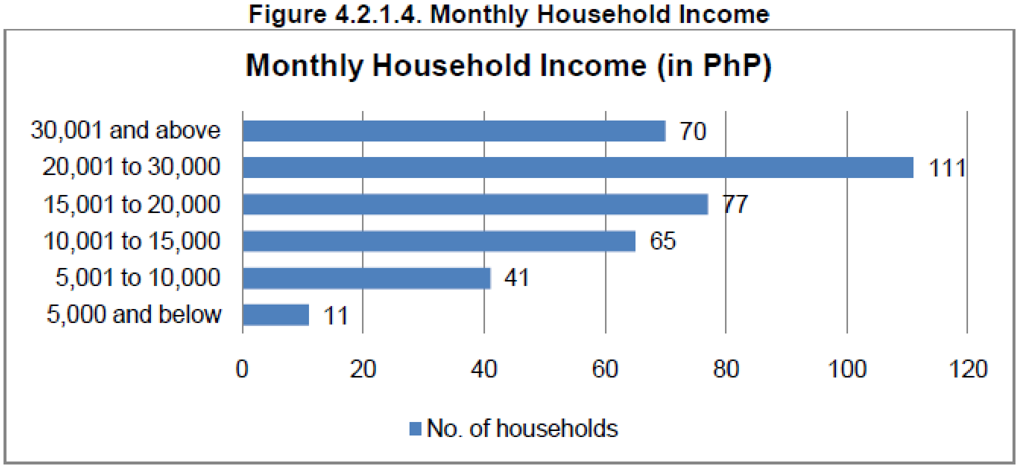
Almost half (49.16%) of the household heads earn PHP 5,001 to PHP 10,000, 23.41% earn PHP 5,000 or lower, and less than 1% receive PHP 30,000 or more.

At the household level, 29.60% earn PHP 20,001 to PHP 30,000 a month. 20% earn PHP 15,001 to PHP 20,000 while 18.67% make above PHP 30,000. Only 2.93% earn PHP 5,000 or less. Findings are detailed in **Table 4.2.1.5** and **Figure 4.2.1.4**.

Table 4.2.1.5. Monthly Income (in PhP)

Monthly Income (in PhP)	Household Heads		Households	
	Count	%	Count	%
5,000 and below	70	23.41	11	2.93
5,001 to 10,000	147	49.16	41	10.93
10,001 to 15,000	60	20.07	65	17.33
15,001 to 20,000	13	4.35	77	20.53
20,001 to 30,000	7	2.34	111	29.60
30,001 and above	2	0.67	70	18.67

Figure 4.2.1.4. Monthly Household Income



Given that the typical household income is below regional averages, it is not surprising that around three-fourths of the surveyed families do not have monthly savings. Of those with savings, only 2.1% set aside PHP 10,000 or more.

Table 4.2.1.6. Monthly Savings

Monthly Savings (in PhP)	Households	
	Count	%
None	291	75.8
Less than 1,000	22	5.7
1,000 to 1,999	16	4.2
2,000 to 2,999	16	4.2
3,000 to 3,999	9	2.3
4,000 to 4,900	7	1.8
5,000 to 9,999	15	3.9
10,000 or more	8	2.1

h. Land Ownership

Only 15.1% of households own property; 84.9% do not own any land. Locations of lands are shown in **Table 4.2.1.7**.

Table 4.2.1.7. Land Ownership

Land Ownership	No. of Households	%
Own Land	58	15.1
Do not Own Any Land	326	84.9
Location of Owned Land		
MMA	8	14.5
Luzon	27	49.1
Visayas	10	18.2
Mindanao	10	18.2

i. Medical/Health Insurance

Medical/ Health Insurance is uncommon in the community. Only 5.29% of the population has household members with health/ medical Insurance.

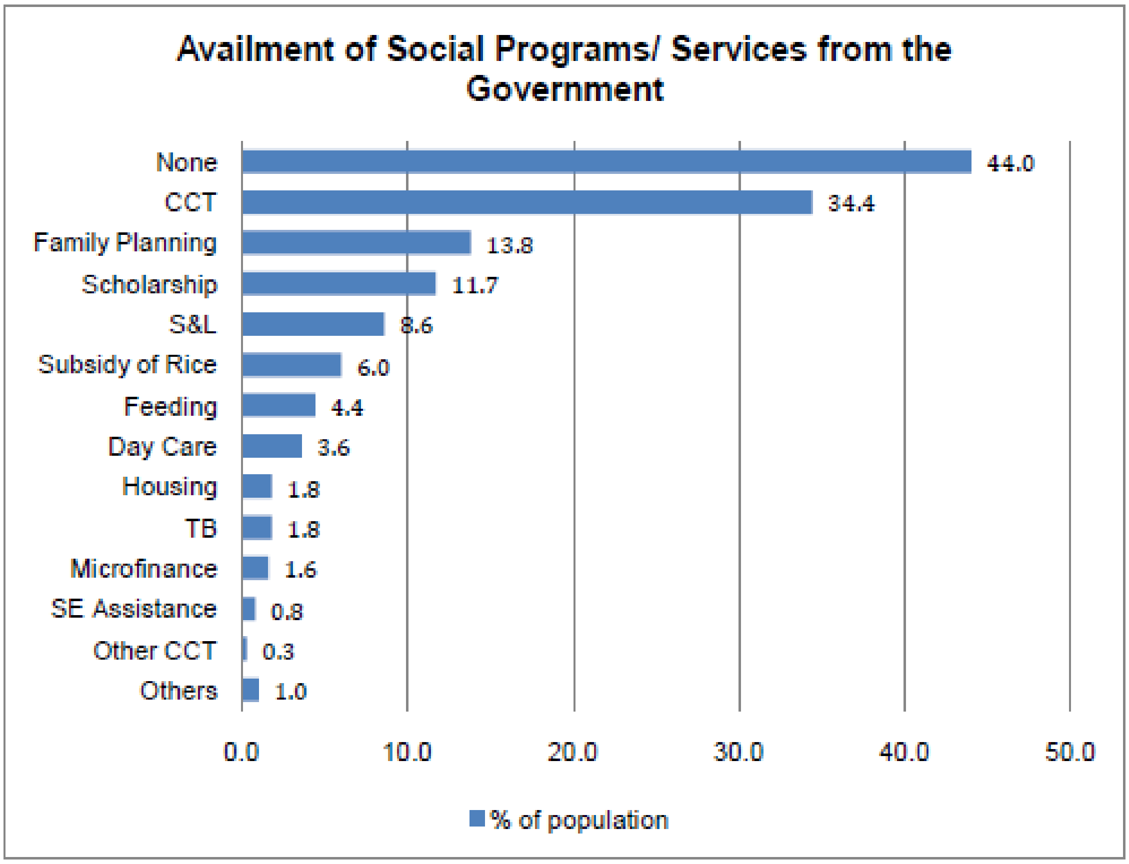
Table 4.2.1.7. Medical/Health Insurance

Possession of Medical/Health Insurance	Households	
	Count	%
At least 1 household member insured	108	5.29
No household member insured	312	81.25

j. Social Programs/Services Provided by the Government

Results show that almost half of the households surveyed have not utilized of any of the programs/services available to them. These programs range from education to housing, health, security, and financial assistance.
As for the recipients, the most popular program (with 34.4% taking part it) is the *Pantawid Pamilyang Pilipino* Program (4Ps), the government's conditional cash transfer (CCT) program. Next is the Family Planning Program used by 13.8%, and then scholarships that benefited 11.7% of the *barangay*.

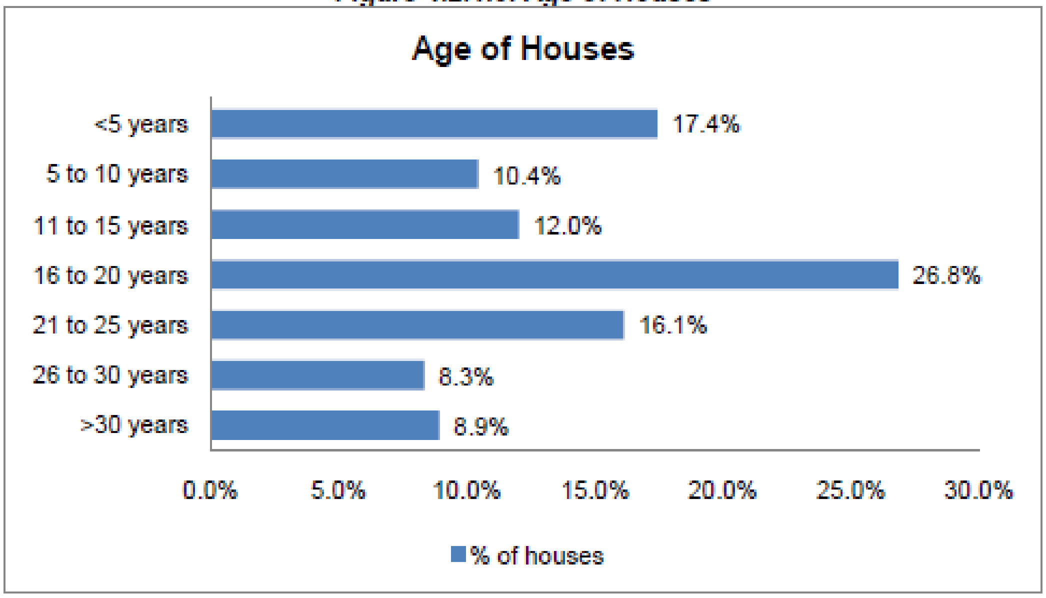
Figure 4.2.1.5. Social Programs/ Services Availed by Households from the Government



k. Age of Houses

Based on the survey, 26.8% of the houses were constructed 16 to 20 years ago while 17.4% were built less than 5 years ago. Only 8.9% of the structures are more than 30 years old.

Figure 4.2.1.6. Age of Houses



l. Structural Types

The average floor area per household in Tumana is 42 square meters, with a minimum of 5 square meters and a maximum of 300 square meters. Five structural types of houses (based on appearance) were identified: Salvaged (Type 1), Light (Type 2), Semi-Concrete (Type 3), Concrete (Type 4), and Mixed Materials (Type 5). 'Salvaged' refers to discarded wood and wood-based products. 'Light' describes wood construction with structural elements made from any materials permitted by the Philippine national building code. 'Semi-Concrete' construction is made up of masonry and wood. Concrete consists of steel, iron, concrete, or masonry. Finally, 'Mixed Materials' are four-hour fire-resistant supplies, with buildings including permanent partitions made from incombustible fire-resistant construction. Most of the houses studied were Semi-Concrete, followed by Mixed Materials and then Concrete. Less than 1% are Salvaged.

Table 4.2.1.8. Types of Structures Based on Appearance

Type of Structure Based on Appearance		No. of Houses	%
Type 1	Salvaged	384	0.78
Type 2	Light	21	5.47
Type 3	Semi-Concrete	179	46.61
Type 4	Concrete	88	22.92
Type 5	Mixed Materials	93	24.22

Table 4.2.1.9. Types of Structures Based on Materials

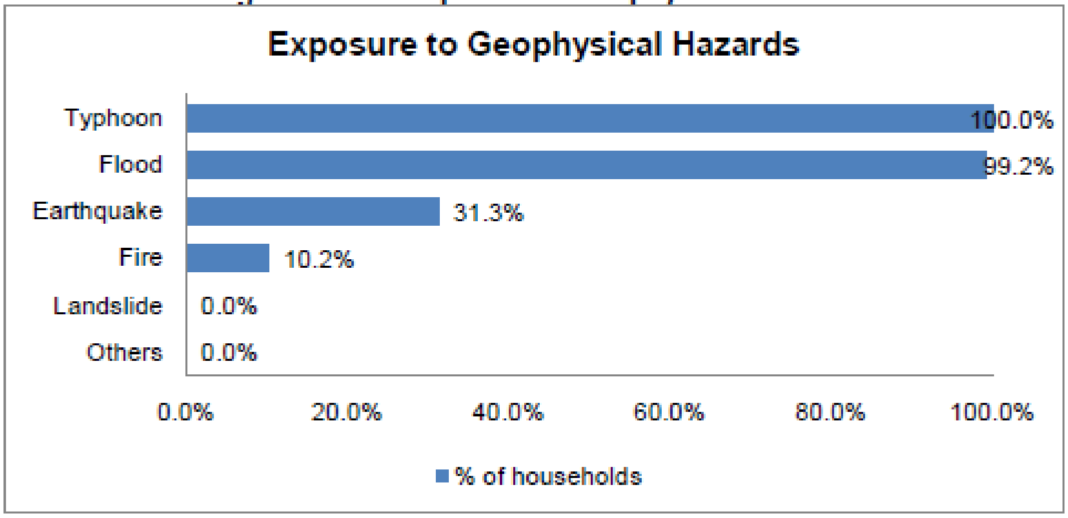
Type Based on Materials	No. of Houses	%
Wall		
Salvaged	1	0.3
Light	27	7.0
Semi-Concrete	249	64.8
Concrete	59	15.4
Mixed Materials	48	12.5
Roof		
Salvaged	2	0.5
Light	10	2.6
Semi-Concrete	350	91.1
Concrete	16	4.2
Mixed Materials	6	1.6
Flooring		
Salvaged	5	1.3
Light	39	10.2
Semi-Concrete	17	4.4
Concrete	290	75.5
Mixed Materials	33	8.6

m. Accounts of Calamity

- Exposure to Geophysical Hazards

The whole *barangay* is affected by typhoons. Almost all (99.2%) of them are affected by flooding. 31.3% have been affected by earthquakes, and 10.2% by fires.

Figure 4.2.1.6. Exposure to Geophysical Hazards



- Experience during Typhoon *Ondoy* and the *Habagat*

The onslaught of Typhoon *Ondoy* and the monsoon rains or *Habagat* affected 98.70% of the population. Flood height averaged 17.3 meters, with 70.7% of the households affected by 11 to 20 feet of floodwater.

92.6% reported that it usually took at least a day for the water to subside. The average duration was 1.2 days, while the shortest and longest durations were one and seven days.

Table 4.2.1.10. Flooding Caused by Typhoon *Ondoy/Habagat*

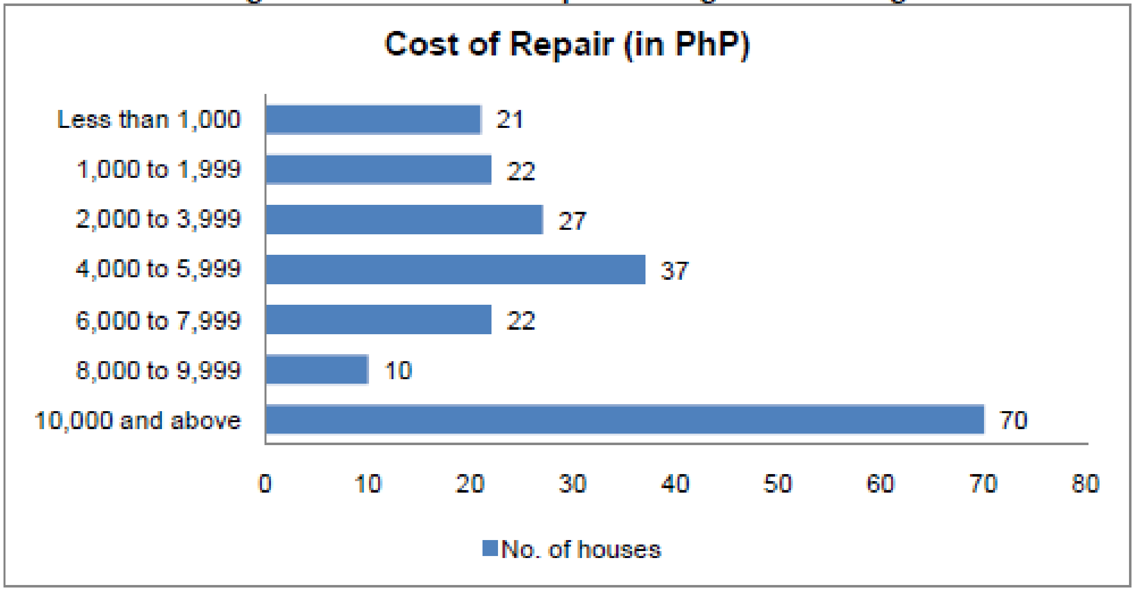
Affected by *Ondoy/Habagat*	No. of Households	%
Yes	379	98.70
No	5	1.30
Height of Flood (in meters)		
Average	17.3	
Minimum	1	
Maximum	40	
Flood Height (in feet)	**Households Affected**	
	Count	**%**
Less than 5	12	3.2
6 to 10	21	5.5
11 to 20	268	70.7
21 and Above	78	20.6

During *Ondoy* and *Habagat*, 54.4% of the houses emerged in need of repairs. Out of these, 33.5% needed PHP 10,000 or more to cover repair costs.

Table 4.2.1.11. Damage to Housing due to *Ondoy/ Habagat*

Need Repair	No. of Houses	%
Yes	209	54.4
No	175	45.6

Figure 4.2.1.7. Cost to Repair Damages to Housing



n. Calamity Preparedness

When asked about the implementation of disaster drills in *Barangay* Tumana, 46.1% confirmed their awareness of these procedures while 53.9% responded that there have been no drills. Of those aware, 33.3% know of the flood drills, 16.4% of fire drills, and 17.7% are aware of earthquake drills.

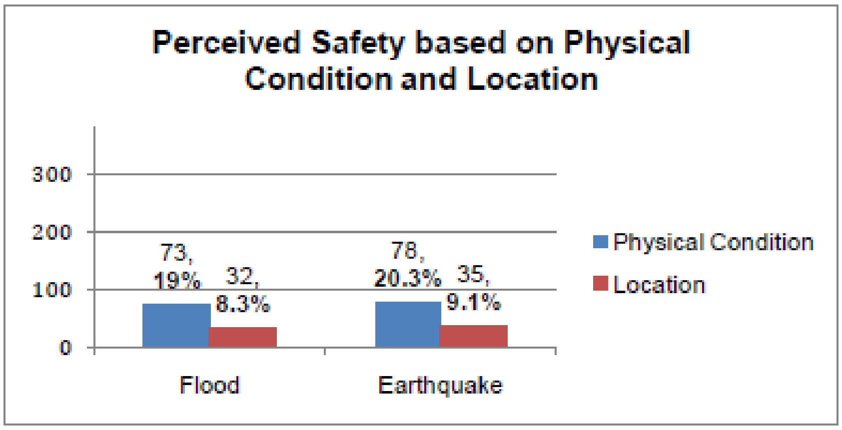
Table 4.2.1.12. Calamity Preparedness

Awareness on Disaster Drills in Tumana	No. of Households	%
Aware	**177**	**46.1**
Flood Drill	128	33.3
Fire Drill	63	16.4
Earthquake Drill	68	17.7
Unaware	**207**	**53.9**

o. Perceived Safety of Houses

19% feel that their houses are safe from flooding while 20.3% feel that their residences can withstand earthquakes based on the physical condition of their houses. Regarding location, 8.3% said that their houses are spared from flooding while 9.1% believe they are safe from earthquakes.

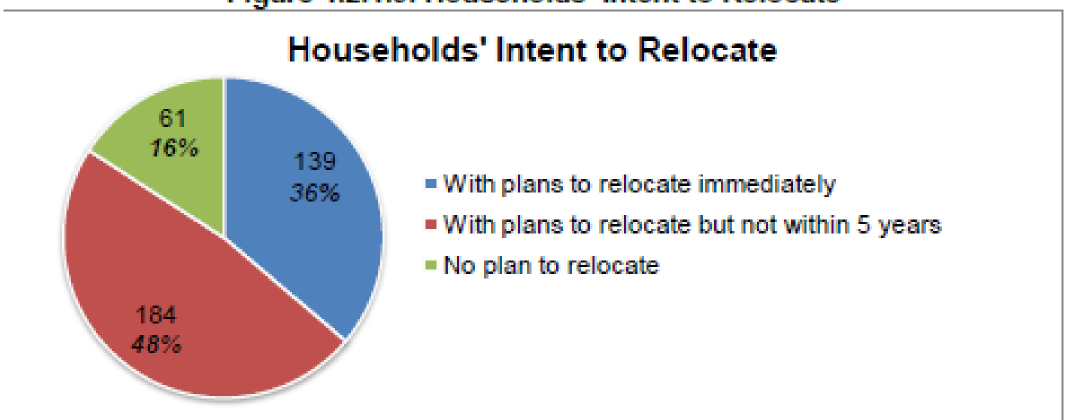
Figure 4.2.1.8. Perception of House Safety based on Physical Condition and Location



p. Willingness to Relocate

Almost half (47.9%) of the households affirmed that they have plans to relocate but not within the next five years. 36.2% plan to immediately transfer while 15.9% do not have plans of transferring at all. Unwillingness to transfer stems from various reasons such as distance from school or place of employment, attachment or length of stay in the area, and lack of financial capability to rent or buy a new house.

Figure 4.2.1.9. Households' Intent to Relocate



10.7% of the surveyed households have been recipients to a Relocation Program. Of these, 7.3% were recipients of the city's relocation program, 2.9% were beneficiaries of the National Housing Authority (NHA) program, and less than 1% received assistance from other organizations.

Table 4.2.1.13. Beneficiaries of Relocation Programs

Relocation Program Beneficiaries (Households)	Count	%
Yes	41	10.7
From Municipal Hall	28	7.3
From NHA	11	2.9
From Other Organization	2	0.5
No	343	89.3

The rest of the population (89.3%) did not receive any form of Relocation Program. 92.4% of those would consider relocating if a program on Housing for People in Risk Areas is to be implemented, while 7.6% still would not.

q. Housing Preferences

- Location

44.1% of the respondents who consider relocation prefer to be relocated within metropolitan Manila, except Marikina. 31.9% favor relocation within Marikina, while 12% prefer another part of the *barangay*. Another 12% do not mind being relocated to other provinces or municipalities outside of Manila.

- Type of Housing

59.3% prefer a single-detached housing, 23.2% prefer medium rise, and 10% favor a duplex. Among those who prefer medium rise residences, 77.7% favor a 2-story building, while 16.2% prefer 3 stories. Only 6.1% prefer 4 floors or higher.

Table 4.2.14. Housing Relocation Preference

Location	Count	%
Current Location	44	12.0
Within Marikina	117	31.9
Within Metro Manila except Marikina	162	44.1
Other Province/Municipality outside Metro Manila	44	12.0
Type Of House		
Single – detached	207	59.3
Duplex	35	10.0
Row House	22	6.3
Medium Rise Building	81	23.2
2 storey	*254*	*77.7*
3 storey	*53*	*16.2*
4 storey	*11*	*3.4*
5 storey	*7*	*2.1*
6 storey	*2*	*0.6*
High Rise Building	4	1.1

r. Relationship Between Plan to Relocate due to Flooding Viz. Gender and Age of House

Table 4.2.15. Test of Relationship of Plan to Relocate viz Demographic & Socioeconomic Factors

Plan to Relocate Due to Flooding vs	Odds Ratio	Odds Ratio 95% CI		p - value
Household Size	1.012	0.886	1.157	0.857
Average Age of Household Members	0.999	0.982	1.016	0.920
Presence of a Senior Citizen	0.673	0.11	4.109	0.668
Number of Males in the Household	1.096	0.914	1.313	0.323
Number of Females in the Household	0.933	0.757	1.151	0.519
Sex of Household Head	0.436	0.19	0.999	0.049
Income	1.000	1.000	1.000	0.922
Religion	1.249	0.535	2.916	0.608
Owned a Land	0.790	0.359	1.738	0.558
Banca Owners	1.329	0.146	12.099	0.801
Age of House	0.947	0.009	0.989	0.014
Experienced Illness during the Rainy Season	1.132	0.769	1.666	0.530
Household with Overseas Filipino Worker	1.653	0.635	4.301	0.303
Household Engagement in Business	1.318	0.737	2.356	0.351

It was observed through quantitative analysis that the tendency of male household heads in Tumana to have a plan to transfer is higher by a factor of 2.29 when compared to females. Results also show that the age of infrastructure is directly correlated to the decision to transfer due to flooding. Specifically, the odds show that for every year added to the age of the infrastructure, there is a 106% decline in the propensity to transfer due to flooding. Thus, the older the house is, the less likely it is that residents will transfer.

5. Summary of Results

The following is a summary of the study results. These are categorized based on the factors that affect the vulnerability of Tumana, following the UNFCC framework that defines vulnerability as a function of exposure, sensitivity, and adaptive capacity.

5.1. Summary and Analysis of Exposure Information

Barangay Tumana has high exposure to the impacts of climate change. Below is a summary of its exposure information.

- *Barangay* Tumana houses 41,809 residents as of 2010.

- Half of the *barangay* (i.e. the Eastern Portion, about 100 hectares) is intermittently flooded due to biophysical and anthropogenic factors. Flood heights reach a maximum of 40 feet.
- Marikina is projected to have fewer but stronger typhoons (comparable to Typhoon *Ondoy*) and sporadic precipitations/monsoon rains (*Habagat*). Projections point to a hotter summer season, particularly during March, April, and May, and heavier rains during the rainy season, particularly during June, July, and August.
- The Socialized Settlement Zone is situated in an environmentally critical area. Parks & Open Space and Low Density Residential Land Uses are also affected by intermittent flooding.

5.2. Summary of Sensitivity and Adaptive Capacity Information

Barangay Tumana has a high degree of sensitivity to hydrometeorological risks, particularly to impacts of global warming, given its socioeconomic condition. This necessitates a proactive approach through mitigation and adaptation strategies towards building resiliency and reducing vulnerability. The following is a summary of the degree of sensitivity and adaptive capacity for the *barangay*.

- There are 47 dependents (6 old and 41 young) for every 100 people.
- Approximately 1 out of 4 of the surveyed population is unemployed.
- Approximately 50% are high school graduates, or have attended high school level but did not graduate.
- About a third of the population has lived in Tumana for 10-20 years.
- About 50% of the household heads earn only PHP 5,000 - PHP 10,000.
- 4 out of 5 households do not have medical insurance/health cards.
- 4 out of 5 households do not have savings.
- 9 out of 10 households do not own land.
- All have experienced the effects of typhoon and flooding when flood height is "*lagpas-tao*", or well above people's heads.
- 4 out of 5 do not feel safe due to typhoon and flooding in Marikina and/or within metropolitan Manila.
- Half of the respondents have experienced disaster drills led by the city government.
- 4 out of 5 respondents have plans to relocate. 9 out of 10 are willing to transfer if given a relocation program. They prefer to be relocated within Marikina and/or within metropolitan Manila

6. Policy Options and Recommendations

The following recommendations to further *barangay* resilience were formulated:

Build resilience through *barangay* development planning

Such high exposure and degree of sensitivity to climate change affect key geographic and spatial contexts where at-risk population and systems operate. In addition, the ability of a unit to address and cope with such impacts affect the facility by which sustainable development and resiliency are pursued. In order to achieve them, it is important to ensure policies and strategies are in place at the onset of *barangay* development planning, and to promote *barangay* programs that increase socioeconomic standards. Specifically, the following strategies and policy options are recommended:

Decrease exposure of vulnerable communities to climate related risks

The enactment and enforcement of local legislative measures to manage and protect the environmentally critical and hazard-prone areas in *Barangay* Tumana can decrease the number of exposed units. Locally institutionalizing these measures with an up-to-date Zoning Ordinance, as well as other complementary regulatory directives (e.g. incentives, sanctions, etc.), can protect high-risk and flood-prone areas. The Socialized Settlement and the Low Density Residential zones must be moved away from this area while the Parks, Open Spaces, and Recreation zone should be maintained and delineated. The national and local easement policies (i.e. maintaining a distance 96 meters on both sides of the river) should be effectively enforced and monitored.

Exploring safer areas for a comprehensive resettlement program can fundamentally decrease the vulnerabilities of the *barangay* population. Designating relocation areas in safer grounds (i.e. low to zero risk of flooding) in Marikina City or within metropolitan Manila, as preferred by the community can enhance community resilience. The possibility of families in older homes located in high flood zones being preferentially targeted for relocation efforts can be explored in addition to further research about appropriate tenurial instruments and housing size and typologies. Most of the building types surveyed in the *barangay* are Type 3, 4, and 5 which resemble permanent housing typologies in high flood zone areas. These areas shall be identified as appicable in the Comprehensive Land Use Plan of Marikina City and of other cities in Manila and enforced through a local Zoning Ordinance. Partnership with the National Housing Authority, Non-Government Organizations, and other private entities may be established to create a comprehensive and effective resettlement program. Further study on determinants and barriers to community relocation, e.g. distance from school and employment, capacity, and willingness to pay for housing, should also be conducted.

Decrease sensitivity through socioeconomic development programs

A comprehensive development program that addresses sustainability should be commenced by the local government. The socioeconomic situation of the communities in Tumana exacerbates the sensitivity of the population to climate related risks. The high total dependency ratio, high unemployment rate, low labor participation, low education, and low income make the *barangay* communities in Tumana more sensitive to the impacts of climate change.

Programs that will address key socioeconomic issues among the *barangay* population can be pursued through the provision of social support facility. The importance of gender mainstreaming and the role of women in the development programs should be prioritized: most of the community has female heads-of-household. Labor market programs and community-based enterprises can be explored to give jobs to the unemployed 23.4%. Child and elderly care projects and support facilities can created. Disaster unemployment programs can also be explored in addition to the institutionalization of academic scholarships and technical/vocational education programs to increase the level of education and income among the *barangay* population. The promotion of government social programs and services is of primary importance to increase access and awareness among community members.

Increase adaptive capacity of *barangay* communities

Barangay Tumana's adaptive capacity be increased through the provision of skills trainings and seminars on Disaster Risk Reduction and Management (DRRM) and Climate Change Adaptation (CCA). This should include flood, fire, and earthquake drills and trainings for calamity preparedness, which at present only 50% of the community have accessed. Funds for climate and disaster losses can be raised with better access to finance and insurance policies. The local government could establish local financing programs and credit facilities, especially for healthcare and medical insurance. With the aid of the national government and private entities, residents can be educated on the national and private financing and insurance programs available. Livelihood programs, financial literacy programs, and other initiatives that boost community capacity may be implemented as well to aid residents in increasing their financial capacity and repairing their credit. *Barangay* communication and public awareness campaigns that increase awareness on local environmental management must be prioritized and must consider possible adaptation mechanisms and technological interventions for disaster resiliency.

7. Conclusion

Barangay Tumana in Marikina City, Philippines is a highly populous locality that has historically been severely affected by flooding due to natural and anthropogenic factors. Primarily affected are residential areas inhabited by households with low socioeconomic status. High population exposure is heightened by the city zoning which places the Socialized Settlement Zone in a high-risk area. Basic societal issues of the *barangay* such as financial capacity, health, and education contribute to the sensitivity of the community. The gravity of disasters in the highly vulnerable *barangay* is set to escalate given the projected increase in extreme weather events in the absence of proper and immediate intervention.

Flooding and its resulting disasters have persisted for years in Tumana. Many may have survived and continue to live in the area, but this cycle of losing and rebuilding physical, economic, and social assets should be put to an end. Resiliency must be strengthened. Various strategies should be employed by the local government to decrease exposure and sensitivity and to and increase the adaptive capacity. Risk and exposure databases must be put in place to provide significant input to the development planning process of the *barangay*. The city must begin to consider resiliency in these plans. Legislative measures that protect critical areas should be enacted and enforced, and a comprehensive resettlement program for those residing in high-risk areas should be established. Adaptive capacity might also be ameliorated with various initiatives such as providing DRRM and CCA trainings, improving access to financial and insurance policies, implementing livelihood, education, and health programs, and promoting awareness of local environmental management. These are just a few of the policy options that the local government can consider to substantially diminish the vulnerability of *Barangay* Tumana. All these options require the active participation of all stakeholders. This includes residents, local officials, the national government, and the private sector, which can offer technical and financial support.

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