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# Thesis title: The spatio-temporal effect of a flooding disaster to the economic geography of a city: The case of tropical storm Sendong to Cagayan de Oro City, Philippines

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## Summary

There are growing empirical evidences on the increased frequency and magnitude of flooding disasters caused by climate change. Coastal cities in the global south are confronted with a big challenge in terms of the rising exposure and vulnerability to climate change-induced hazards. In 2011, the Philippines's deadliest and the world's second most catastrophic disaster struck Cagayan de Oro City, the study area of this research. Tropical Storm Sendong (Washi) brought city-wide flooding that caused fatalities, population displacement and enormous damages to economic assets. Several areas in the city experienced varying levels of inundation and those areas adjacent to the two rivers suffered deeper, wider and longer submergence. The magnitude of the flood effects was unprecedented prompting urban managers to improve disaster risk reduction and climate change adaptation strategies.

To determine the potential impact of the flooding disaster of TS Sendong, this research calculated the flood impact magnitude index using the Analytical Hierarchy Process. Different parameters of the flood hazard (extent, depth and duration) and exposure (population and business assets) are collected from rich secondary datasets. The computed composite flood index is then subjected to the spatial statistics of ArcGIS to get the hot spot of affected areas in the city. Spatial concentration of business establishments was also generated using similar spatial statistic tool to know the location and distribution of human economic activities particularly the city's business establishments. Mediation test for the population density changes (as a consequence of the flood) and moderation analysis of the inventory of commercial areas were also conducted apart from determining the causality strength of the flood towards the business establishments. These robust quantitative and spatial statistical tests are performed to derive the relationship of the variables and establish their degree of causality as solid basis for this explanatory case-study research.

The result of the hot spot analysis for the flood impact magnitude index is consistent with the River Basin Flood Modelling simulation and the satellite flood footprint of TS Sendong. However, a key finding of this study revealed that the flood hotspot areas shows similar spatial pattern with the business establishments. The flood affected central business district and its adjacent areas are also the cluster of thriving business locations in the city. One significant finding also revealed that the changes in population concentration due to the fatalities, displacement and relocation do not have significant mediation effects to the resulting number of business establishments in a barangay in the short- and long-run viewpoints. On the contrary, the presence of commercial areas have significant moderation effects to the number and location of business establishments after the flood. Although the flooding disaster has a statistically significant negative effect to the number of business establishments, the spatial clustering trend of the thriving business areas persisted even after the disaster. This research complements the economics of disaster literature by focusing into the smaller unit of the geographic consequences of the flood at the urban level. Further, the findings herein highly suggest as well for urban managers and decision-makers to have a science/research-based disaster adaptation measures to steer development direction away from disaster-prone areas to manage hazard exposure and safeguard lives and economic development.



## Keywords

Flooding disaster, economic geography, geospatial statistical analysis, spatial regression,

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# Abbreviations

| | |
|---|---|
| AHP | Analytical Hierarchy Process |
| BII | Business Industry Index |
| CCA | Climate Change Adaptation |
| ClimEx.Db | Climate Exposure Database |
| CPDO | City Planning and Development Office |
| DPWH | Department of the Public Works and Highways |
| DRR | Disaster Risk Reduction |
| FIMI | Flood Impact Magnitude Index |
| GIS | Geographic Information System |
| GOP | Government of the Philippines |
| HSA | Hot Spot Analysis |
| IHS | Institute for Housing and Urban Development Studies |
| NEDA | National Economic and Development Authority |
| PSA | Philippine Statistics Authority |
| RBFM | River Basin Flood Modeling Study |
| RDC | Regional Development Council |
| SLX | Spatial Lag X |
| UP-TCAGP | University of the Philippines Training Center for Applied Geodesy and Photogrammetry |

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# Chapter 1: Introduction

## 1.1 Introduction

Urban flooding is one of the major challenges faced by many cities as a result of climate change. The Intergovernmental Panel on Climate Change (IPCC) Synthesis Report evidently elaborates the imminent threats of a changing climate through increased occurrence and magnitude of storms, floods and droughts (Pachauri et al., 2014). Trends on global warming-induced storms and flooding are predicted to persist despite the attainment of the 2015 Paris Agreement (Berlemann and Steinhardt, 2017; Hammond et al., 2015; Parsons, 2019; Peduzzi et al., 2012); Aerts et al., 2009). Flooding in urban areas can be further exacerbated by the problems brought by rapid urbanization which causes imperviousness. As a compounded result, numerous system disruptions happen in a city affecting also human economic activities (Hammond et al., 2015).

Pászto (2020) derived a common understanding about economic geography referring to the location and distribution of human economic activities. In examining the concept, Leyshon et al. (2011) emphasized however the importance of analyzing the circumstances and the geographical and historical context to which the term is applied in practice. Thus, looking at the urban flooding lens, this research attempts to determine if there are significant effects of such disruption to the city's economic geography. Possible correlation will be examined among different inundation levels as against the seemingly thriving clusters of economic activities and population densification patterns. Spatial regression shall also be conducted to determine strength of causal relationships. This is related to the first law of geography introduced by Waldo R. Tobler's in 1969 which states that "Everything is related to everything else but near things are more related than distant things", in the context of neighboring areas.

### 1.1.1 Background information and problem statement

#### 1.1.1.1 Urban Flooding

According to the Centre for Research on the Epidemiology of Disasters (CRED) (2015), flooding constituted the highest percentage among all global disasters (43%), from 1994-2013, which is supported by the International Disaster Database as shown in Figure 2. This is further categorized to riverine floods (30%), flash floods (6%), coastal floods (1%) and unspecified floods (6%). There are different types of urban flooding depending on a single or multi-causal factors, to wit: Pluvial – flooding due to insufficient urban drainage to hold rainwater; Fluvial – flooding that occurs when defenses adjacent to rivers are spilling over; Groundwater flooding – caused by overflowing groundwater levels; and Coastal flooding – as a consequence of waves and tidal surges (Hammond et al., 2015).

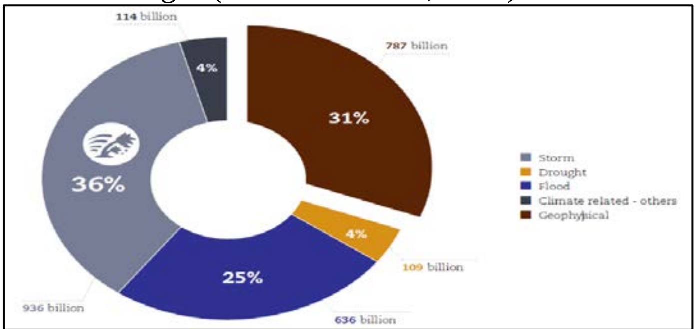


**Figure 1. Breakdown of recorded economic damage (US$) by Disaster Type, 1994-2013 (Source: CRED, 2015)**

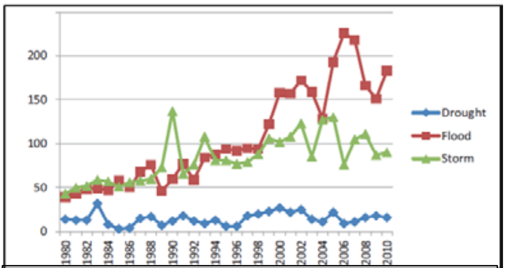


**Figure 2. "EM-DAT: The OFDA/CRED International Disaster Database, www. Emdat.be – Universite Catholique de Louvain – Brussels – Belgium. (Source: Black et al., 2013)**

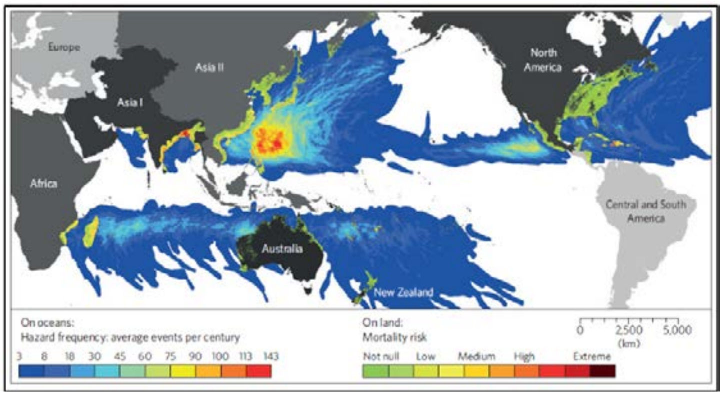


**Figure 3. Hazard frequency distribution and mortality risk from tropical cyclones for the year 2010. (Source: Peduzzi et al., (2012), p. 290)**

Increase in precipitation caused by climate change is expected to cause more rainfall-related flooding as hydrological system (lakes and rivers) will tend to overflow, resulting to severe floods (Alfieri et al., 2017; Peduzzi et al., 2012). The study of Peduzzi et al., (2012) drawn from a large set of physically observed global events of storm frequency and intensity, including exposure analysis revealed that extreme tropical cyclones cause wide-ranging flooding and affects nearly all tropical areas, with Asia suffering the most (Figure 3). Moreover, looking at Figure 1, these results were aligned by the findings of CRED that Asia has the biggest share (50%) in terms of absolute value for damages from storms and floods. The socio-economic impacts on people and assets from the future flood risk at global scale were simulated by Alfieri et al., (2017). Their modelling and scenario building of a 1.5∘C, 2∘C, and 4∘C warming level rendered a positive correlation between global warming and global flood risk.

Bijay et al. (2012) identified two factors that contribute to the higher vulnerability of small island developing states in the pacific against climate-induced disasters: 1) geographical location that increases exposure and 2) limited adaptive capacity due to access constraints in financial resources and technologies. Moreover, urban growth and population increase at the same time will escalate potential flooding damages and vulnerability (Novoa, 2012). The Philippines is one of the tropical countries located in south-east Asia and the pacific which confronts such challenges. On average, 20 tropical cyclones form and/or cross the Philippine Area of Responsibility (PAR) every year with increasing frequency and increasing rainfall amounts[1]. The World Risk Report of the United Nations University Institute for Environment and Human Security (UNU-EHS) ranked the Philippines third in terms of high disaster risk. The German watch's Global Climate Risk Index has consistently identified the country also due to the high number of fatalities and amount of economic losses from extreme weather events.

In 2011, Tropical Storm (TS) *Sendong*, with international name *Washi*, was the 19th tropical cyclone that entered the PAR and heavily hit Cagayan de Oro City, the study area. It is characterized with torrential rain with a corresponding return period of 75[2] years. The two major river systems in the city overflowed and flooded a huge portion of the urban area (Figure 4). Many sub-area units called *barangays* suffered inundation as shown in Table 1 comprising approximately 2,161.65 hectares. Death toll reached 1,495 persons (Regional Development Council-Northern Mindanao, 2012). The flood triggered by TS *Sendong* resulted to unjustifiable loss of human lives, substantial damage to properties, displacement of people, loss

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[1] *Based on the 2014 report of the Philippine Atmospheric Geophysical and Astronomical Services Administration*

[2] *Based on the plotting of the rainfall intensity duration and frequency curve using log normal distribution as conducted by the Flood Control and Sabo Engineering Center of the Department of Public Works and Highways.*

of livelihood and economic activities, destruction of critical facilities, and decimation of communities.

**Figure 4. Flooded areas in Cagayan de Oro City, Philippines (NEDA Region 10, 2012)**

| Name of Barangay | Area of Barangay (has.) | Flooded Area (has.) | % of Flooded Area to Area of Barangay |
|---|---|---|---|
| Baikingon | 475.64 | 109.26 | 22.97 |
| Balulang | 726.27 | 180.29 | 24.82 |
| Barangay 1 | 14.58 | 4.66 | 31.95 |
| Barangay 10 | 4.4 | 4.4 | 100 |
| Barangay 11 | 5.18 | 0.74 | 14.37 |
| Barangay 13 | 6.51 | 6.51 | 100 |
| Barangay 14 | 4.15 | 0.31 | 7.38 |
| Barangay 15 | 7.93 | 7.65 | 96.5 |
| Barangay 17 | 6.45 | 6.45 | 100 |
| Barangay 18 | 1.83 | 0.59 | 32.39 |
| Barangay 2 | 4.57 | 2.27 | 49.7 |
| Barangay 6 | 5.31 | 4.87 | 91.81 |
| Barangay 7 | 7.16 | 7.14 | 99.69 |
| Barangay 8 | 4.27 | 0.19 | 4.34 |
| Bayabas | 227.87 | 15.37 | 6.75 |
| Bonbon | 162.24 | 149.35 | 92.05 |
| Bulua | 476.44 | 217.46 | 45.64 |
| Canito-An | 1,069.44 | 257.8 | 24.11 |
| Carmen | 317.69 | 46.02 | 14.49 |
| Consolacion | 54.15 | 42.81 | 79.06 |
| Iponan | 271.66 | 264.45 | 97.35 |
| Kauswagan | 336.4 | 64.88 | 19.29 |
| Lumbia | 3,412.26 | 18.2 | 0.53 |
| Macabalan | 96.28 | 47.62 | 49.46 |
| Macasandig | 1,346.05 | 375.37 | 27.89 |
| Nazareth | 160.62 | 40.71 | 25.35 |
| Pagatpat | 1,593.17 | 115.8 | 7.27 |
| Patag | 429.99 | 38.99 | 9.07 |
| Puntod | 105.53 | 8.9 | 8.43 |
| San Simon | 970.12 | 122.57 | 12.64 |
| Total | 12,304.14 | 2,161.65 | 17.57 |

**Table 1. Flooded Area per Barangay (Source: City Planning and Development Office)**

Rapid urbanization also caused unmanaged urban development which led to imperviousness. Thus, urban flooding is expected to increase due to the growing number of people that live in cities (Hammond et al., 2015). Su et al. (2014) posits that land use, urban development and zoning must be properly laid out by planners to manage flood and water flow. In the case of Cagayan de Oro, permanent structures along riverbanks affected the behavior of the river systems. The presence of dense settlements in flood-prone areas, including in floodplains, former mangrove areas, old waterways and in geologically unstable areas also contributed to the disaster. The city is also set to become the country's fourth metropolitan area by 2025 which puts the entire urban area and its population of 687,427[3] in a higher risk of potential flooding losses. Further underlying economic implications, especially on the economic geography of the city, caused by the flood may have been under-reported as there is a less well-developed ideas on the effects of flooding on the wider economy of the city (Hammond et al., 2015).

## 1.1.1.2 Economic Geography

Pászto (2020) provided a comprehensive review of the definitions of economic geography. According to the author, in summary of the scholarly articles of Maryáš and Vystoupil (2004), Aoyama et al. (2011), Leyshon et al. (2011), and Castree et al. (2013), the concept can be defined in simple term as a subset of geography focusing on the distribution and location of human economic activities. The author also added that it is an open discipline and flexible to ongoing changes and development as there are also sub-themes under the field such us on tourism as studied by Faisal et al. (2020). Some of the notable ideas associated with economic geography are the location theories by the likes of Heinrich Von Thünen, Alfred Weber, Walter

[3] *Based on the 2015 population census of the Philippine Statistics Authority*

Christaller, August Lösch, and Walter Isard. Alfred Marshall's concept of industrial agglomerations and so-called economies of scale also influenced the concept.

In economic geography, resilience thinking is linked with an emerging discussion around evolutionary economic geography (EEG) that encompasses generalized complex adaptive systems, Darwinism and complexity theory (Plummer and Yamamoto, 2019). The concept of EEG has been very useful to understand how the spatial economy self-transforms through a dynamic economic processes emerging from the micro-behavior of economic agents such as firms and individuals (Brouder and Eriksson, 2013) or from Japanese nuclear host communities (Plummer and Yamamoto, 2019). The affected areas undergo transformative urban recovery processes including how businesses cope from loss of operations due to transportation and infrastructure breakdowns, temporal closure of an area, and dislocation of customer base, among other impacts (Faisal et al., 2020).

In a post-disaster context, a key finding in the study of Lam et al. (2012), on the case of New Orleans with Hurricane Katrina, revealed that the most important predictors of business reopening were the flood depth experienced, business size and the decision of the community to return in the flood inundated areas. The study of Faisal et al. (2020), using the niche construction theory for the tourism sector, discovered significant population changes in the city center after a strong earthquake that affected the customer demographics and markets for hospitality businesses. In a similar light, the spatial implications on how the economic geography of Cagayan de Oro changed after TS Sendong was left unexamined. While the patterns across the city where human economic activities interplay are governed by rational choices, a critical point of view to also consider is how urban flooding influence the spatial and temporal distribution and location of these economic activities across the central business district, city edges and sub-urban areas of Cagayan de Oro City.

## 1.2 Relevance of the Research Topic

This research will be helpful to identify how economic activities vary spatially and temporarily across the city, before and after perturbations such as flooding. The case study area will be in the Philippines particularly in Cagayan de Oro City. Thus, this research will also give insights on how a developing country experience, manage and cope-up with climate change effects. The study will contribute to the existing bodies of knowledge related to the spatial and socio-economic changes of flood inundated urban areas using spatial and statistical methods. Existing empirical studies investigate mostly the damage costs and its implication to economic growth using complex economic modelling (Akao and Sakamoto, 2018; Kousky, 2014). Hence, this research will add valuable knowledge and insights to the economics of disaster discourse in the academia by introducing a micro-level spatial and quantitative viewpoints in the context of a highly urbanized city in a developing country in Asia.

Results from this research may provide sound basis for urban managers and planners on appropriate policy or governance interventions to improve the business environment of hazard-exposed and/or lagging sub-area units. The empirical and quantitative findings may guide the urban development to ensure proper investment decisions to significantly flood-affected clusters to stimulate its economy while ensuring potential adverse effect of disasters are abated. Another point of relevance as well is in understanding the spatial relationship of the location and distribution of economic activities and the demographic changes and how patterns form among the variables.

## 1.3 Research Objectives

The main objective of the study is to explain how a major catastrophe such as flooding affects the location and distribution of human economic activities across a city. To further substantiate this aim, the research shall examine the spatial and temporal elements of urban flooding and the potential locational shifts and economic performance of the different clusters of sub-area units of Cagayan de Oro City. The analysis shall then contribute to the understanding how urban flooding does not only cause systems disruptions, and social, economic, environmental and infrastructural damages, but also influences the resulting patterns and clusters of economically thriving areas within a city.

To operationalize the objectives, spatial statistical methods will be deployed. In particular, statistical significance of different sub-area unit shall be analyzed to determine emerging patterns of hot-spot and cold-spot areas based on a set of economic performance indicators[4] that shall measure its economic productivity and output. This will be performed against a backdrop of flood inundation levels to see significant correlations or relationships, including how population concentration takes place in various spots.

## 1.4 Main research question and research sub-questions

The following research questions are formulated to shed answers and attain the abovementioned objectives. The central research question is:

“What are the spatio-temporal effects of a **flooding disaster** to the **economic geography** of Cagayan de Oro City?”

To further elaborate the main research question, the sub-questions below are articulated:

1. How does the shift in the population concentration (as a result of the flooding disaster) affect the number of business establishments per sub-area (barangay) in the city?
2. How does the availability of commercial areas influence the concentration of business establishments after the flood?
3. Is there a correlation between the varying levels of flood impact to the resulting number of business establishments in a barangay in the short- and long-term perspectives?
4. How does a major catastrophe like a flooding disaster affect the post-spatial cluster and number of business establishments in a barangay?

[4] Dependent on the available data of the city local government and the sub-area units

# Chapter 2: Literature review

## 2.1 Introduction

This chapter outlines a comprehensive review of the relevant and state-of-the-art literature in the economics of disaster domain with a prelude to set the tone of the discussion. The main concepts are discussed separately to expound their epistemological definitions, discourse in the academia and its practical application in the field. Section 2.2 elaborates the case of urban flooding disaster and all its related empirical studies. On the other hand, section 2.3 elucidates on the economic geography sphere and this includes a discussion on its theoretical underpinnings and contextual arguments. Following a logical flow, section 2.4 then provides the interconnection where the aforementioned two main school of thoughts merge together to form their ontological foundation as basis of this research. In the fifth and last sub-chapter, crucial findings of the existing literature are summarized and synthesized, conjoining them into a theoretically-sound and empirical-based conceptual framework.

**Prelude**:

Many cities around the world are facing the threat of flooding in its urban plains. Flooding is reported to be one of the most devastating natural disasters worldwide; (Dahri and Abida, 2020; Tanaka et al., 2020) and constituted the highest percentage of global catastrophes (Centre for Research on the Epidemiology of Disasters, 2015). Associated risks and potential damages from flooding are mounting due to the increased precipitation caused by global warming coupled with a growing population and higher rate of urbanization. Aside from the effects of climate change, the unregulated land use changes, uncontrolled urban development, destruction of green spaces, and other anthropogenic settings also amplify flood risks (Chang and Huang, 2015; Dahri and Abida, 2020; Su et al., 2014).

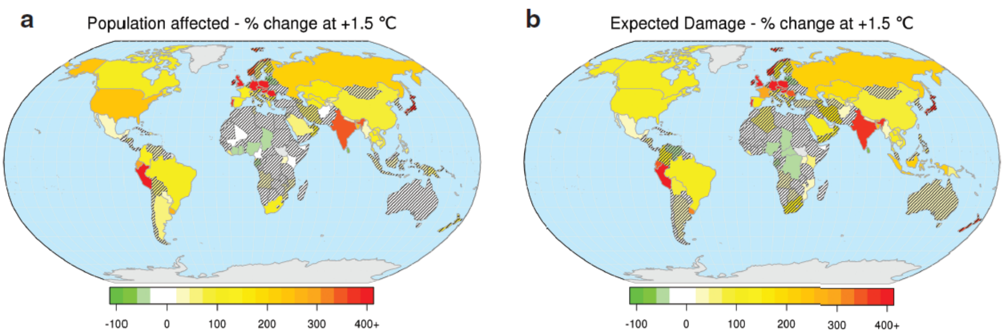
Most of the existing literatures point to the fatalities, damage assessment, and economic growth consequences from urban flood disasters brought about by tropical cyclones, storms and other extreme weather events (Akao and Sakamoto, 2018; Dahri and Abida, 2020; Tanaka et al., 2020; Uddin et al., 2019; Yonson, 2016). On the other hand, literatures on economic geography, which is gradually taking a developmental and evolutionary turn in recent decades, is very much inclined towards market shifts, technological advances, competitors and regulatory developments as shocks that affect the economic landscape (Martin and Sunley, 2011; Martin and Sunley, 2015; Pike et al., 2016). Literature is scant on how perturbations such as flooding affects the location, distribution and perhaps the type of economic activities that emerge in a city from a post flooding disaster scenario. Moreover, the topic on economic geography is also characterized by a plurality of methodological approaches which take different directions but equally insightful results (Pike et al., 2016). The empirical literatures on economic vulnerability and economic resilience paradigms (Kousky, 2014; Noy and Yonson, 2018) contribute to the understanding of disaster risk which then links to the study of the city's post-disaster economy geography.

## 2.2 Urban Flooding Disasters

### 2.2.1 Climate Change induced effects

The Synthesis Report of the Intergovernmental Panel on Climate Change (IPCC) explicitly mentions with very high confidence that there will be heightened risks for people, assets, economies and ecosystems from climate change-induced storms and extreme precipitation, inland and coastal flooding, sea level rise, storm surges, among other disasters (Pachauri et al., 2014). Peduzzi et al. (2012), Alfieri et al. (2017) and Tanaka et al. (2020) provided empirical evidences on these scenarios through study simulations drawn from a large set of observed meteorological data. According to the authors' modelling, hydrological systems such as lakes, rivers, watersheds, among other bodies of waters will be overwhelmed by more intense rainfall resulting to fluvial and pluvial floods in urban areas. Extreme rainfall is a major source of damage via flooding to humans and assets in two ways: 1) pluvial flooding - rainfall intensity exceeding infiltration and urban drainage system capacity, and 2) fluvial flooding - high-water levels in river over and above bank heights and/or beyond the dike capacity (Tanaka et al., 2020). This susceptibility of cities to the adverse effects of climate variability or extremes has been given focus by the IPCC when dealing with vulnerabilities.

**Figure 5. Average change in population affected and expected damage per country at 1.5 degree celcius standard warming level. Hatching indicates countries where the confidence level of the average change is less than 90% (Source: Alfieri et al., 2017, p. 178)**




Coastal and delta cities as well as low-lying urban areas are at greater risks to these potential threats of flooding disasters as shown in Figure 6. The IPCC further stated in its synthesis report the increasing possibility of submergence, flooding and erosion for coastal systems and low-lying areas throughout the 21st century and beyond due to sea level rise (Pachauri et al., 2014). Aggravating the risks are demographic pressure and assets exposure attributed to economic development, population growth and rapid urbanization (Dahri and Abida, 2020; Hammond et al., 2015; Pachauri et al., 2014). Several small island states and low-lying developing countries are projected to face intense impacts from these climate change-induced disasters (Pachauri et al., 2014; Peduzzi et al., 2012) that could also wreak havoc to a country's gross domestic product (Hammond et al., 2015; Parsons, 2019) and the long-term economic growth (Akao and Sakamoto, 2018). Thus, vulnerability assessment has emerged in climate science and climate policy application (Füssel & Klein, 2006, in (Uddin et al., 2019) to reduce the negative impact of future extreme climate (Adger, 2006). The IPCC (2014) vulnerability framework identifies these three components: 1) exposure – encompasses the presence of people, livelihoods, species or ecosystems (including environmental functions), economic (services and resources), infrastructure, and social or cultural assets in disaster-prone areas, 2) sensitivity – the degree to which the system is affected and 3) adaptive capacity – the ability of the system to cope and maintain crucial functions. Economic vulnerability and economic resilience, interacting with the hazard itself and the exposure of populations and physical assets, are considered to be the critical determinants of the resulting disaster damages and losses (Noy and Yonson, 2018).

**Figure 6. Major natural disasters in different countries from 1960-2012 (Source: EM-DAT, the OFDA/CRED International Disaster Database. Universite Catholique de Louvain, Brussels, Belgium; Guha-Sapir et al., 2017 in Akao and Sakamoto, 2018)**

| | Total | Type (count) |
|---|---|---|
| United States | 770 | Storm (484), Flood (148), Wildfire (60) |
| China | 664 | Storm (216), Flood (206), Earthquake (121) |
| India | 560 | Flood (234), Storm (137), Epidemic (63) |
| Philippines | 521 | Storm (283), Flood (131), Landslide (30) |
| Indonesia | 405 | Flood (151), Earthquake (99), Volcanic (46) |
| Bangladesh | 299 | Storm (148), Flood (85), Epidemic (29) |
| Japan | 228 | Storm (116), Earthquake (40), Flood (35) |
| Mexico | 216 | Storm (82), Flood (57), Earthquake (27) |
| Australia | 209 | Storm (98), Flood (59), Wildfire (28) |
| Russia | 198 | Flood (69), Earthquake (28), Storm (24) |
| Brazil | 197 | Flood (114), Landslide (21), Drought (17) |
| Viet Nam | 179 | Storm (88), Flood (68), Epidemic (10) |
| Iran | 178 | Earthquake (90), Flood (66), Storm (12) |

Through the changing temperatures, precipitation and sea levels, among other factors, global climate change is already modifying hazard levels and exacerbating disaster risks. The United Nations (2015) projected that by 2050, 40% of the global population will be situated in river basins that are very likely to experience severe water stress. The report particularly identified Africa and Asia as the most affected. Economic losses from disasters, including flooding, are now reaching an average of US$250 Billion to US$300 Billion each year. Projected future losses are estimated at US$314 Billion in the built environment alone (United Nations, 2015). In light of the potential losses from extreme weather events, the Disaster Risk Reduction (DRR) and Climate Change Adaptation (CCA) paradigms have figured prominently over the years. The United Nations Office for Disaster Risk Reduction strongly emphasized the systematic response to manage the causal factors of disasters. The IPCC (2014) also put forward the importance of CCA to do necessary adjustments to respond to climate change stimuli or their effects and reduce adverse impacts. While DRR and CCA are interrelated and focus on climate-related disasters, several challenges have been identified in integrating both concepts (Islam et al., 2019).

### 2.2.2 Rapid urbanization and its implication to land use changes and imperviousness

Urban sprawl, being one of the characteristics of fast urbanization, affects land use which is then linked to urban floods (Su et al., 2014). The authors further examined the impacts of urbanization to flooding which extends across hydraulic channels, imperviousness ratio and pattern and urbanized basins. As more people move to the cities they inevitably turn green areas into impervious areas, increasing urban run-off, and as more people live in densely populated urban areas, often situated on flood plains and low-lying coastal areas, their exposure to flood hazards is increased (Hammond et al., 2015). Moreover, the dynamics of the socio-economic system and the expansion of urban areas especially in flood prone plains may significantly contribute to raise the damages from flooding events (Elmer et al., 2012 in (Dahri and Abida, 2020)). The United Nations (2015) reported that since 2000, some 1.6

billion have lost their homes and livelihoods or have suffered other damage as a result of natural disaster.

Floods are also strongly influenced by many human activities impacting catchments, making the attribution of detected changes to climate change difficult. However, recent detection of increasing trends in extreme precipitation and discharges in some catchments implies greater risks of flooding on a regional scale (Pachauri et al., 2014). Moreover, the inadequacy of the urban drainage network to cope up with the rapid urbanization leads to pluvial flooding even with just short-term high-intensity rainfall. This results to city-wide flooding impacting people and economic assets (Tanaka et al., 2020). The emergy approach of Chang and Huang (2015) in assessing urban flooding vulnerability revealed that cities that are experiencing intense urbanization are characterized with high potential impact from flood. This finding emerged from studying urban development pressure, land use and land cover changes, and loss of ecosystem services in the peri-urban environments. Kellenberg and Mobarak (2008) posited that this intense urbanization and development processes can also create or enhance vulnerabilities. Yonson et al. (2018) further supported this view stating that unplanned urbanization is positively correlated with mortality such that disaster fatalities is influenced more by the vulnerability and exposure than by the hazard strength.

Low-income households are often forced to occupy hazard-exposed areas with low land values, deficient or non-existent infrastructure and social protection, and high levels of environmental degradation. Opportunities for employment attracts these low-income families despite the fact that relocation to the urban fringe means enhanced exposure to disasters. The United Nations (2015) raises awareness on the emerging risk-inequality – socially segregated urban development in turn generates new patterns of disaster risk. Thus, urbanization in this case increasingly entices people with inherent vulnerability into harm's way such that they have relatively fewer resources and inadequate capacities to adapt and cope in times of disaster (Noy and Yonson, 2018). Escalated risks were identified for the urban populations who live in slums which therefore do not have enough protection during disasters. Oftentimes, these informal settlers are internal migrants who come from inland remote areas and who are less likely equipped to face catastrophes (Black et al., 2013). Climate change is projected to increase displacement of people. Displacement risk increases when populations that lack the resources for planned migration experience higher exposure to extreme weather events, such as floods and droughts. Relocation and changes in migration patterns can be responses to both extreme weather events and longer term climate variability and change, and migration can also be an effective adaptation strategy (IPCC, 2014). Migration and population mobility therefore play a critical role in the urbanization dynamics of cities and in the creation of more vulnerabilities.

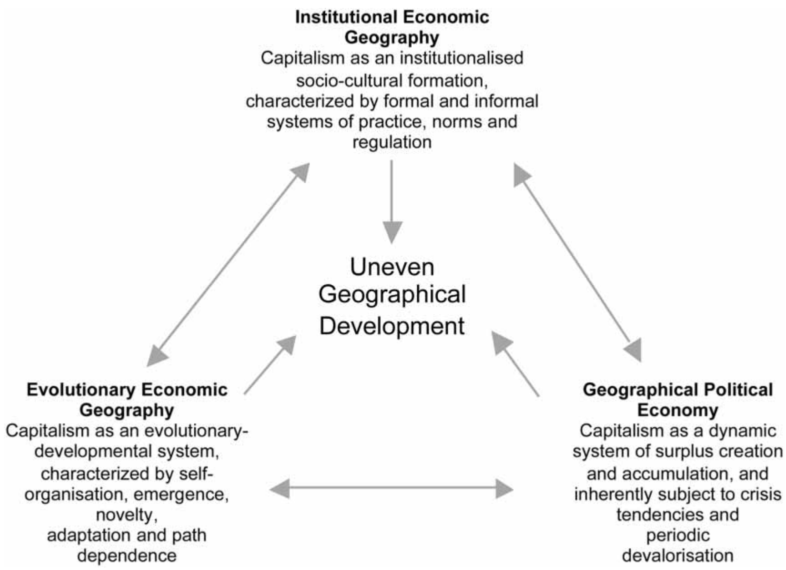
## 2.3 Economic Geography

### 2.3.1 Definition: Establishing a fundamental understanding towards its evolution

The most straightforward definition is given by Barnes (2009, 2013a, in Pászto, (2020) remarking how the concept describes and explains the varied places and spaces in which economic activities emerge and circulate. The author added that it is a contextual subject that is more empirically grounded, less abstract and has been subject to so much change due to its empirical basis. Definitions coming from Maryáš and Vystoupil (2004), Aoyama et al. (2011), Leyshon et al. (2011), and Castree et al. (2013) were synthesized by Pászto (2020), summarizing the concept as a subset of geography focusing on the distribution and location of human economic activities. In modern times, economic geography is divided into positivism, structuralism, and post-structuralism (Coe et al. 2013 in Pászto, (2020). Generally this categorization seeks for principles behind spatial patterns of economic activities using quantitative methods and statistical analysis. Martin and Sunley (2011) introduced cluster-based approach in understanding economic geography, urban studies, regional economics and related disciplines.

Figure 7 below shows the different perspectives when using economic geography in the attempt to better understand the uneven geographical development. There have an increasing interests in recent times in evolutionary theory related with economic development that includes complexity theory and path dependence in its conceptual foundations (Brouder and Eriksson, 2013). Mechanisms and models of evolution and change such as robustness, evolvability, emergence, and self-organization appeared as valuable concepts for understanding systems evolution especially when confronted with external shocks (Martin and Sunley, 2015). Thus, evolutionary economic geography (EEG) gives emphasis on the important elements of change, micro-level agency of firms and individuals, and localised pre-conditions in studies of sectoral development (Brouder and Eriksson, 2013).

**Figure 7. Multiple perspective in economic geography (Source: Martin and Sunley, 2014, p. 726)**



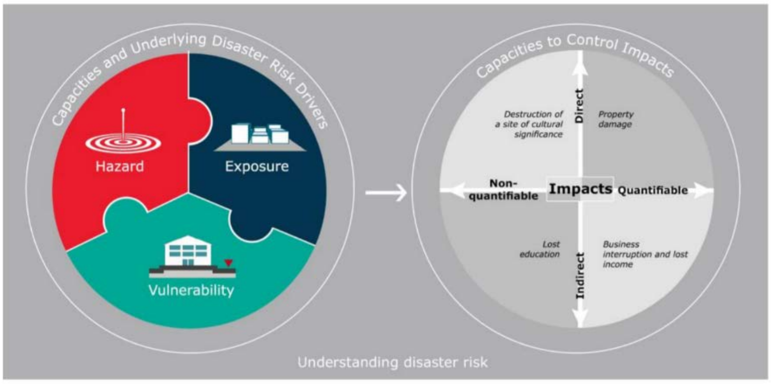
### 2.3.2 Contextualization and Praxis

The actual practice of economic geography should always link to the times (historical) and places (geographic) of the study and must be sensitive to the circumstances in which they happen (Leyshon et al. 2011). Empirical studies conducted related to economic geography is highly contextualized and usually involves economic dimensions. For example, Faisal et al. (2020) explored changes in the tourism sector using distinct parameters of Christchurch City in New Zealand. Noteworthy to mention is how the authors factored in disaster such as an earthquake as a shock that triggered spatial and temporal changes to the tourism landscape of the area. This study took off from the comprehensive technical guide on the economic evolution of the tourism sector studied by Brouder and Eriksson (2013). On the other hand, Plummer and Yamamoto (2019) combined the conceptual foundation of EEG, resilience thinking paradigm and complex adaptive systems in studying nuclear host communities in Japan. Their study uses a quasi-experiment and econometrics methodology to examine how these communities developed ecological resilience in the face of shocks such as an earthquake, economy stagnation and financial crisis. Another applied study was conducted by Imaizumi et al., (2015) to investigate the damages inflicted by the Great Kantō Earthquake in 1923 to the industries in Tokyo prefecture. The authors used a ward- and county-level panel data and examine whether the said temporary shock had a long-lasting impact on the spatial distribution of industries including the changes and shifts in the number and share of industrial workers. In a micro-economic level, Lam et al. (2012) explored the effects of flooding disaster to the business landscape of New Orleans. Key finding in their study were the important determinants for the decision of business owners to re-open. While their study may imply a deployment of economic geography concepts in that it revealed that the business recovery was spatially uneven, the study itself did not explicitly mention about the economic geography concepts.

It can be noted from the above-mentioned studies that, although they differ in methodologies and measurements, their approach on examining changes in economic geography hinges on shocks caused by disasters. These observations support the finding of Barnes et al. (2007, in Pike et al., 2015) that a standardized methodology is rare such that the study of economic geography is methodologically diverse. However, in the disaster discourse, one of the more prominent allied concept of economic geography is the complex adaptive systems theory, which provides an understanding of the cumulative impacts of hazards and the resulting evolution in the economy (Noy and Yonson, 2018; Plummer and Yamamoto, 2019). In line with the complex adaptive systems, the resilience thinking paradigm is also connected. Thus, in the economy and disasters literature, economic vulnerability and economic resilience are both important paradigms. Studying them simultaneously will assist in painting a more comprehensive picture of the total impacts of disasters and how these affected the economic landscape of a city. Related studies also employ quantitative analysis most of the time. It is therefore important for economic vulnerability and resilience to be studied together (Noy and Yonson, 2018) as both are fundamental concepts in understanding the post-disaster economic geography of an area.

In the economic vulnerability and economic resilience literature, Noy and Yonson (2018) conducted a survey of concepts and measurement while Kousky (2014) reviewed empirical literature pertaining to the economic costs of natural disasters. Their findings revealed that the deepened application of economic theory has aided in concretizing the concepts and measurements along the economics of disasters. The myriad of mathematical and statistical methodologies provided a picture of the changes in the economic geography in a country, and regional level. Overall, the number of fatalities and the cost of damage are the main proxies for disaster risk which in most cases are used as dependent variables (Noy and Yonson, 2018). Other equally important approaches, for instance, Rose (2009) stressed the relevance of differentiating between damages to stocks (i.e. property damage incurred at once at the time of the shock) and damage to flow (damages to production of goods and services which continues until recovery is attained) as an important dimension of economic resilience. The United Nations-Economic Commission for Latin America and the Caribbean (UN-ECLAC) introduced the Damage and Loss Assessment (DALA) methodology which adopts the principle of stock-flow damages of disaster impacts. The framework of Hallegatte (2014) attempts to capture the economic resilience by looking at the immediate losses in income resulting from losses in assets (macro-level) and the consumption expenditure trend at the household (micro-level), respectively. The risk assessment process flow outlined in the international standards on risk management (ISO 31000:2009) and on risk assessment (31010:2009) is the most commonly used as reflected in Figure 8.

**Figure 8. Disaster Risk Drivers and Impacts of Disasters (Source: UNISDR, 2017, p. 15)**




As a general consensus, the cross-country empirical studies conducted agree that the level of economic development of a country has a huge bearing to its vulnerability to disasters (Toya and Skidmore, 2007; Raschky, 2008, Anbarci and Escaleras, 2005; Kahn, 2005, in Noy and Yonson, 2018). However, Noy and Yonson (2018) argued that despite the advancement there is still a need for further refinements. Improvements such as the adoption of an integrated approach with a macro- and micro-levels of analysis and identifying a plausible set of indicators to capture and measure the distinct economic vulnerability and resilience of different contexts and circumstances, among many other underlying factors, are still needed. Kousky (2014) also saw the need to capture more the endogenous factors in a disaster-stricken economy which means the internal factors in a country to consider when estimating economic impacts. Indeed, diverse methods and data are employed in the economics of disaster, similar with economic geography, to come up with meaningful calculations and insightful results in determining the economic vulnerability and resilience of a study area.

## 2.4 The Nexus: Linking the effects of urban flooding to the spatio-temporal economic activities of a city

Economic activities in a city tend to spatially cluster in areas where factors of production and other growth-facilitating environment, such as transportation infrastructure support and related services, are available. The concepts of agglomeration and economies of scale are underpinning forces that could explain the spatial clustering of these activities as economic agents seeks to capture the benefits of these economic phenomena (Fujita and Thisse, 2002; Helbing et al., 2007). Location theories, which are regarded as the foundation stone of economic geography, explain some forces why firms and industries decide to locate in certain areas. These theories provide a representation of a landscape-economic pattern and are also considered the disciplinary roots of economic geography (Aoyama et al., 2011 in (Pászto et al., 2020). Location theories try to address the inquiries on 'how' and 'why' spatial patterns of economic activities evolve. Some of the assumptions from these location theories are still valuable today although these are considered classical concepts and therefore some arguments are no longer applicable in modern times.

#### 2.3.3.1 Location Theories and Exposure

Heinrich von Thünen's and Alfred Weber's location theory highly considered factors of production as a critical criteria and regarded land as the most important resource factor. The Central Place Theory developed by Walter Christaller posits two main concepts: 1) the range of good (maximum distance) which consumers are willing to travel for it and 2) the threshold of good which is the required minimum sales to sustain the selling of that good. August Lösch worked on his theory on the Economic of Location where he argued that the optimal location is best acquired such that the difference between total revenue and total cost is the largest. Both Christaller and Lösch came up with hexagonal diagrams to represent this spatial idea which divides a certain geographical area into activity-rich (core which might be the central business district) and activity-poor (periphery). Aoyama et al., 2011 in (Pászto et al., 2020) duly noted the importance of critical factors that shape the area's growth like the regulations, entrepreneurship and migration which are excluded in the hexagonal market models. While there are other location theories espoused by other authors this will not be exhaustively discussed here. The aforementioned location theories are the most prominent ones and they establish foundational understanding on how firms' and industries' locations vary in space.

In recent decades, investments tend to flow to locations that offer comparative advantages, including access to markets, infrastructure services, low labor costs and stability. Investment decisions hardly take into consideration the potential level of hazard exposure in those locations, and opportunities for short-term profits continue to offset concerns about future sustainability. Consequently, large volumes of capital flow into hazard-prone areas, leading to significant increases in the value of exposed economic assets (United Nations, 2015). In the context of developing countries, Kellenberg and Mobarak (2007) argue that such type of economic development may actually aggravate the risk for people in urban areas due to disaster-insensitive micro-behavior decisions of firms. The empirical studies of Akao and Sakamoto (2018) and Tanaka et al. (2020) provided evidences of the negative economic effects of floods and disasters which could potentially undo many years of capital accumulation. As part of the global attempt to develop assessment indicators for the Sendai Framework for

Disaster Risk Reduction 2015–2030, the United Nations General Assembly adopted the following formulation: "Disaster Risk = f (Hazard, Exposure, Vulnerability, Capacity)". Disaster Risk is defined as "the potential loss of life, injury, or destroyed or damaged assets which could occur to a system, society, or a community in a specific period of time, determined probabilistically as a function of hazard, exposure, vulnerability, and capacity." Disaster Risk is a crucial element which must be examined to measure its impacts on the economic growth and performance of a city.

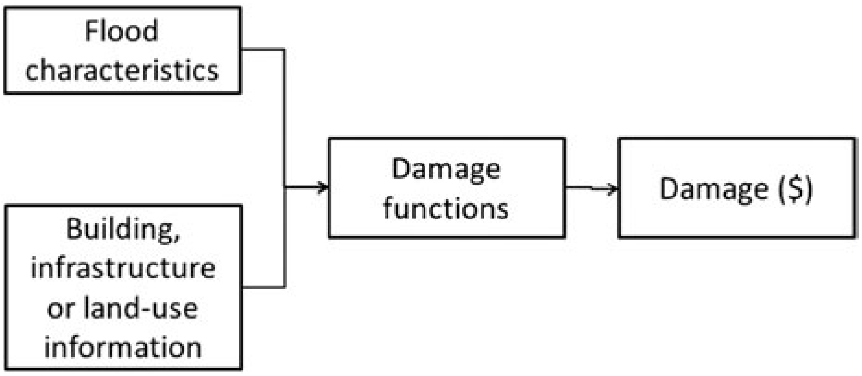
#### 2.3.3.2 The economics of disaster: looking at consequential damages

A point of convergence for urban flooding and economic geography can be understood first by looking at the direct and indirect damages from a disaster. Table 2 below basically captures these categorical damages and provides insights on how these impact the economic landscape of an area. An important point to mention, however, is that the full range estimation of economic costs from natural disasters is complex and very challenging on the conceptual and practical level (Kousky, 2014). In the empirical literature, scholars used different variables and indicators to get the best estimates, applying resourcefulness and analysis amidst limited datasets. GDP and GDP-related indices are the most commonly used measures in disaster impact studies (Toya and Skidmore, 2007; Noy, 2009; Noy and Yonson, 2018; Noy and Vu, 2010). These empirical studies however are usually examined at the cross-country, country and provincial levels where data is available on aggregate levels. They also differ as to the short-run or long-term economic consequences. The methodologies in these researches also came with criticisms. For instance, endogeneity problems arise as some socio-economic and political factors may also have affected the GDP trend in a country (Kousky, 2014) and not just merely attributable to the disaster.

**Table 2. Direct and Indirect impacts from a disaster (Source: Kousky, 2014, page. 578)**

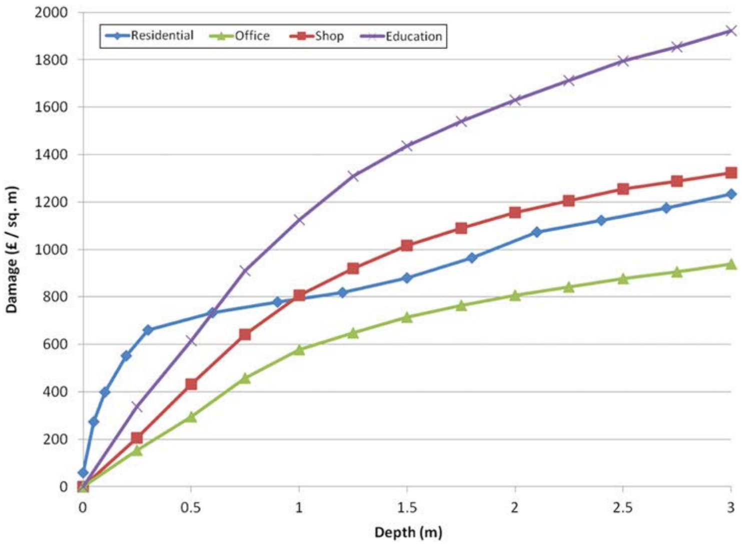
| Direct impacts | Indirect impacts |
|---|---|
| • Damage to homes and contents<br>• Damage to firm capital and lost production<br>• Damage to infrastructure<br>• Mortality and injury<br>• Environmental degradation<br>• Emergency response and clean-up | • Business interruption (for those without direct damage)<br>• Multiplier effects<br>• Costly adaptation or utility reduction from loss of use<br>• Mortality and injury<br>• Environmental degradation |

**Figure 9. Main steps in flood impact assessment (Hammond et al., 2013, p. 19)**



Hammond et al. (2015) explained two main approaches to developing damage functions from floods as shown in Figure 9. The first one is the empirical method which acquires data through the use of real flood damage or survey data. The second approach is the synthetic method which is a more hypothetical analysis based on land use cover and patterns, type of objects, information of questionnaire survey, etc. Accordingly, it is similar to a 'what-if' analysis, and asks what damage would have resulted if the flood waters were have reached a certain depth within a property. However, some authors argued that empirical damage functions derived from real data are more accurate than synthetic data (Gissing and Blong 2004, in (Hammond et al., 2015)). In simpler terms, Ranger et al. (2011, in (Hammond et al., 2015)) assessed flood damage in city large scale modelling as a binary or boolean function of whether the area is flooded or not. Much of the focus on determining the damage caused by flooding inclined towards the flood depth. This points back to the concept of stage-damage curves introduced by Gilbert F. White (1945, in (Hammond et al., 2015)). Depth-damage or stage-damage curves (Figure 10) have been applied in many areas around the world and is considered a standard technique within flood risk management (Hammond et al., 2015)

**Figure 10. Typical depth-damage functions (adapted from UK multi-coloured Manual (Penning-Rowsell et al., 2005, in Hammond et al., 2013, p. 18)**




Looking on the effects of flooding, Seifert et al. (2009 in (Hammond et al., 2015) determined flood loss data in 2002, 2005 and 2006 in Germany and discover significant correlations between the length of business interruption and flood depth, duration, velocity, flow, contamination and business size. In terms of infrastructure, determining flood effects is rather complicated to estimate as these elements are often highly specialized and they form part of a wider network (Hammond et al., 2015). Identifying the interdependent linkages of these infrastructure networks (e.g. interruptions in electricity and water supply and telecommunications due to damaged roads) is especially difficult. Merz et al. (2004, in (Hammond et al., 2015) studied nine flood events from 1978-1994 and found that flood inundation depth alone cannot explain the variation in property damages. Noy (2009) suggested the indexing approach as a measure of disaster effects. However, he noted that the primary data collection to create such index would be a tedious undertaking. Table 4 shows the projected damages to several sectors and effects to population from flood disasters.

**Table 3. Modeled population affected and damage for each continent in the baseline scenario (ensemble mean), together with sector disaggregation of damage (Source: Alfieri et al., 2017, p. 177)**

| | | Damage | | | | | |
|---|---|---|---|---|---|---|---|
| | Population Affected (millions/yr) | (B€/yr) | Agriculture (%) | Residential (%) | Commercial (%) | Infrastructure (%) | Industrial (%) |
| Africa | 16.5 | 6.5 | 13 | 36 | 33 | 0 | 17 |
| Asia | 35.0 | 35.9 | 7 | 39 | 32 | 1 | 21 |
| Europe | 0.5 | 4.6 | 1 | 45 | 32 | 1 | 21 |
| North America | 0.8 | 1.8 | 2 | 46 | 27 | 6 | 20 |
| Oceania | 0.1 | 4.9 | 1 | 48 | 32 | 0 | 19 |
| Russia | 0.2 | 3.2 | 1 | 43 | 34 | 0 | 22 |
| South America | 1.1 | 1.5 | 7 | 39 | 31 | 1 | 22 |

As previously mentioned, empirical literatures on the economics of disaster are dominated by country-level studies. One of this is the study of Noy (2009) which attempted to quantify disaster risk impacts to the macro-economy in the short-run as well as examine its determinants. Key findings in his study using 109 cross-country panel data show that disaster damage to capital stock results in reduced macro-economic growth and the change in output growth (in percent Gross Domestic Product) among developing countries with small economies are greater than the developed nations. GDP and GDP-related indices are the most commonly used measures of economic performance, including in disaster impact studies (Toya and Skidmore, 2007; Noy, 2009; Noy and Yonson, 2018). More recently, by focusing on countries' exposure to tropical cyclones during the 1950–2008 period, Hsiang and Jina (2014, 2015 in Akao and Sakamoto, 2018) present evidence that national incomes decline, relative to their pre-disaster trend, and do not recover within 20 years. It is observed that there is a very limited empirical literatures pertaining to disaster cost and economic consequences on a city scale. Most literatures cover country, inter-country level data, and provincial level. The study of Faisal et al. (2020) of a post-earthquake Christchurch City in New Zealand (Figure 11), as well as the research of Lam et al. (2012) on post-hurricane New Orleans, USA (Figure 12) can be considered exceptions but their analysis are highly qualitative in nature. Both studies conducted interview and focus group discussions with stakeholders.

**Figure 11. Spatial shifts in economic activity from East to West: Composite Activity Indicator Map as of November 2012 (Source: CDC, 2013, in Fasial et al., 2020, p.10)**

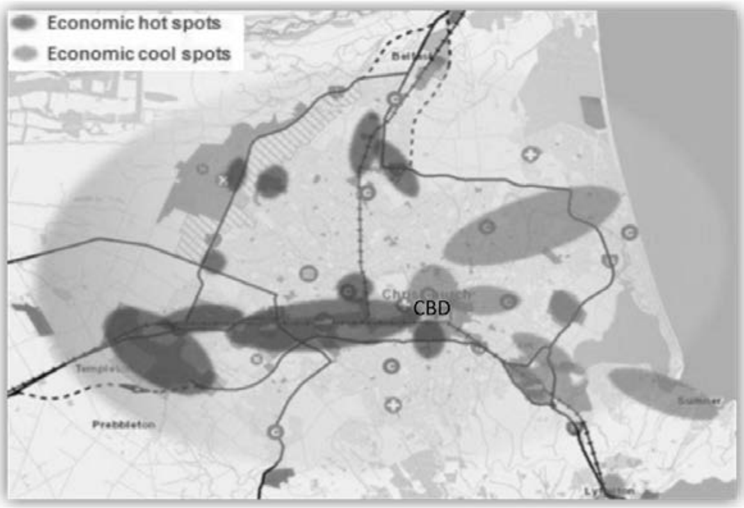
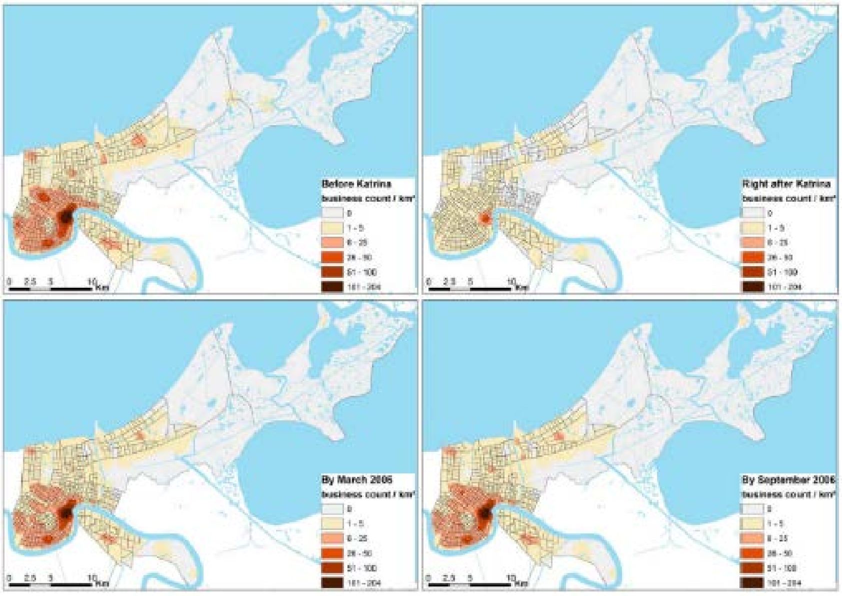


**Figure 12. Kernel density maps of opened businesses in New Orleans Parish in different time periods (Source: Lam et al., 2012, p. 5)**



In another spatial perspective, disaster impact to the economic landscape or geography can be understood in terms of cluster changes. For example, in the perspective of small and medium business firms, Lam et al. (2012) studied the predictors of business returns from a post-hurricane scenario and found out that disaster impact (flood depth experience), business size and the decision of the community to return are important determinants for business re-opening. Another example is the study of Imaizumi et al., 2015 which shows the mean shifts and trend shifts in the share of industrial workers in order to derive the spatial distribution of industries in the affected and non-affected prefectures in Japan. Relevant findings of the study also reveal that the growth trend of the number of workers in non-damaged areas is relatively higher than that of the damaged areas from a large disaster shock. Both the studies of Imaizumi et al. (2015) and Lam et al. (2012) show uneven spatial development after a disaster in a district and prefecture district levels, respectively. The work of Faisal et al. (2020) on the other hand showed a locational shift of the thriving tourism sectors caused by an intense earthquake. Key findings in their study showed that the Central Business District's rebuild and regeneration, long-term closure of city center areas, adapted destination marketing strategies, changes in resident and visitor demographics, and significant shifts in market demand cumulatively caused significant changes in the built environment and economic landscape of the area in terms of customer and market demographics. Therefore, spatial clustering of the industries, businesses and other certain economic indicators can provide insightful reflections of locational shifts that happened after a major disaster.

#### 2.3.3.3 Population density changes: Fatalities, Displacement and Relocation

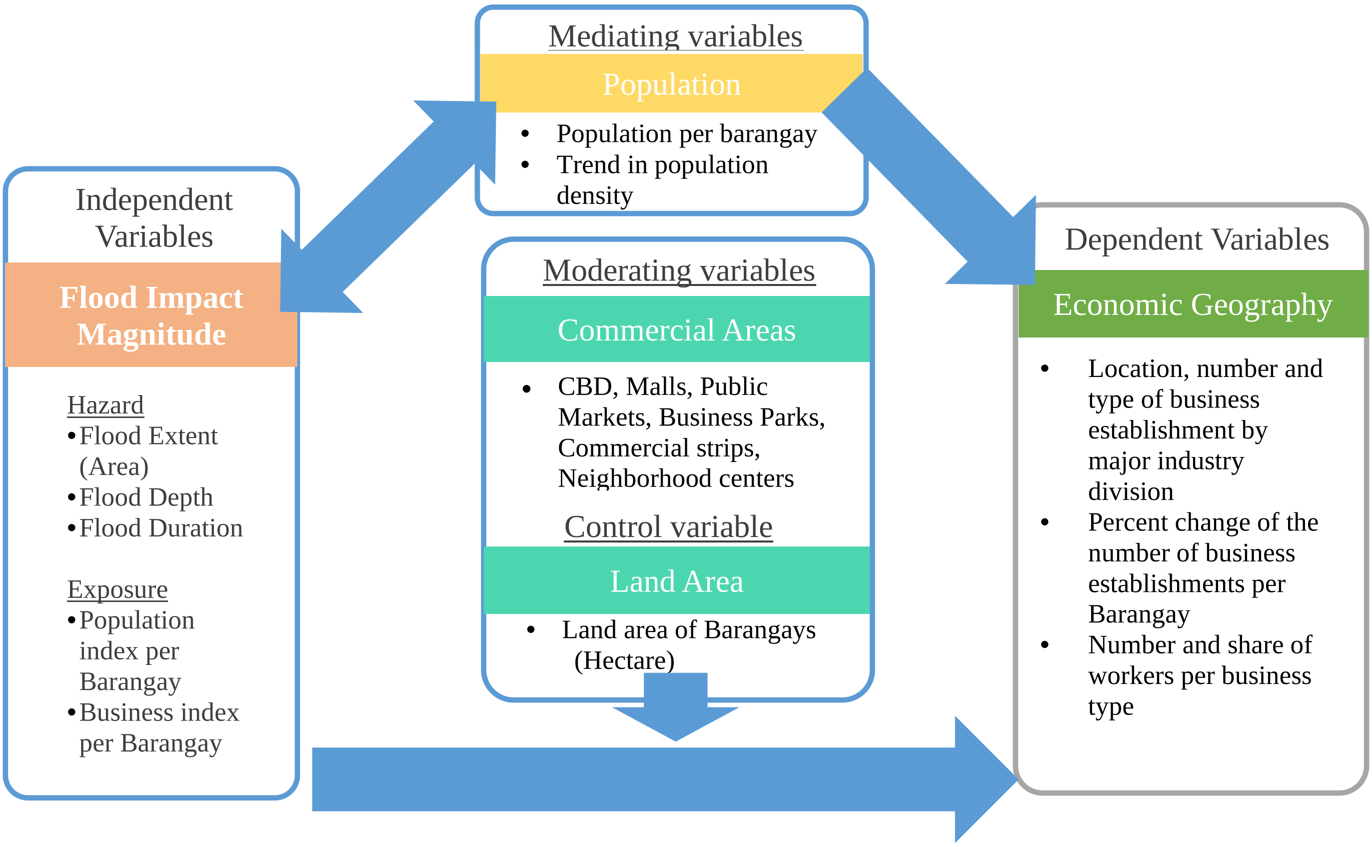
Apart from physical damages, disasters also cause fatalities and displaced people. These consequences can extend to functioning disruptions of the affected communities and traumatic change of survivors' lifestyle and living conditions (Carrasco et al., 2016). Various outcomes of mobility like displacement, immobility and migration (Black et al., 2013) are evidences of adaptive capacities with regards to exposure to climate-induced disasters (McLeman and Smit, 2006; Sakdapolrak et al., 2016); Foresight, 2011). Internal migration also happens as an outcome of the interaction of exposure and vulnerability to climatic and environmental threats, and community's adaptive capacity (Black et al., 2013; McLeman and Smit, 2006; Sakdapolrak et al., 2016). There are empirical evidences from literature that attest people's tendency to migrate in order to adapt depending on their endowed capitals. On a study by Frey et al. (2007, in(Henry, 2013) following post-Katrina demographic data in 2006 of New Orleans, the metropolitan area's population was fewer compared to pre-disaster scenario. The movement adaptation strategy a household pursues is based on the type of change, constraints and available resources (Berlemann and Steinhardt, 2017). Henry (2013) concludes that there were various reasons but no specific factor, and the recovery aspects, such as jobs or housing (or its absence) may not assure the return or relocation of affected people.

Population also plays a major role in economic growth and performance. The study of economic growth always includes a purely demographic and purely economic component (Peterson, 2017). As mentioned above, economic growth is usually measured in GDP (indicator of economic output) and it is also associated by the population times per capita GDP. There are extensive literature studying the relationships between them yet little consensus on the actual effects of population on economic growth (Heady and Hodge, 2009, in Peterson, 2014). Famous neoclassical growth model of Robert Solow (1956) and Thomas Maltus (1993) both argued that population growth has negative relationship with economic growth in terms of the finite resources and distributional effects of economic output. Bucci (2015) and Mierau and Turnovsky (2014) counter-argue emphasizing the population's positive effects towards innovation and greater specialization. Despite these opposing claims, there seems to appear some agreement in the literature that the nature of relationship of both concepts is highly dependent on the particular circumstance (e.g. demographic structure) in the various countries and regions that determines the type of workforce and employment (Peterson, 2014).

**Postlude:**

The literature pertaining to the empirical methods of studying economic geography has rather taken a diverse directions (Martin and Sunley, 2015; Pászto et al., 2020; Pike et al., 2016). However, the linkage of the urban flooding to the human economic activities (Hammond et al., 2015) is clear enough by looking at the economic vulnerability and economic resilience paradigms (Noy and Yonson, 2018; Uddin et al., 2019) to understand disaster risk. Deploying spatial and statistical analytical tools may provide a story that could tell the city's post-disaster economic revitalization and developmental evolution. Thus, this research hopes to contribute to the understanding of uneven geographical development with a different type of shock (flooding). The perspective and parameters in this research attempts to shed more light towards an enriched understanding of the economic geography literature in the context of disasters.

## 2.5 Conceptual Framework




Source: Author, 2020

There are four main elements identified to model the conceptual framework. The independent variable is the flood impact magnitude in which the research will attempt to examine its effect to the dependent variable, the city's economic geography. In a spatial context, the research will take a closer look at the extent, depth and duration scales of the flood and the post-disaster hot-spots and cold-spots clusters of economically thriving sub-area units. The independent variable is further subdivided into two parts: hazard and exposure. The hazard basically captures the characteristics and intensity of the flooding disaster. Exposure refers to the people and assets situated in the hazard-prone areas. The hazard and exposure applied herein are consistent with the definition of the UNISDR (2017) in the operationalization of the disaster risk assessment. A before and after scenario shall be studied to determine if there are significant changes in the location and distribution of human economic activities. So, aside from the more popular location theories, economies of scale and agglomeration, among other economic forces, this research will examine flooding as another factor that influence economic geography.

Density shifts of the population shall be treated as a mediating variable. This indicator captures population changes per barangays due to fatalities, displacement, and relocation of people as a result TS Sendong, as well as a migration patterns where people locate to areas which are not flood-prone. Several areas in the city have been designated as no-build zones, and buffer zones were also established to mitigate future losses from flooding disasters. Some areas in the city are allocated for residential uses to accommodate resettlements and displaced people. In a related study, Su et al. (2014) found that zoning affects imperviousness of urban areas to manage urban flood and water flow. Applying the neo-classical location theories, these land-use change-induced population movements implies consequential effects to the location of the businesses and industries in the city. Typically, both the number and composition changes in the population occur with economic changes (Faisal et al., 2020; Peterson, 2017). Thus, the assumption is that where there is greater population concentration in an area, there are more likely economic activities thriving within. This is one of the findings of Faisal et al. (2020), Lam et al. (2012) and Imaizumi et al. (2016) when factoring in population density changes in disaster affected areas. The behavioral economics in the climate adaptation research may shed light on people's mobility within a city in avoiding flood prone areas and relocating to a relatively safer/higher grounds. Also, the study of Lam et al. (2012) related to Hurricane Katrina in New Orleans revealed that the decision of community to return is a significant predictor for the re-opening of the business establishments in flood inundated areas.

Commercial areas is also included as a moderating variable. Intuitively, the availability of the commercial areas such as the CBD, Malls, Public Markets, Business Parks, Commercial Strips and Neighborhood Centers also influences the survival and/or recovery of businesses establishments. These are considered pre-conditions of agglomeration and economies of scale wherein its presence can facilitate market exchange and can spur high market activities to help business establishments recover, thrive and/or survive. Such endowment of economic infrastructures in select areas in the city enhances access to market and information which are critical elements of agglomeration. As mentioned in section 2.3.3, agglomeration and economies of scale are supporting forces that could explain the spatial clustering economic activities (Fujita and Thisse, 2002; Helbing et al., 2007). This is also aligned with the location theories as extensively discussed by Paszto (2020). Additionally, land area is included as a control variable and is hypothesized to influence the number of business establishments that a barangay can accommodate to make space for other non-commercial land uses. These variables are included in the analysis which will be discussed further in the next chapter.

The dependent variables encompass the spatial and quantitative dimensions of the business establishments in the city. As economic geography refers to the location and distribution of human economic activities, this research shall examine the trend in the dependent variable. These changes shall cover the immediate effects (one year: 2011-2012) and long-term effects (4-years: 2011-2015) effect of the flooding disaster. This study shall also look at the spatial and temporal changes in the number and distribution of the business establishments in the city.

# Chapter 3: Research design, methods and limitations

This chapter discusses the logical and methodological approach undertaken towards the research design, data collection, and data analysis. As an explanatory research, the primary purpose is to explain how the flooding disaster from TS Sendong affected the number, location and distribution of the identified economic variables and examine their relationships (Yin, 2002, in Yazan 2015). This research seeks to explain the relational linkages among the variables supported by the concepts and empirical findings presented in chapter 2 on urban flooding and the consequential impacts to the population density shifts and economic geography of Cagayan de Oro City.

## 3.1 Description of the research design and methods

The research follows a mixed design of a case study and desk research. This will give more focus towards having an in-depth approach rather than breadth in studying a real-life setting (van Thiel, 2014). Thus, the main question is contextualized to an urban phenomenon that occurred in a specific city. Key reasons for the choice of case study and desk research is to be able to extensively describe and explain the effects of such event by drawing in a relatively small research units – the sub-area of the city called 'barangays' – and many variables from an extensively available secondary datasets. A case study is also suitable in a sense that it was the first time for the city to experience such kind of a flooding disaster with immense magnitude and impact.

Specifically, a co-variation type of a case study is conducted. The co-variance analysis allows a close investigation of how certain factors from the independent variables make differences in the dependent variable (Blatter and Haverland, 2012). In this case, the independent variable will be the urban flooding (X), the mediating variables is the population density shift (M), the commercial areas (W) shall be treated as the moderating variable and the economic geography will be the dependent variable (Y). Moreover, the co-variance type of case study assumes concrete observations and values of the variables over space or time to establish causal relationship among them (Blatter and Blume, 2008). Various research methods are also applied which results can be triangulated and analyzed independently as well as their interrelations and spatial characteristics. The details on triangulation are described in the section about validity and reliability section of this chapter.

A mixed complementary method of quantitative and spatial analyses is employed. The correlation analysis among the variables is done through a cluster methodology approach using the geospatial software, ArcGIS and GeoDa. Descriptive and inferential statistics were also conducted for data processing. Sub-units 'barangays' will be distinguished within the larger unit (city) to have layered or nested approach in the design (van Thiel, 2014). A large number of empirical observations from a rich secondary datasets are used to arrive at a statistical generalization of cases (Blatter and Haverland, 2012). The details of these methodologies will be further described in the succeeding sections.

## 3.2 Operationalization: variables, indicators

Based on the conceptual framework, research variables and indicators are derived and categorized under four types: independent variables (X), dependent variable (Y), mediating variable (M) and moderating variables (W).

The X variable, urban flooding, is further subdivided into three indicators: flood extent, flood depth and flood duration. The data per indicator will be aggregated in altogether to derive the flood impact and magnitude index together with the exposure indicators. This will be further discussed in the data analysis methods in 3.2.2. The purpose of computing the index score is to put a value in each barangay which will be subjected into geospatial processing to get the cluster-based pattern of hotspot areas where extent of flood damages are relatively high.

The Y variable, economic geography, is composed of the location, distribution and quantity of the business establishments per barangay. This variable will be processed further to derive the business industry index which will then be subjected into geospatial processing to get the cluster-based pattern of hotspot areas where economic activities are relatively high, before and after the flooding disaster.

The relevant empirical information from the secondary data sources are used to determine the scores for each of the variables. In the case study design, this is what Blatter and Haverland, (2012) refer to as 'variable-scoring observations'. This explanatory case study will also utilized a large number of empirical observations to ensure that each score is valid. Data analysis and geospatial processing will then be conducted taking off from the rectangular data sheet (attribute table in the GIS parlance) where all scores have been transferred.

The M-variable is the population density shifts per barangay. This mediates the independent and dependent variables in the sense that the flood affected the people and consequently this also affected the business establishments of the barangay. This variable attempts to capture population changes due to fatalities, relocation of affected people and settling-in of the population to relatively safer plains away from the flood-prone areas.

The W-variable encompasses all the commercial areas in the city. These include the Malls, Public Markets, Business Parks, Commercial Strips, Neighborhood Centers and the CBD-conditionality. The presence of these economic infrastructure also produces a moderating effect as its availability can influence the survival or creation of new business establishments in the post-disaster scenario.

Table 5 provides an overview of the concepts operationalized by different variables and indicators and also shows the corresponding research analysis done.

**Table 4: Operationalization of research concepts**

| Concept | Variable | Definition | Indicators | Source of data | Analysis |
|---|---|---|---|---|---|
| *Independent Variables* | | | | | |
| Disaster | Urban Flooding | Submergence of urban plains into water as a result of fluvial and pluvial flooding caused by increased intense rainfall or precipitation in year 2011 | flood extent in hectares (ratio of flooded area against the city's total area) (Chang and Huang, 2015; Hammond et al., 2015) | • City planning and development office<br>• River Basin Flood Modelling Study | Geospatial Hot Spot Analysis, Descriptive and Inferential statistics, spatial regression |
| | | | flood depth (level of flood waters experienced in meters) (Dahri and Abida, 2020; Hammond et al., 2015) | • Climate Exposure Database (ClimEx.DB)<br>• River Basin Flood Modelling Simulation Study | |
| | | | flood duration (days in took for the flood waters to subside) (Hammond et al., 2015; Tanaka et al., 2020) | • Climate Exposure Database (ClimEx.DB) | |
| *Dependent Variables* | | | | | |
| Economic Geography | Economic Performance / Output | The growth or decline of economic activities per sub-area unit (barangay) from 2011-2015 | Number and type of business establishment by major industry division (e.g. agriculture, fishery & forestry, mining & quarrying, manufacturing, construction, transport, storage & communication, wholesale and retail trade, financing, community | City finance department | Geospatial Hot Spot Analysis, Descriptive and Inferential statistics |

| Concept | Variable | Definition | Indicators | Source of data | Analysis |
|---|---|---|---|---|---|
| | | | social services, etc.) (Faisal et al., 2020; Imaizumi, 2016; Lam et al., 2012) | | |
| | | | Number and share of workers per business type (Imaizumi, 2016) | | |
| *Mediating Variable* | | | | | |
| Population | Population density shift | Number of people per sub-area unit (barangay) in year 2010 and 2015 | Trend in population density (Lam et al., 2012; Peterson, 2017) | Philippine Statistics Authority and Local census | Mediation analysis, spatial regression |
| *Moderating variable* | | | | | |
| Commercial areas | Inventory of commercial areas in the city | Places of high economic or market activities. Pre-requisite for agglomeration and economies of scale to happen | Presence of the Central Business District, Malls, Business Parks, Public Markets, Commercial Strips and Neighborhood centers (Fujita and Thisse, 2002; Helbing et al., 2007) | City Planning and Development Office | Moderation analysis and spatial regression |
| *Control variable* | | | | | |
| Land Area | Barangay land area | The administrative /political boundary of a barangay | Barangay land area | City Planning and Development Office | Spatial regression |

### 3.2.1 Data collection

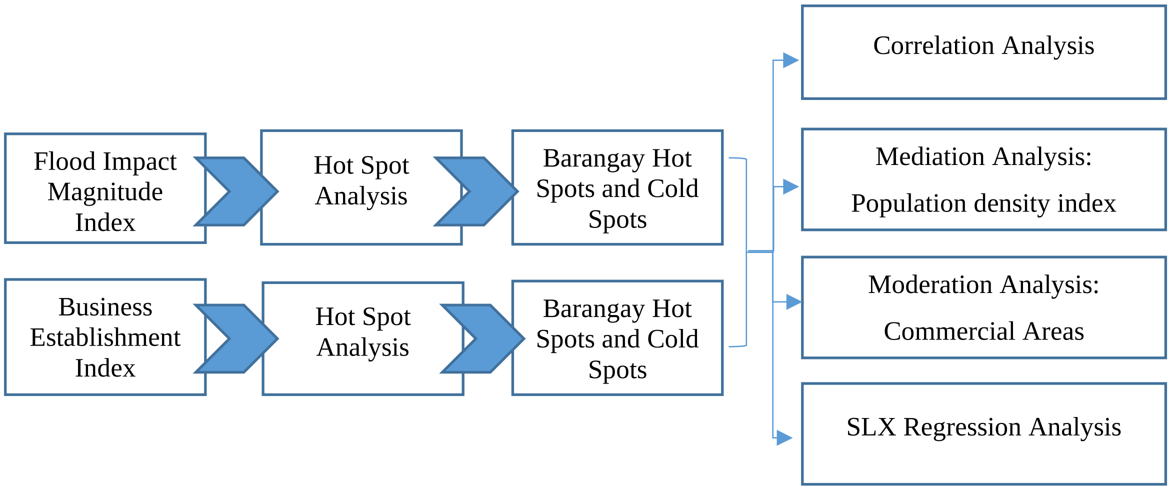
This study utilized a rich quantitative secondary datasets gathered from a survey and those available at the local government offices in Cagayan de Oro. All the 80 sub-area units or barangays will be used as the sample units. In 2014, a comprehensive survey was conducted among the population of flood affected barangays where 11,251 household samples are gathered, compiled and stored in the Climate Exposure Database (ClimEx.DB). This is a rich dataset composed of household profile and the disasters experienced including building characteristics and production areas to be used for disaster risk reduction and planning purposes. Household data are georeferenced with coordinates. The Climex.DB will be used for secondary statistical analysis. It has been designed as a tool to ascertain the vulnerability of people, structure, and socio-economic activities of a risk-communities due to flooding.

Another excellent data source also used in this research is the River Basin Flood Modelling. This flood modelling simulated the resulting fluvial and pluvial flooding based on the actual TS Sendong hydrologic parameters and rainfall data. As mentioned in Chapter 1, the urban flooding that happened was characterized with a 75-year return period. This flood modelling comes in a form of a shapefile – a GIS-ready file format. The map depicts different flood depth levels ranging from 0 to above 5-meter levels. The flooding simulation covered the profile and cross-section surveys, inflow measurements, and flood inundation modeling and, watershed and climate change impact analyses as well as actual rainfall and land cover data. Robust and sophisticated hydrodynamic methodologies were used in this simulation making it a reliable source of data.

Economic indicators are also requested from the city finance department of Cagayan de Oro. This is in the form of a master list of the business establishments in the city from 2010 to 2015. The data are disaggregated per barangay. The number of business establishment operating within a certain barangay shall serve as the proxy indicator of the economic performance/dynamism of the area. Based on this registry of business establishments, employment data will be extracted to determine changes in the major sources of employment at the city level.

### 3.2.2 Data analysis Methods

**Figure 13. Overview of the Research Methodology**




The flow of methods is presented in Figure 13. The details of each process is further elaborated in the next sections. As an overview, two types of hot spot maps are generated to determine: 1) the clustering of areas where flood impact was severe, and 2) the areas in the city where the business establishments are highly concentrated. One hot spot map is created for the flood impact of TS Sendong which happened in 2011 and five hot spot maps are produced for the business establishment index covering the period 2011 to 2015. These gave a visualization of how the flooding disaster affected the concentration of business establishments in the city in the short-term (2012) and long-term (average change of business industry index from 2011-2015). In a purely quantitative measure, the correlation analysis tested the statistical relationship of the flood impact magnitude index as against the business establishment index spanning the temporal stretch of five years. A test of mediation is also conducted to determine the effect of the population density shifts to the resulting number of business establishments per barangay. The moderation effect of the city's commercial areas is measured to see how it alters the causal relationship of the flooding disaster to the business establishments. Considering the non-causality nature of the correlation analysis, a spatial regression using the SLX model is performed to determine the strength of the effect of the flooding explanatory variables to the business establishments per barangay and also factoring in the predictor variables of the neighboring barangays. Each of these methods will be further discussed in the succeeding sections.

### 3.2.2.1 Weighting and Aggregation of Variables, and the Creation of Indexes

The flood variables, which cover three indicators, are weighted and aggregated together. Thus, the Flood Impact Magnitude Index (FIMI) is created to determine the extent of the flood effects per barangay. For alignment and consistency, the FIMI takes off from the disaster risk formulation adopted by the United Nations General Assembly for the Sendai Framework for the Disaster Risk Reduction 2015-2030. The derivation of the index is contextualized as follows where hazard refers to the characterization of the flooding indicators and exposure refers to the people and asset exposed in the flooding disaster:

**Equation 1. Flood Impact Magnitude Index as a function of Hazard and Exposure:**

*Disaster Risk = f (Hazard, Exposure, Vulnerability, Capacity)* → *FIMI = f (Hazard, Exposure)*

The vulnerability and capacity are excluded in the derivation of the index to abate over complication of this research. Further, the focus of this research per se also delves into the economic geography and not on the intense in-depth examination of the overall disaster risk.

The population and business establishments per barangay were also indexed using the simple Location Quotient (LQ) formula where S refers to the share of the unit being measured, the sum of the shares (sum of S), and T refers to the total of all units measured and the sum grand total (sum of T)

**Equation 2. The Location Quotient Formula**

$$LQ = (S \div \Sigma(S)) / (T \div \Sigma(T))$$

The LQ is a tool used to determine the spatial distribution (clustering/dispersal) of a phenomenon in a sub-area unit, compared to the entire city. It is commonly used for spatial data, human geography and economics. It gives a result of <1, 1 or >1. The greater the quotient the more there is high spatial concentration in an area. The LQ is the method used to normalize the variables in this study. Thus, taking off from the location quotient formula, the population index and business industry index are computed as follows:

**Equation 3. Derivation of Population Index per Barangay**

$$PopIndex_i = (BPopn_i/BLA_i)\ /\ (CityPopn\ /\ \text{CLA}),$$

where $_i$ refers to the barangay level; BPopn refers to the barangay population; BLA refers to barangay land area; CityPopn refers to the whole city population; and CLA refers to the total land area of the city.

**Equation 4. Derivation of Business Industry Index per Barangay**

$$BizIndex_i = (BBiz_i/BLA_i)\ /\ (CityBiz\ /\ \text{CLA}),$$

where $_i$ refers to the barangay level; BBiz refers to the number of business establishments per barangay; BLA refers to barangay land area; CityBiz refers to the total number of business establishments in the city; and CLA refers to the total land area of the city

As one of the parameters of the FIMI, the flood extent index (FEI) is computed first being the relative measure of the ratio of percentage of the flooded area experienced in the barangay to the percentage of the city level. This will provide information on which areas in the city are relatively more affected than the others in terms of flooded area. Taking off from Equation 2, this is computed as follows:

**Equation 5. Derivation of the Flood Extent (flooded area) using the location quotient formula:**

$$FE_i = (FEB_i/\ \Sigma\ BA_i)\ /\ (FEC\ /\ \Sigma BA_{total}),$$

where $_i$ refers to the barangay level; FEB refers to the flooded area of a barangay; BA refer to the total land area of a barangay; FEC refers to the total flooded area of the entire city; and BA refers to the total land area of affected barangays. An FEI of greater than 1 indicates that the extent of the flooded area within a barangay is greater than that at the city level. Conversely, a value of less than 1 means relatively lower barangay-level flooded area.

The weighting and aggregation of the hazard and exposure variables are done using the Analytical Heirarchy Process (AHP) developed by Saaty (1971). AHP is both a theory and methodology for relative measurement which proportionate different components for a multi-criteria decision-making (Brunelli, 2015). This method has been used extensively in the literature to derive the flood hazard index such as in the study of Kazakis et al. (2015a) and the additional parameters introduced in the investigation of Dou et al. (2017). Weighting by AHP is widely used in many applications (Valle Junior et al., 2014; Oikonomidis et al., 2015 in Brunelli, 2015) and is recommended to be used for geographical studies (Ayalew and Yamagishi, 2005 in Brunelli, 2015).

After the FEI is computed, weights are then assigned to the flooding variables as shown in Equation 4 below. This to derive the flooding impact magnitude index (FIMI). Based on the literature, the focus most often on determining the damage caused by flooding is towards the flood depth ((Lam et al., 2012); Gilbert F. White, 1945, in (Hammond et al., 2015). However, the AHP method is used in deriving the weights for it to be methodologically sound and unbiased. Therefore, the FIMI is an aggregation of three flood indicators based on their respective weights that shall form the latent construct of the degree of flooding experienced per sub-area in the city. The whole methodology of deriving the weights for each parameter of the FIMI is further discussed in Chapter 4.

**Equation 6. Derivation of the Flood Impact Magnitude Index**

$$FIMI_i = \sum_{i=1}^{n} r_i * w_i = (FE_i * W_{FEI}) + (FDe_i * W_{FDEI}) + (FDu_i * W_{FDUI}) + (PopIndex_i * W_{PopIndex}) + (BizIndex_i * W_{BizIndex})$$

where $r_i$ refers to the value of the parameter per barangay; $FE_i$ is the flood extent (area); $FDe_i$ is the flood depth (meters); $FDu_i$ is the flood duration (days); $PopnIndex_i$ is the population concentration per barangay; $BizIndex_i$ is the business establishment concentration per barangay; the W are the corresponding weights of each parameter; and n is the number of criteria/parameters.

### 3.2.2.2 Hot Spot Analysis: Flood Impact Magnitude Index (FIMI)

Clustering of sub-area units within the city is first determined to check whether there are patterns emerging based on the extent of the urban flooding following the 2011 Tropical Storm Sendong. The extent will be determined through the FIMI, which is the flooded area, flood depth, flood duration, population index and business index. Various reports have indicated that the flood waters had significantly damaged roads and bridges in the city (Regional Development Council, 2012). The purpose is to identify barangays with greater or lesser extent of flood impact experienced relative to the rest of the city. As Noy (2009) posited, indexing of disaster impacts can derive meaningful cumulative impact of a disaster.

The FIMI is then subjected to the Hot Spot Analysis (HSA). The HSA is a spatial statistical analysis tool of ArcGIS that identifies statistically significant clusters of features (in this case the barangays), which in this case is the degree of flooding experienced per barangay based on the FIMI latent variable. To group the features in the dataset, the HSA tool computes a statistic called the Getis-Ord or Gi* for each feature as follows:

**Equation 7. ArcGIS Hot Spot Analysis Formula using the GI* statistics**

$$G_i^* = \frac{\sum_{j=1}^{n} w_{i,j} x_j - \bar{X} \sum_{j=1}^{n} w_{i,j}}{S \sqrt{\frac{\left[ n \sum_{j=1}^{n} w_{i,j}^2 - \left( \sum_{j=1}^{n} w_{i,j} \right)^2 \right]}{n-1}}}$$

$$\bar{X} = \frac{\sum_{j=1}^{n} x_j}{n}$$

$$S = \sqrt{\frac{\sum_{j=1}^{n} x_j^2}{n} - \left(\bar{X}\right)^2}$$

where $x_j$ is the value of a given indicator for feature j; $w_{i,j}$ is the inverse distance spatial weight between features i and j; n is the number of features in the dataset.

The outcome of the Gi* statistic is a z-score for the value of the FIMI in each barangay. Also returned are p-values which are probabilities that the spatial clustering is a result of a random process. These z-scores and p-values indicate where there is a spatial clustering of features with either high or low values of a given variable or indicator. For z-scores that are positive and statistically significant, the higher the z-score, the greater is the intensity of clustering of features with high values (Hot Spot). Conversely, for z-scores that are negative and statistically significant, the lower the z-score, the greater is the clustering of the low values (Cold spot).

The HSA tool evaluates a feature relative to its neighboring features. A feature can have high value of a given variable but is not necessarily a Hot Spot. For a feature to be statistically significant Hot Spot, it must have a high value of a given indicator and be surrounded by features with also high values of the indicator. Thus, in the first HSA process, for a barangay to be statistically significant FIMI Hot Spot, it must have a high FIMI and be surrounded by other barangays with high FIMI. Conversely, for a barangay to be a statistically significant cold spot, it must have low FIMI and be surrounded by barangays with low FIMI. The output of this step is an HSA map that depicts the clusters of Hot Spot and Cold Spot barangays based on the FDI.

#### 3.2.2.3 Hot Spot Analysis on the measures of economic activities

In this part, patterns of clustering of barangays based on measures of economic performance is determined. As mentioned in the literature review, economic activities tend to spatially cluster in areas where factors of production and other growth facilitating factors, such as transportation infrastructure and services, are available. Spatial clustering of economic activities also occur as economic agents attempt to capture the benefits from agglomeration and from economies of scale (Fujita and Thisse, 2002; (Helbing et al., 2007).

Since the unit of analysis in this study considers the barangay as the sub-area units of the city, GDP and GDP-related indices, which are the most commonly unit of measure in the empirical literature (Noy, 2009; Toya and Skidmore, 2007), cannot be used. Most of the developing countries, such as the Philippines, have GDP available at the regional level and national level only. Hence, for this purpose, a proxy indicator will be used to gauge the economic activities per barangay from 2010-2015. The number of business establishments will be used as a proxy indicator. Such data, as measure of economic performance, will be supplemented by the type of the business establishment by major industry division. Through this, a better picture of the economic geography will be captured indicating which economic activity happens where and which barangay reaps the benefits of these economic activities.

#### 3.2.2.4 Correlation analysis of clusters

A correlation analysis will be conducted between the FIMI and the economic activities measure. A p-value of 0.05 will be used as the criteria to determine whether there is a significant association between flooding impact magnitude index, as against the economic performance of the sub-area units.

As previously mentioned, infrastructure plays a vital role in the flow of economic activities and is considered a key underlying factor of the location of economic activities and movement of population. In the event of flooding, it is assumed that the extent, depth and duration of the flood waters caused disruptions in the flow of goods and services as well as movement of the people. It is expected that there will be a negative association between the FIMI measure and economic performance. FIMI is also projected to be negatively correlated with population density changes.

### 3.2.2.5 Mediation analysis for the Population Data

As indicated in the conceptual framework, a mediated path between the flooding disaster (X-variables) and economic geography (Y-variable) through population density shift (M-variable) is hypothesized. Mediation is a assumed to be a linear causal relationship whereby the X-variable causes the mediator, M, and the M-variable causes the Y-variable. The intervening variable, M, is called the mediator since it "mediates" the relationship between a predictor, X, and an outcome, Y (MacKinnon et al., 2007). Figure 14 shows a single-mediator model wherein the relations among the X, M and Y variables are depicted by the arrows a, b, and c'.

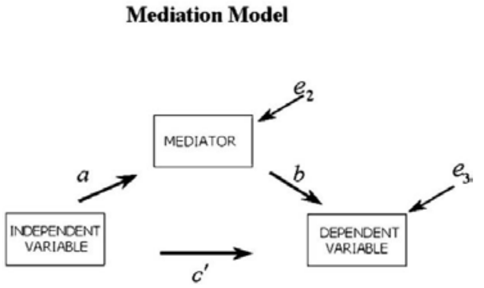



**Figure 14. Simple Mediation Model (Source: MacKinnon, et al., 2007)**

Population density changes (M) will be examined to determine whether it has a significant relationship with the flood impact magnitude index (X) and the economic performance per barangay (Y). This will be done through several regression analyses as developed by Baron and Kenny (1986) to determine if there is a mediated path between the variables. The first to third steps involve a simple regression analysis between X and Y, X and M, and M and Y. If one or more of these relationships are non-significant, it is usually conclude that mediation is not possible or likely. The fourth step which involved multiple regression will only be conducted if all previous relationships are found to be significant. The results can indicate partial or full mediation depending if X is still significant or not when M is controlled. It is hypothesized that the population density changes will capture the effect of flood-induced population movement to the economic landscape of Cagayan de Oro.

### 3.2.2.6 Moderation Analysis for the Barangay Land Area and Commercial Areas

The moderation analysis assumes a linear causal relationship of X to Y. A moderator variable W influences the strength of the said causal relationship. This type of analysis usually measure the causal relationship between X and Y by using a regression coefficient. Classically, moderation implies a weakening of a causal effect, a moderator can amplify or even reverse that effect (Kenny, 2018). The following multiple regression equation is estimated:

**Equation 8. Moderation test regression model**

$$Y = i + \alpha X + \beta W + CXW + \varepsilon$$

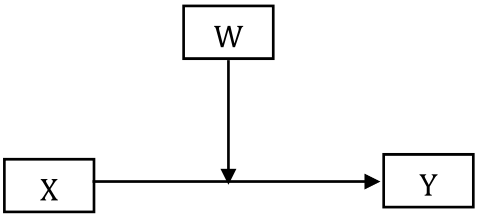



**Figure 15. Simple Moderation Model (Source: Hayes, 2017)**

Moderation analysis measures causal interacting relationships among variables (Hayes, 2017). The interaction of X and W or coefficient $C$ measures the moderation effect. Note that path $\alpha$ measures the simple effect of X, sometimes called the main effect of X, when W equals zero. As will be seen, the test of moderation is not always operationalized by the product term XW. Given the equation, the effect of X on Y is $\alpha + C$ M (Kenny, 2018). The inventory of the commercial areas in the city as well as the land area per barangay are taken as moderator variables to derive more insightful result on the effect of X to Y. As previously mentioned in the conceptual framework, these are hypothesized to have influence on the number of the business establishments per barangay. A simple moderation analysis will be conducted looking at variables X, W, and their interaction effect, XW, towards Y. Thus, the moderation analysis shall determine if the effect of W and XW alters the strength of the causal relationship of FIMI towards the number of business establishments.

### 3.2.2.7 Spatial Regression Analysis using Spatial Lag X Model

Regression analysis is also designed for this research to supplement the non-causality nature of the correlation test. Spatial regression/econometrics is a discipline that integrates analytical techniques which are designed to consider dependence among observations (regions or points in space) in close geographical proximity. Latent unobservable influences, among other factors, which may be due to limited data can be accounted for by taking on neighboring values to help explain the variation in the dependent variable. This works when the latent influences change slowly moving across areas in a specific region (LeSage, 2008). Extending the standard linear regression model, spatial methods identify cohorts of nearest neighbors and allow for dependence between the observations in a region (Anselin, 2010; LeSage, 2008).

Specifically, spatial regression is performed to see possible spatial dependence or spatial autocorrelation of the variables. The spatial regression is divided into two parts looking at the short-term and long-term impact of the flooding disaster. The short-term covers the percentage change of business index from 2011 to 2012 while the long-term looks at the average percentage change of business index from 2011-2015. The Spatial Lag X or also known as the Spatial Cross-regressive model examines both the endogenous and exogenous effects of the explanatory variables to the dependent variable. This means that the predictor variables shall include those of the referenced barangay and its neighboring barangays as well. Taking the neighboring barangays' variables is expected to produce more insightful results to the dependent variables. The SLX Spatial regression is characterized with the following model which will be further discussed in the next chapter:

**Equation 9. SLX/Spatial Cross Regressive Model**

$$\boldsymbol{y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots \beta_k X_k + W x_2 + \cdots W x_k + \varepsilon}$$

**Table 5. Overview of Data Analysis and Methods**

| Research Question | Data Used | Method | Tool/ Software | Outcome |
|---|---|---|---|---|
| 1. How does the shift in the population concentration (as a result of the flooding disaster) affect the number of business establishments per sub-area (barangay) in the city? | Secondary data | Mediation effect and spatial regression analysis | R, SPSS and ArcGIS for visualization | • Test of mediation effect (no mediation, partial mediation or full mediation) of the population density changes to the economic performance and number of businesses in a sub-area unit;<br>• Map indicating population concentration changes per barangay to support the analysis |
| 2. How does the availability of commercial areas influence the concentration of business establishments after the flood? | Secondary data | Moderation effect and spatial regression analysis | R and SPSS | • Moderation analysis of the commercial areas to the number of business establishments in a sub-area unit |
| 3. Is there a correlation between the varying levels of flood impact to the resulting number of business establishments in a barangay in the short- and long-term perspectives? | Secondary data | Correlation analysis | SPSS and ArcGIS for visualization | • Correlation analysis of the FIMI and the annual percentage change of the BizIndex from 2011-2015 |

| Research Question | Data Used | Method | Tool/ Software | Outcome |
|---|---|---|---|---|
| 4. How does a major catastrophe like a flooding disaster affect the post-spatial cluster and number of business establishments in a barangay? | Secondary data | Hot-spot analysis, and spatial regression analysis | ArcGIS, GeoDa, R, SPSS | • Regression coefficients as determinants of the degree of causality of the flood<br>• Hotspot areas of the pre- and post-disaster spatial clusters of thriving business areas in the city |

## 3.3 Challenges and limitations

Based on the empirical literatures reviewed, availability of datasets is a common challenge when studying the economics of disasters (Kousky, 2014). The challenge is even greater in collecting data at the city level and sub-area units in the context of a developing country. In the case of the economic performance/output indicators, proxies are used as alternatives as these can also indicate the economic dynamism of an area. Several literatures have shown that the usage of these data is justifiable such as the studies of Faisal et al. (2020), Lam et al. (2012) and Imaizumi (2016).

### 3.3.1 Reliability and Validity

Van Thiel (2014) refers to reliability in social research as the degree to which the study variables are measured accurately and consistently. On the other hand, case study type of research are also known to have low external validity because of its deep contextualization which means that it can't be generalized (Van Thiel, 2014). The multiple data sources in the flood variables is strategically used to enhance the reliability of the data processing and findings. The River Basin Flood Modelling (62,495 polygons) and the experienced flood depth by the households (10,587 points) are each processed systematically via spatial join tool in ArcGIS to derive a triangulated flood inundation levels. The ClimEx.DB was also cleaned to remove outlier points (e.g. points in the maps that are outside the city boundary) which may have been the result of erroneous data encoding during the survey period. However, it is also observed that eight out of the 41 barangays have less (only one, if not none) surveyed household. In such cases, multiple imputation through the linear regression methodology in SPSS is used to fill and/or reinforce the values for more reliability. The various robust methodology of imputation are presented in the next chapter.

The Analytical Heirachy Process (AHP) method used in the weighting, aggregation and creation of the flood impact magnitude index (FIMI) usually involves experts and stakeholders to determine the relative importance of each parameter. However, in this study the weights are derived based on the relevant and related literatures on flooding. Nevertheless, the necessary justifications are provided and discussed in the next chapter. Also, results of the FIMI highly suggests consistency between the flood footprints and the hot spot of potentially badly damaged areas.

As previously mentioned, the use of proxy indicators such as the number and type of business establishment, inventory of commercial areas and share of employment per industry division are deemed as reliable enough to measure economic performance/output per barangay. This can be justified by relating it with the post-disaster investigations of Imaizumi et al. (2016) on the employment share per industry, the use of the number of businesses by Lam et al. (2012) the analysis of Faisal et al. (2020) using the number of tourism-related business establishments which altogether substantially and significantly contributed to the study of a contextualized economic geography of a specific area. This research also attempted to make it more reliable by being transparent about the research process through the documentation of every procedures as well as in the presentation of logical steps described in the data analysis methods.

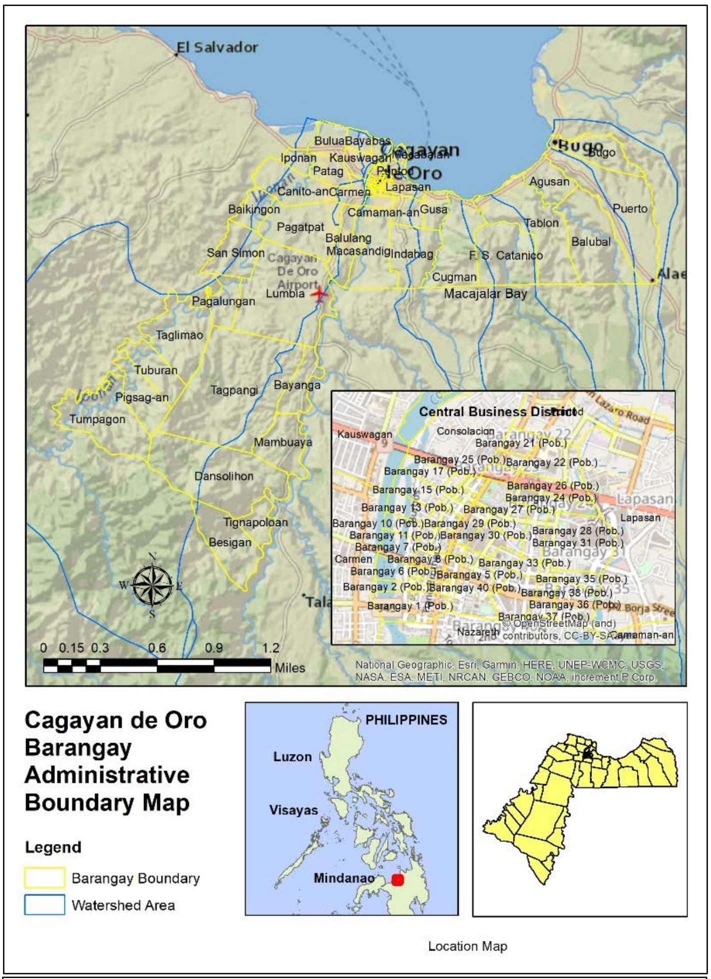
### 3.3.2 Effects of COVID-19

The unprecedented global pandemic put the local governments at the forefront of critical response. Thus, despite the early data request sent to the Office of the City Mayor of Cagayan de Oro, the data were given a bit late. Several follow-ups were also done to fast-track the data collection amidst the immense work load of the local government staff. Among the itemized data requested, one important data pertaining to the barangay financial report was unfortunately not available. This data could have reinforced and complemented the BizIndex have a better picture of the economic performance per barangay in terms of revenue. Nevertheless, the masterlist of business establishments given by the local government sufficiently captures the economic dynamism. This made possible to carry out the robust methodologies for this research.

# Chapter 4: Presentation of data and analysis

Presented in this chapter are the description of the case study, the analysis and discussion of the results of the collected data. As a preliminary introduction, the background information for the case is laid out for contextualization purposes. This section describes the characterization of the tropical storm and the resulting flooding disaster. Afterwards, quantitative analyses methods on the data are performed including the creation of composite index for the independent, mediating and moderating variables. Quantitative data processing were conducted using SPSS an these are complemented by the spatial statistics tools of ArcGIS, GeoDa and R. Additional analysis on the major sources of employment per business type is also presented in the last section to support the findings in relation with the theoretical framework.

## 4.1 Defining the Case Study: Cagayan de Oro City, Philippines

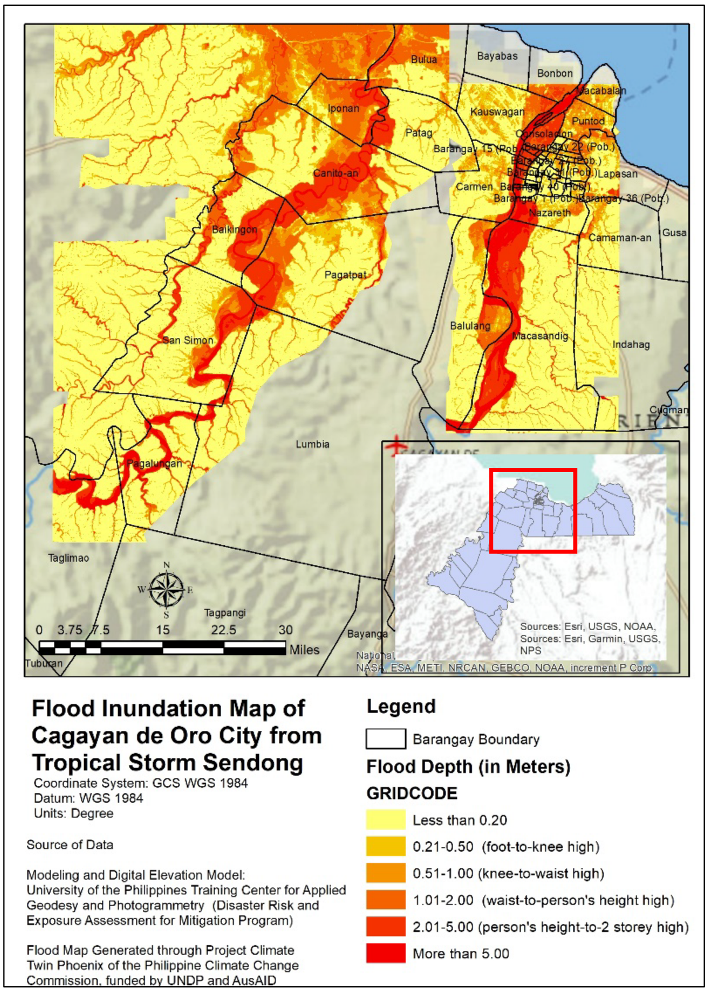



**Map 1. Cagayan de Oro City Barangay Administrative Boundary Map (Author, 2020)**

The study area is Cagayan de Oro City located in the southern part of the Philippines and situated in the northern part of the island of Mindanao. It has an area of 57,851 hectares which is sub-divided into 80 sub-area units called *barangays* as shown in Map 1 with *barangays* 1-40 comprising the central business district. As early as 1983, the city was classified as “highly urbanized” (GOP, 1983), and has continued to undergo rapid urbanization even after more than three decades. Its population growth rate for the period 2010–2015 is 2.23%, which is higher than the national average. Based on the result of the 2015 Census, Cagayan de Oro is the ninth most populous city in the country, with a total population of 675,950 and population density of 1383 persons per square kilometer (PSA, 2016b). Several geographic characteristics of the city make it susceptible to coastal, riverine, and urban floods. Cagayan de Oro is a coastal city located along the Macajalar Bay. It is traversed by two major rivers, Cagayan de Oro and Iponan Rivers that comprise a network of rivers, creeks, and tributaries that drain into the bay. The city’s floodplains have a high concentration of institutional, industrial, and commercial establishments, as well as residential areas. Considered as the regional center of and largest city in Northern Mindanao, this highly urbanized area serves as one of the bustling economic hubs in the Philippines.

However, amidst the city's vibrant economic activities, the Philippine's most destructive catastrophic floods and the world's second most deadly disaster of 2011 occurred in the northern east coast of Mindanao. This flooding disaster brought about by Tropical Storm Sendong (with international name: Washi) had killed 1,292 lives, 1,049 missing, 2,002 injured and a total of 695,195 people (110,806 families) affected (Rasquinho et al., 2013). This disaster brought damage to capital and disrupted economic activities that may have translated to long-term adverse impacts, including welfare losses among affected areas (Hallegatte et al. 2017; Noy and duPont 2016). The succeeding sections elaborate more the case study to gain an in-depth understanding of the flooding disaster.

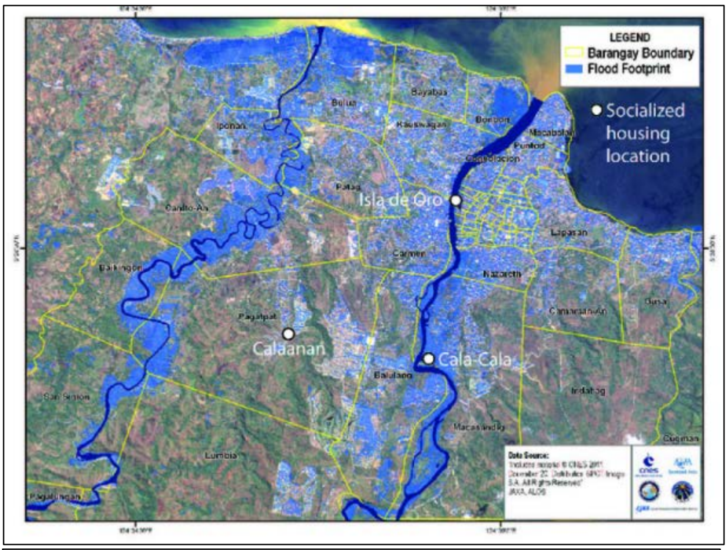
### 4.1.1. The Flooding Disaster: Onslaught of Tropical Storm Sendong




**Map 2. Flood Inundation Simulation Map of Tropical Storm Sendong using 1 in 100 Year Rainfall Data (Author, 2020)**

The flooding disaster shown in Map 2 was considered the worst in the history of the Northern Mindanao Region. River levels rose drastically after 12 hours of torrential rain which caused river banks to burst and flooded 41 barangays with varying extents and depths. The tropical storm did not reach a 'typhoon' status as its winds were not strong enough. However, the combined effects of the excessive rainfall volume in the headwaters of the city's major rivers, and the high tidal level of the Macajalar Bay brought widespread flooding (Ginnetti et al. 2013; Guha-Sapir et al. 2012; NDRRMC 2012; NEDA 2012). The rampaging waters carrying debris and mud wiped out the burgeoning settlements along these rivers, particularly on former riverbeds, and on sandbars and deltas that formed as result of silt accumulation (Ginnetti et al. 2013; LGU-CDO 2016; NEDA 2012).. This massive rainfall and the very steep slope of the mountains highly contributed for catastrophic floods including river flood, flash flood, landslide and mudflow. The muddy water full of sediment and debris flowed downstream and washed out communities in the two islets of the city which are located on sandbars. According to the Department of Public Works and Highways the maximum flood height reached 7 to 9 meters which corresponds to a return period of 75 years. The disaster reached enormous proportions due mainly to three simultaneous factors: very intense rainfall, occurrence of rainfall during early morning when people were asleep, and high tide that prevented a greater flow of the Cagayan de Oro and Mandulog rivers to the sea (ESCAP/WMO Typhoon Committee, 2012).

Map 2 shows the maximum flood extent and depths resulting from the 100 year rainfall event for the 2013 land cover and digital elevation model (DEM). Projected river discharge, water runoffs and outflows were generated for the Cagayan de Oro watershed that includes the Cagayan de Oro and Iponan rivers based on the actual rainfall data (UP-TCAGP, 2014). This simulation is by far the most comprehensive and sophisticated modelling done by a team of experts from the University of the Philippines Training Center for Applied Geodesy and Photogrammetry. Although the flooding disaster is characterized with a 75-year rainfall (DPWH, 2012) return period, the 100-year flooding simulation is chosen for this research in order not to undermine the magnitude of the disaster effects and the unprecedented catastrophy while accounting all possible flooding extent.




**Map 3. Flood Footprint Extracted from SPOT4 taken December 20, 2011 over ALOS Pansharpened taken June 5, 2010 (Data sources: JAXA, ALOS, includes material (c) CNES 2011, December 20. Distribution SPOT. Image S.A. All Rights Reserved. Map Production: Geomatics for Environment and Development.**

Map 3 shows the flood footprints of TS Sendong which further supports the flooding simulation modelling of the UP-TCAGP. Located in the downstream area of the Cagayan de Oro river basin are the island bars, old river channels/creeks and former oxbow lakes such as Isla de Oro and Isla Delta, and Isla Bugnaw, portions of Consolacion, Tibasak, Cala-cala, Biasong and river bank in Upper Balulang within Roa Quarry. In 2009 the local government allowed development along the river banks which were developed into residential and commercial areas. These built-up areas were consequently severely affected by the flood and were later on relocated. Cagayan de Oro historically attracted rural migrants that caused rapid and uncontrolled urban growth with its population quadrupling from 1975 to 2010. These phenomena promoted the illegal establishment of squatter and slum settlements in public land, located in the central urban areas in the bank of the river and near public markets that constitutes the residents’ places of employment (Carrasco, 2016). The December 2011 flood event was characterized by the interplay of climatic, environmental and social factors leading to the disaster. The encroachment in the sandbars and the river banks due to urbanization and industrialization impeded the flow of water. In addition, the timing of the high tide constrained the flow of the flood waters that resulted to widespread flooding in the downstream areas.

### 4.1.2 Damages and Impacts[5]

Quantification of the flood damages and impacts were done at the regional level of the Philippines. Thus, specific and detailed damage assessment for Cagayan de Oro city alone is scant. Nevertheless, this section aims to discuss the negative impacts of the flooding disaster in order to establish a bigger picture of the damage and how the city consequently recover. The exposure of the settlements areas where people reside as well as the economic assets in hazard-prone areas such as river banks, floodplains, and alluvial plains highly aggravated the impacts of the floods. The following damage assessment are highlights from the final report on the Post-Disaster Needs Assessment conducted by the Regional Diaster Risk Reduction and Management Council or RDRRMC (2012). The damage estimation was based on the guidelines of the World Bank-Global Facility for Disaster Reduction and Recovery (2012). Particularly, the Damage and Loss Assessment (DaLA) methodology was used to generate the sector-by-sector consequential damages and losses.

The floods brought by Washi resulted in a massive and unprecedented destruction of urban areas resulting to the displacement of 228,576 persons in Cagayan de Oro which represents almost 40 percent of the total city population (Carrasco et al., 2016). Unsafe location of housing and living conditions increased further the vulnerability of the residential areas along the Cagayan de Oro and Iponan rivers to the flood. Many of these affected communities are informal settlers who had substandard housing materials and construction quality. In Cagayan de Oro City, around 18,436 houses (47 percent of total) were either completely or partially destroyed, causing an estimated damage of PhP 901.64 Million. 5,801 houses were totally destroyed and 12,635 were partially damaged. Approximately 85% of the affected households were informal settlers of highly vulnerable and marginal areas located near the river banks. In the aftermath of this disaster, no-build zones were declared and designated and forced households out of the areas with the highest susceptibility to floods. Government calculations state that approximately 2700 households in Cagayan de Oro are within the No Build Zones (REACH, 2012). The impact of the No Build Zones means that households are required to relocate – regardless of whether they are completely damaged, partially damaged, or even unaffected. Due to higher demand for housing materials, prices also soared in the construction-related industries.

The agriculture and fisheries sector was among the most severely affected. There were more than 67,000 livestock and poultry combined which perished in Cagayan de Oro. Total of damaged agricultural areas reached 568 hectares in Cagayan de Oro. Negative impacts of TS Sendong were also felt in the sub-sectors of mining and quarrying, manufacturing, construction, wholesale and retail, restaurants and real estate. The losses to the private sector in the form of foregone income were not fully assessed due to the lack of readily available information as well as the difficulty in gathering such information in the aftermath of the disaster. But while the impact on the overall macro economy may not cause a decline in overall regional level of production, huge negative impacts are expected to be felt by certain sectors and at the micro economy level. Hardly hit are the micro, small and medium establishments which directly lost their capital and business opportunities as a consequence. The tourism sector has already felt the slowdown in business. The hotel and restaurant business in Cagayan de Oro, on the other hand, estimated between 50-60 percent income reduction due to canceled functions, and disruption in operations due to lack of water and power. However, occupancy for some hotels with functional water facilities and electricity generators have soared in the

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[5] *Photos are provided in the annex to visualize the catastrophic damages of TS Sendong*

aftermath of TS Sendong as affected families with the capacity to spend opted to stay in hotels while waiting for power and water to be restored in their homes. Some sectors in the informal economy are similarly affected. Women tending sarisari stores, men working part-time, and fish vendors reporting sales reduction (due to rumors about fish feeding on human corpses), see harder times ahead due to losses in household incomes.

The forces of floods which brought massive silt, logs/debris, and uprooted trees during TS Sendong caused many major road networks to be impassable. There were bridges totally washed-out while many others were partially damaged in different areas of the city and other areas in the region. Some roads in the city were also closed temporarily due to abate high tendency of landslides. These were reopened after authorities declared it safe to be reopened. Due to damaged roads and bridges, delivery of agricultural products from hinterlands going to Cagayan de Oro were also disrupted because of unserviceable road networks. To avert further adverse impact on the flow of goods and services from other areas to the markets in Cagayan de Oro, emergency repairs were deemed urgent which caused unexpected expenditures to the government. Cagayan de Oro City incurred a road damages and losses amounting to Php 45.00 and 49.70 Million, respectively. The estimated damages to flood control structures and drainage system amounted to Php 681.527 million. Cagayan de Oro city was the hardest hit with overtopped/breached dike along Barangays Carmen, Kauswagan and Bonbon along the Cagayan de Oro River, and the seawall in Barangay Macabalan, which all amounted to Php 572 Million.

TS Sendong floods also caused damages to water supply systems that include deep wells and pump houses, distribution system, chlorination systems and other support facilities. The biggest share of damage was sustained by the Cagayan de Oro Water District amounted to about PhP 157 million. In the power sector, a number of power transmission and distribution networks were damaged including electric facilities, electricity poles and lines. Trees in various locations were toppled and caused damages to sub-transmission and primary distribution lines. The damages to the generation and distribution systems of the power companies resulted in massive brownout in many areas. Because of these damages, economic losses due to lost revenues from unmet electricity demands reached PhP 216 million.

## 4.2 Data Analysis

Several procedures were conducted to analyze the collected data. Prior to deeper quantitative and spatial analysis, data from secondary sources were sorted and organized to see the extent of the available data. This is to check missing values and determine methodologically sound steps to logically impute these data. Different Hot Spot Analyses using ArcGIS are then generated each for the flood and the number of business establishments.

### 4.2.1 Data on Flood Magnitude

The flood variable is composed of three indicators: extent (hectares), depth (meters) and duration (days). Table 7 below shows these indicators as well as the computed and imputed values. The flood depth and duration are simple averages computed per barangay based on its corresponding number of households surveyed. According to the reports, 41 out of 80 barangays were flooded (RDC, 2012; RDRRMC; 2012). However, the City Planning and Development Office has derived the flooded area of only 30 barangays using their GIS analysis. The Climate Exposure Database (ClimEx.DB) on the other hand has flood depth and duration of the 30 barangays, but eight of these have no data from the 10,857 surveyed households.

Geo-imputation was used to derive the missing values. To fill the missing values for the flood extent experienced by the 11 barangays and flood depth of 8 barangays, the River Basin Flood Modelling (RBFM) simulation study was utilized to spatially derive the values. The data from the RBFM was also used for the eight barangays with very few (1-2) observed flooding depth gathered from households to make it more reliable. The 100-year return period flooding simulation was overlaid with the barangay administrative boundary map of the city and subjected it to a *spatial join analysis* in ArcGIS. A spatial join involves matching rows from the Join Features to the Target Features based on their relative spatial locations. For this type of analysis, parameter used was Join-one-to-one with the completely-contains criteria. The features in the join features will be matched if a target feature completely contains them. In simpler terms, each of the area per polygon of the flooding simulation shapefile was computed, joined with and summed up per barangay boundary as shown in Figure 14. Mean depth was also computed in that process based on the flood shapefile's gridcode. The spatially joined polygons column indicates the number of polygons in the RBFM geospatial data contained within a barangay.

**Figure 16. Geo-imputation process in ArcGIS (Left: Snippet of Flood footprint; Right: Attribute Table)**

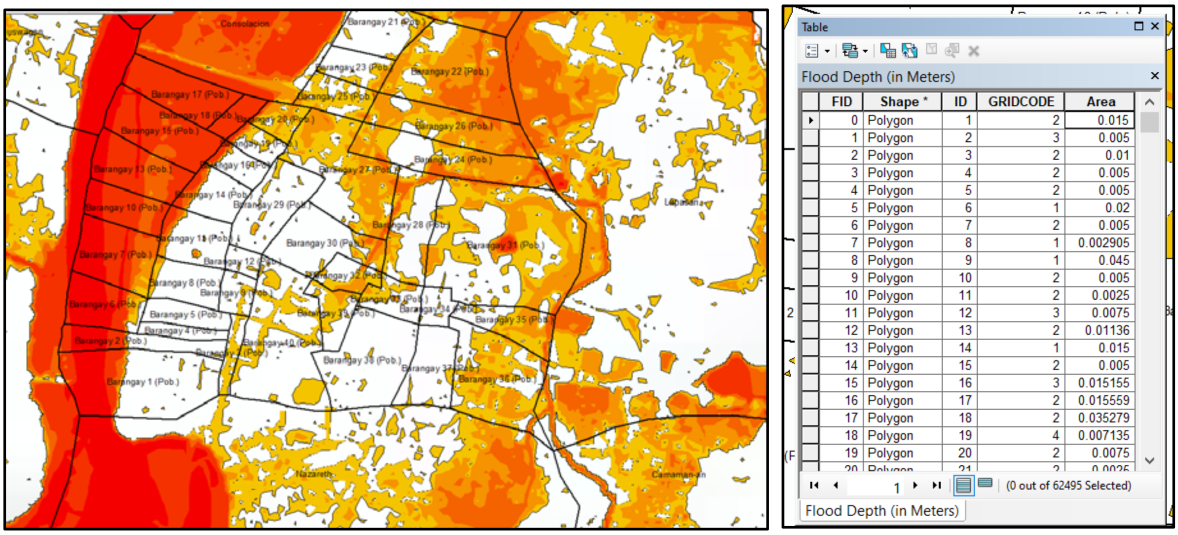



**Table 6. Flood Extent, Depth and Duration per Barangay**

| CPDO | | | ClimEx.DB | | | RBFM | Computation | |
|---|---|---|---|---|---|---|---|---|
| Name of Baranggay | Area (Has) | Flooded Area | Depth Mean | Duration Mean | Number of Household | Spatially joined polygons | % of Flooded Area to Total Area | FEI |
| Baikingon | 475.64 | 109.26 | 2.02 | 1.66 | 128 | 1294 | 22.97 | 1.17 |
| Balulang | 726.27 | 180.29 | 3.25 | 1.95 | 1027 | 1923 | 24.82 | 1.26 |
| Barangay 1 | 14.58 | 4.66 | 2.60 | 1.50 | 10 | 75 | 31.95 | 1.63 |
| Barangay 10 | 4.40 | 4.40 | 5.00 | 2.91*** | 1 | 4 | 100 | 5.10 |
| Barangay 11 | 5.18 | 0.74 | 3.00** | 1.84*** | 0 | 36 | 14.37 | 0.73 |

| CPDO | | | ClimEx.DB | | | RBFM | Computation | |
|---|---|---|---|---|---|---|---|---|
| Name of Baranggay | Area (Has) | Flooded Area | Depth Mean | Duration Mean | Number of Household | Spatially joined polygons | % of Flooded Area to Total Area | FEI |
| Barangay 13 | 6.51 | 6.51 | 4.00** | 2.72*** | 0 | 9 | 100 | 5.10 |
| Barangay 14 | 4.15 | 0.31 | 3.00 | 1.76*** | 1 | 34 | 7.38 | 0.38 |
| Barangay 15 | 7.93 | 7.65 | 3.4 | 3.4 | 98 | 9 | 96.5 | 4.92 |
| Barangay 16 | 2.57 | 0.23* | 3.00 | 1.86*** | 1 | 30 | 0.09 | 0.46 |
| Barangay 17 | 6.45 | 6.45 | 4.0 | 2.44*** | 0 | 4 | 100 | 5.10 |
| Barangay 18 | 1.83 | 0.59 | 3.7 | 2.1 | 101 | 1 | 32.39 | 1.64 |
| Barangay 2 | 4.57 | 2.27 | 4.5 | 2.00 | 2 | 1 | 49.7 | 2.53 |
| Barangay 20 | 2.10 | 0.21* | 3.79 | 2.18 | 139 | 24 | 0.10 | 0.51 |
| Barangay 21 | 4.72 | 0.19* | 2.00 | 1.71*** | 1 | 19 | 0.04 | 0.21 |
| Barangay 22 | 11.79 | 2.29* | 3.84 | 2.42 | 276 | 47 | 0.19 | 0.99 |
| Barangay 23 | 8.25 | 0.14* | 4.43 | 2.00 | 7 | 7 | 0.02 | 0.09 |
| Barangay 24 | 11.83 | 2.21* | 4.10 | 2.21 | 534 | 84 | 0.19 | 0.95 |
| Barangay 25 | 5.23 | 0.11* | 4.25 | 2.21 | 145 | 15 | 0.02 | 0.11 |
| Barangay 26 | 8.85 | 0.46* | 3.00 | 1.81*** | 1 | 45 | 0.05 | 0.26 |
| Barangay 3 | 7.69 | 0.03* | 1.00 | 2.00 | 8 | 8 | 0.00 | 0.02 |
| Barangay 6 | 5.31 | 4.87 | 3.00** | 2.28*** | 0 | 24 | 91.81 | 4.67 |
| Barangay 7 | 7.16 | 7.14 | 3.00** | 2.54*** | 0 | 9 | 99.69 | 5.08 |
| Barangay 8 | 4.27 | 0.19 | 2.00** | 1.64*** | 0 | 5 | 4.34 | 0.23 |
| Bayabas | 227.87 | 15.37 | 2.00 | 1.89*** | 1 | 24 | 6.75 | 0.34 |
| Bonbon | 162.24 | 149.35 | 2.99 | 2.25 | 239 | 193 | 92.05 | 4.69 |
| Bulua | 476.44 | 217.46 | 3.19 | 2.35 | 1403 | 580 | 45.64 | 2.33 |
| Canito-an | 1,069.44 | 257.8 | 3.00 | 2.01*** | 1 | 1615 | 24.11 | 1.23 |
| Carmen | 317.69 | 46.02 | 3.62 | 2.02 | 696 | 1109 | 14.49 | 0.74 |
| Consolacion | 54.15 | 42.81 | 4.03 | 2.13 | 1751 | 207 | 79.06 | 4.03 |
| Indahag | 1405.39 | 400* | 3.00 | 2.00 | 1 | 2994 | 28.46 | 1.45 |
| Iponan | 271.66 | 264.45 | 2.78 | 2.01 | 2671 | 255 | 97.35 | 4.96 |
| Kauswagan | 336.4 | 64.88 | 3.34 | 2.16 | 514 | 1025 | 19.29 | 0.98 |
| Lapasan | 227.26 | 180* | 3.00** | 2.44*** | 0 | 1109 | 79.20 | 4.04 |
| Lumbia | 3,412.26 | 18.2 | 3.00** | 1.53*** | 0 | 3277 | 0.53 | 0.03 |
| Macabalan | 96.28 | 47.62 | 1.93 | 1.49 | 280 | 309 | 49.46 | 2.52 |
| Macasandig | 1,3406.05 | 375.37 | 4.38 | 2.05 | 736 | 10561 | 27.89 | 1.42 |
| Nazareth | 160.62 | 40.71 | 3.68 | 1.85 | 84 | 445 | 25.35 | 1.29 |
| Pagatpat | 1,593.17 | 115.8 | 3.00** | 1.27*** | 0 | 2513 | 7.27 | 0.37 |
| Patag | 429.99 | 38.99 | 2.00** | 1.72*** | 0 | 783 | 9.07 | 0.46 |
| Puntod | 105.53 | 8.9 | 2.00** | 1.63*** | 0 | 353 | 8.43 | 0.43 |
| San Simon | 970.12 | 122.57 | 3.00** | 1.49*** | 0 | 5904 | 12.64 | 0.64 |
| **TOTAL** | **13772.58** | **2564.39** | **-** | **-** | **10,857** | **35,854** | **19.00** | **1** |

| CPDO | | | ClimEx.DB | | | RBFM | Computation | |
|---|---|---|---|---|---|---|---|---|
| Name of Baranggay | Area (Has) | Flooded Area | Depth Mean | Duration Mean | Number of Household | Spatially joined polygons | % of Flooded Area to Total Area | FEI |
| ** values imputed using the spatial join tool of ArcGIS to derive flooded area from the sum of all the flood polygon areas contained within a barangay boundary*<br>*** values imputed by computing the mean value of the gridcode of all polygons of the RBFM flood simulation shapefile*<br>**** values imputed using the multiple imputation in SPSS through linear regression method (due to only 1 or zero surveyed household)* | | | | | | | | |

### 4.2.1.1 Normalization

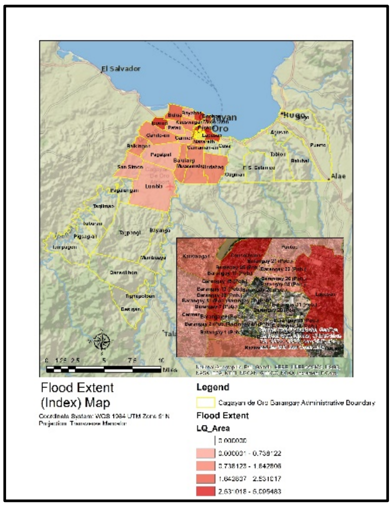
On the computation side, the percent of flooded area to total area of barangay and the Flood Extent Index (FEI) is shown. As previously stated in chapter 3, FEI is similar with the way Location Quotients (LQ) are computed. This determines the spatial distribution and concentration of the flooding phenomenon in a smaller area (barangay), compared to the larger area (city) in reference. Thus, Equation 5 (refer to page 26) in section 3.2.2.1 is utilized taking into account the flooded area and land area per barangay and comparing it to the city level.

The FEI therefore is a ratio that quantifies and compare how concentrated the flooding extent in a barangay is compared with the city level. A high FEI signals high concentration and conversely, a low flood concentration with low FEI. A similar indexing method is also performed on the population and the number of business establishments per barangay. This is to determine the exposure elements of the flooding disaster risk potential damages. These indices are computed through the Equation 3 and Equation 4 from section 3.2.2.1 (refer to page 25) taking into the computation the population and number of business establishments, respectively, dividing each with the corresponding barangay land area. The population variable, as a parameter of the FIMI, is from the 2010 actual census for a more realistic appraisal instead of using 2011 which is just a projected population growth estimation.

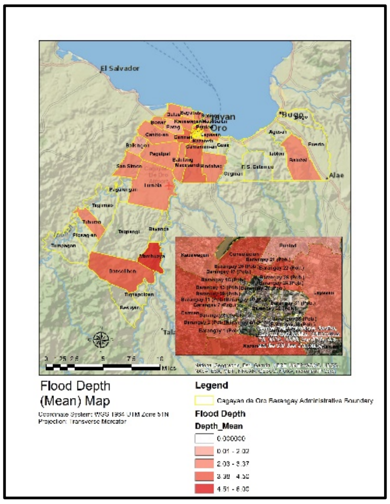
### 4.2.1.2 Deriving the Flood Impact Magnitude Index (FIMI)

This research refers to FIMI as the degree of potential flood damages calculated per barangay. The index aims to assist the identification of hotspots related to flood damages and allow a comparative analysis between different barangays. FIMI comprises five criteria-parameters: flood extent, flood depth, flood duration, population index and business industries index. The selection of these parameters has been theoretically based on their relevance to flood hazards as documented in the literature (Hammond et al., 2015; Lam et al., 2012). Input data for each parameter is processed in a GIS environment and the five parameters are visualized in independent thematic maps as shown in Map 4-8. The color symbology indicates that a darker color means a wider, deeper and longer floods. Map 7 and 8 indicates the indices for the population and business industry. The map visualization can already depict a heavy concentration of flooding, population and businesses in the central part of the city especially in and around the CBD.

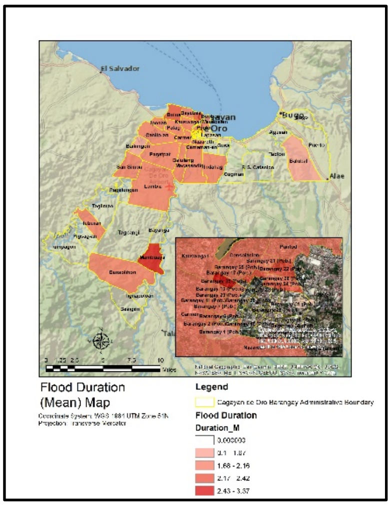
**Map 4. Flood Extent Index**




**Map 5. Flood Depth (Mean)**

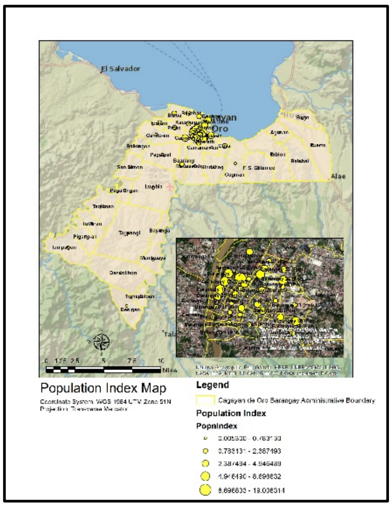



**Map 6. Flood Duration (Mean)**

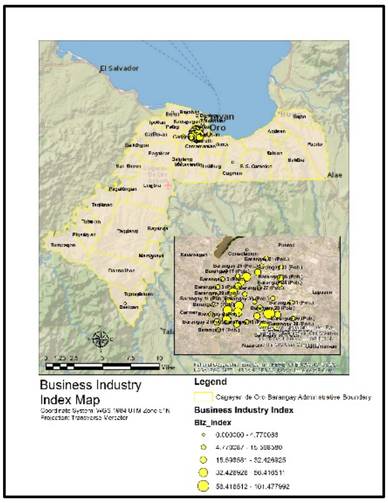



*(Source: Author, 2020)*

**Map 7. Population Index 2010**




**Map 8. Business Industry Index, 2011**




*(Source: Author, 2020)*

### 4.2.1.3 Weighting and Aggregation using the Analytical Hierarchy Process (AHP)

The AHP is a technique widely applied in multi-criteria decision making and planning (Saaty, 1990a,b, in Bernasconi et al., 2010). As both a theory and methodology for relative measurement, AHP is a structured technique used for analyzing complex phenomena, where a large number of interrelated objectives or criteria are involved. The goal of AHP in this research is to assess the overall flood impact magnitude based on the hazard and exposure. The weights of these criteria are defined after they are ranked according to their relative importance. The measure of 'importance' in this study is contextualized to refer to how each parameter contributes to the flood impact to the city. Kazakis et al. (2015b) noted however the subjective nature of the weighting process. Equation 6 from section 3.2.2.1 (refer to page 26) is used for the computation of the FIMI value per barangay taking in the values of its flood extent, depth and duration as well as its population index and business index.

Once all criteria are sorted in a hierarchical manner, a pairwise comparison matrix for each criterion is created to enable a significance comparison as shown in Table 8. The relative significance between the criteria is evaluated from 1 to 5 indicating less important to much more important criteria, respectively, with 2 and 4 as intermediary values. AHP is both linear and geometric which means that weights are trade-offs and not importance coefficients (OECD, 2008). A deficit in one dimension can thus be offset (compensated) by a surplus in another. Furthermore, minimizing the number of variables in the index may be desirable on other grounds, such as transparency and parsimony as well as avoiding collinearity of variables if too many parameters are selected for the index. Basis for the relative importance comparisons are indicated below to justify the weights. The values in decimal are the inverse weight of the parameters being compared which can be easily identified below the diagonal values of 1.

**Table 7. Pair-wise comparison matrix of the FIMI parameters**

| Parameters | Flood Depth | Flood Extent | Flood Duration | Population Index | Business Index |
|---|---|---|---|---|---|
| Flood Depth | 1.00[1] | 3.00[2] | 2.00[3] | 4.00[4] | 4.00[5] |
| Flood Extent | 0.33 | 1.00[1] | 4.00[6] | 3.00[7] | 4.00[8] |
| Flood Duration | 0.50 | 0.25 | 1.00[1] | 3.00[9] | 2.00[10] |
| Population Index | 0.25 | 0.33 | 0.33 | 1.00[1] | 1.00 |
| Business Index | 0.25 | 0.25 | 0.50 | 1.00 | 1.00[1] |
| **TOTAL** | **2.33** | **4.83** | **7.83** | **12.00** | **12.00** |

[1] *A value of 1 indicates the same importance;* [2]*Hammond et al., 2013; Tanaka et al., 2020* [3] *Tanaka et al., 2020; Lam et al., 2012;* [4] *Chang and Huang, 2015;Kousky, 2012;* [5] *Chang and Huang, 2015; Mediodia et al., 2013;* [6] *Tanaka et al., 2020;* [7,8,9, and 10] Kousky, 2012; Noy and Vu, 2010.

To derive the normalized values of the matrix, each value is divided by the total of each parameter. This is shown in Table 9 below. The criteria weights is then calculated by adding all the values per row.

**Table 8. Normalized FIMI parameters**

| Parameters | Flood Depth | Flood Extent | Flood Duration | Population Index | Business Index | **Criteria Weights** |
|---|---|---|---|---|---|---|
| Flood Depth | 0.43 | 0.62 | 0.26 | 0.33 | 0.33 | **0.39** |
| Flood Extent | 0.14 | 0.21 | 0.51 | 0.25 | 0.33 | **0.29** |
| Flood Duration | 0.21 | 0.05 | 0.13 | 0.25 | 0.17 | **0.16** |
| Population Index | 0.11 | 0.07 | 0.04 | 0.08 | 0.08 | **0.08** |
| Business Index | 0.11 | 0.05 | 0.06 | 0.08 | 0.08 | **0.08** |

The consistency matrix below in Table 10 is computed by multiplying each value in the pair-wise comparison matrix (Table 8) by the corresponding criteria weight per parameter in Table 9. Afterwards, the weighted sum value is derived by adding all the values per row.

**Table 9. Consistency matrix for the FIMI parameters**

| Parameters | Flood Depth | Flood Extent | Flood Duration | Population Index | Business Index | **Weighted sum value** |
|---|---|---|---|---|---|---|
| Flood Depth | 0.39 | 0.87 | 0.32 | 0.31 | 0.31 | **2.20** |
| Flood Extent | 0.13 | 0.29 | 0.65 | 0.23 | 0.31 | **1.61** |
| Flood Duration | 0.20 | 0.07 | 0.16 | 0.23 | 0.16 | **0.82** |
| Population Index | 0.10 | 0.10 | 0.05 | 0.08 | 0.08 | **0.40** |
| Business Index | 0.10 | 0.07 | 0.08 | 0.08 | 0.08 | **0.41** |

## 4.2.1.4 AHP Consistency Check

The ratio score per parameter in Table 11 is calculated by dividing each parameter's criteria weight (Table 9) by their respective weighted sum value (Table 10). λMax is then derived by taking the mean value of the ratios of all the parameters. λmax is the maximum eigenvalue of the comparison matrix.

**Table 10. Ratio score per FIMI parameter**

| Parameters | Ratio |
|---|---|
| Flood Depth | 5.59 |
| Flood Extent | 5.58 |
| Flood Duration | 5.05 |
| Population Index | 5.23 |
| Business Index | 5.22 |
| λMax | 5.33 |
| Consistency Index | 0.08 |
| Consistency Ratio | 0.07456958 |

In Table 12, the standard values for the Random Index are tabulated. These values are dependent on the number of criteria. In this study the criteria (n) are five, thus RI = 1.12. Consistency Index (CI) is then calculated using Equation 10 below:

**Equation 10. AHP consistency index computation**

$$CI = \frac{(\lambda max - n)}{(n - 1)}$$

Following the creation of the eigenvector matrix of the AHP, its consistency needs to be evaluated. The required level of consistency is evaluated using the following:

**Equation 11. Standard formula for computing AHP consistency ratio**

$$CR = \frac{CI}{RI}$$

where CR refers to the consistency ratio; CI the consistency index; RI the random index.

AHP's theory suggests that the consistency ratio (CR) must be less than 0.1. RI values are given in specific tables. The consistency ratio has been calculated at 0.07. Since CR's value is lower than the threshold (0.1) the weights' consistency is affirmed.

**Table 11. Random index (RI) used to compute consistency ratios (CR)**

| N | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| Random Index | 0 | 0 | 0.58 | 0.90 | 1.12 | 1.24 | 1.32 | 1.41 | 1.45 |

### 4.2.1.5 Application of AHP Results

The five parameters of FIMI are multiplied based on their corresponding weights derived from the AHP method. The FIMI indexes of the barangays are reflected in Table 11. This indexes are then subjected to the spatial statistics of ArcGIS using the Hot Spot Analysis (HSA) tool. The HSA calculates the Getis-Ord (Gi*) statistic for each FIMI value of a barangay in the dataset. The resultant z-scores and p-values indicates where features with either high or low values cluster spatially. This tool works by looking at each barangay within the context of neighboring barangays. A barangay with a high FIMI value is interesting but may not be a statistically significant hot spot. To be a statistically significant hot spot, a barangay will have a high FIMI value and be surrounded by other barangays with high values as well.

After the ArcGIS HSA is performed, the Global Moran's I tool is run to determine spatial autocorrelation of the FIMI values. It is an inferential statistic which means that the results of the analysis are always interpreted within the context of its null hypothesis. For the Global Moran's I statistic, the null hypothesis states that the attribute being analyzed is randomly distributed among the features in the study area. In other words, the spatial processes promoting the observed pattern of values is random chance. When the p-value returned by this tool is statistically significant, the null hypothesis is rejected. The table below summarizes interpretation of results. The p-value is statistically significant, and the z-score is positive therefore the null hypothesis is rejected. The spatial distribution of high values and/or low values in the dataset is more spatially clustered than would be expected if underlying spatial processes were random.

**Table 12. Flood Impact Magnitude Index Value, Parameters and its HSA z- and p-values**

| Barangay | FEI (LQ) | Depth (Mean) | Duration (Mean) | Pop’n Index (LQ) | Biz Index (LQ) | FIMI | Z-values | P-values |
|---|---|---|---|---|---|---|---|---|
| | **0.29** | **0.39** | **0.16** | **0.08** | **0.08** | | | |
| Baikingon | 1.17 | 2.02 | 1.66 | 0.11 | 0.01 | 1.40 | 0.30 | 0.766 |
| Balulang | 1.26 | 3.25 | 1.95 | 1.04 | 0.48 | 2.07 | 3.56 | 0.000 |
| Barangay 1 | 1.63 | 2.60 | 1.50 | 0.72 | 9.81 | 2.57 | 4.10 | 0.000 |
| Barangay 10 | 5.10 | 5.00 | 2.91 | 3.26 | 10.77 | 5.01 | 4.10 | 0.000 |
| Barangay 11 | 0.73 | 3.00 | 1.84 | 1.54 | 32.43 | 4.39 | 4.10 | 0.000 |
| Barangay 13 | 5.10 | 4.00 | 2.72 | 8.32 | 9.58 | 4.90 | 4.10 | 0.000 |
| Barangay 14 | 0.38 | 3.00 | 1.76 | 2.68 | 39.27 | 4.92 | 4.10 | 0.000 |
| Barangay 15 | 4.92 | 3.4 | 3.40 | 8.70 | 7.97 | 4.61 | 4.10 | 0.000 |
| Barangay 16 | 0.46 | 3.00 | 1.86 | 1.29 | 22.65 | 3.51 | 4.10 | 0.000 |
| Barangay 17 | 5.10 | 4.0 | 2.44 | 8.44 | 4.77 | 4.49 | 4.10 | 0.000 |
| Barangay 18 | 1.64 | 3.7 | 2.10 | 19.01 | 13.178 | 4.83 | 4.10 | 0.000 |
| Barangay 2 | 2.53 | 4.5 | 2.00 | 0.43 | 22.75 | 4.66 | 4.10 | 0.000 |
| Barangay 20 | 0.51 | 3.79 | 2.18 | 1.34 | 38.81 | 5.19 | 4.10 | 0.000 |
| Barangay 21 | 0.21 | 2.00 | 1.71 | 1.25 | 7.75 | 1.83 | 4.10 | 0.000 |

| Barangay | FEI (LQ) | Depth (Mean) | Duration (Mean) | Pop'n Index (LQ) | Biz Index (LQ) | FIMI | Z-values | P-values |
|---|---|---|---|---|---|---|---|---|
| | **0.29** | **0.39** | **0.16** | **0.08** | **0.08** | | | |
| Barangay 22 | 0.99 | 3.84 | 2.42 | 3.83 | 8.11 | 3.13 | 3.94 | 0.000 |
| Barangay 23 | 0.09 | 4.43 | 2.00 | 2.58 | 7.06 | 2.84 | 4.10 | 0.000 |
| Barangay 24 | 0.95 | 4.10 | 2.21 | 1.83 | 8.22 | 3.03 | 3.94 | 0.000 |
| Barangay 25 | 0.11 | 4.25 | 2.21 | 5.76 | 23.21 | 4.36 | 4.10 | 0.000 |
| Barangay 26 | 0.26 | 3.00 | 1.81 | 6.26 | 20.39 | 3.67 | 3.94 | 0.000 |
| Barangay 3 | 0.02 | 1.00 | 2.00 | 0.54 | 19.57 | 2.32 | 3.94 | 0.000 |
| Barangay 6 | 4.67 | 3.00 | 2.28 | 0.93 | 7.99 | 3.60 | 4.10 | 0.000 |
| Barangay 7 | 5.08 | 3.00 | 2.54 | 1.76 | 14.63 | 4.36 | 4.10 | 0.000 |
| Barangay 8 | 0.23 | 2.00 | 1.64 | 0.85 | 43.04 | 4.62 | 4.10 | 0.000 |
| Bayabas | 0.34 | 2.00 | 1.89 | 1.33 | 0.37 | 1.32 | 3.83 | 0.000 |
| Bonbon | 4.69 | 2.99 | 2.25 | 1.32 | 0.41 | 3.02 | 3.65 | 0.000 |
| Bulua | 2.33 | 3.19 | 2.35 | 1.53 | 1.27 | 2.52 | 4.05 | 0.000 |
| Canito-an | 1.23 | 3.00 | 2.01 | 0.33 | 0.21 | 1.89 | 3.79 | 0.000 |
| Carmen | 0.74 | 3.62 | 2.02 | 4.95 | 5.69 | 2.80 | 4.14 | 0.000 |
| Consolacion | 4.03 | 4.03 | 2.13 | 4.26 | 1.78 | 3.56 | 4.10 | 0.000 |
| Indahag | 1.45 | 3.00 | 2.00 | 0.10 | 0.012 | 1.92 | 2.80 | 0.005 |
| Iponan | 4.96 | 2.78 | 2.01 | 1.77 | 0.81 | 3.05 | 3.80 | 0.000 |
| Kauswagan | 0.98 | 3.34 | 2.16 | 2.39 | 2.14 | 2.30 | 3.99 | 0.000 |
| Lapasan | 4.04 | 3.00 | 2.44 | 4.29 | 5.01 | 3.47 | 3.51 | 0.000 |
| Lumbia | 0.03 | 3.00 | 1.53 | 0.10 | 0.03 | 1.43 | -0.39 | 0.692 |
| Macabalan | 2.52 | 1.93 | 1.49 | 4.90 | 1.77 | 2.25 | 3.42 | 0.000 |
| Macasandig | 1.42 | 4.38 | 2.05 | 0.40 | 0.25 | 2.50 | 3.05 | 0.002 |
| Nazareth | 1.29 | 3.68 | 1.85 | 1.54 | 2.74 | 2.45 | 3.94 | 0.000 |
| Pagatpat | 0.37 | 3.00 | 1.27 | 0.08 | 0.02 | 1.49 | 3.74 | 0.000 |
| Patag | 0.46 | 2.00 | 1.72 | 0.93 | 0.56 | 1.31 | 4.19 | 0.000 |
| Puntod | 0.43 | 2.00 | 1.63 | 4.05 | 1.98 | 1.65 | 3.94 | 0.000 |
| San Simon | 0.64 | 3.00 | 1.49 | 0.03 | 0.002 | 1.60 | -0.66 | 0.509 |

The HSA result as depicted in Map 9 suggests strong consistency from the TS Sendong flood footprints in Map 2 and Map 3. Of the 41 barangays with flood data, 38 have been identified as flood hotspots and only three barangays are not excluded (Baikingon, Lumbia and San Simon). To recall, the HSA may have found these areas to have high FIMI but they are not surrounded with areas with high FIMI as well. There is also a strong clustering of high flood impacts in the central business district and its surrounding areas especially those adjacent to the two rivers in the city. The Moran's I test in Figure 16 further attests the clustered results with a positive index (0.257), a high z-score (10.610) and statistically significant p-value (0.000).

**Map 9. FIMI Hot Spot Analysis (Source: Author, 2020)**

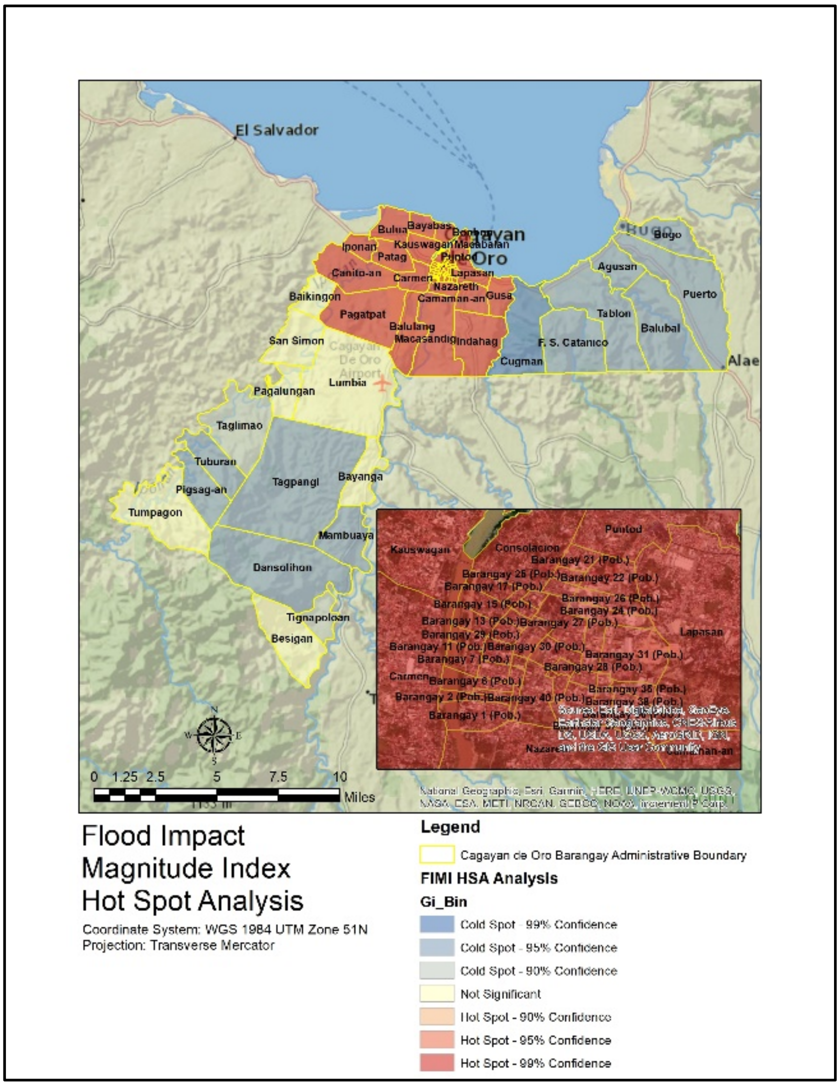
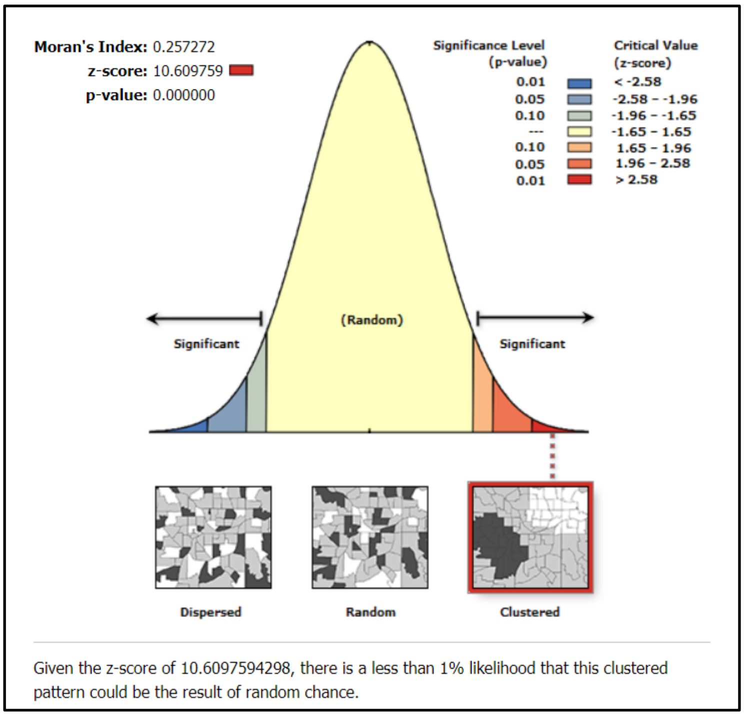


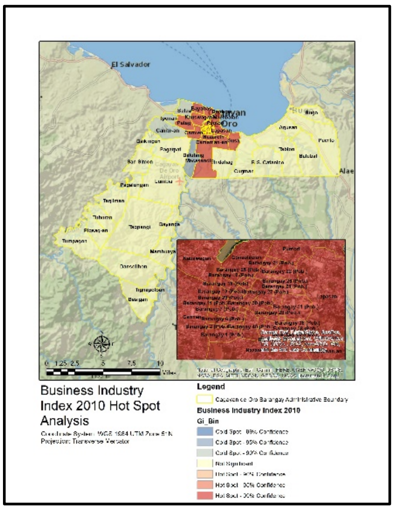

**Figure 17. Global Auto-correlation (Moran's I) (Source: Author, 2020)**



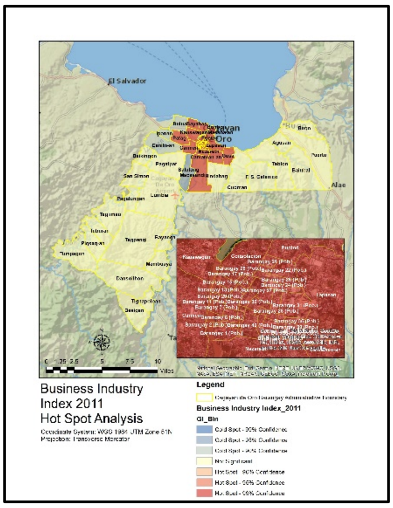
### 4.2.2 Data on the Business Industry Index

The annual Business Industry Index (BII) per barangay derived by the BizIndex$_i$ (Equation 4) was also subjected to the Hot Spot Analysis (Equation 7) of ArcGIS. Map 10-15 depicts the concentration of the city's business establishments in the central business district and some of its adjacent surrounding areas. It can be observed that from 2010 to 2013 there have been no significant changes in the hot spot and cold spot areas. However, significant changes occurred in 2014 and 2015 where cold spot areas have started to disappear. Former cold spot areas of barangays Bulua, Iponan, Canitoan and Balulang have become not significant in the Gi* statistic context. Although they are not included in the hot spot areas, this could still mean that these barangays have experienced higher share of business establishments in the city in the long term.

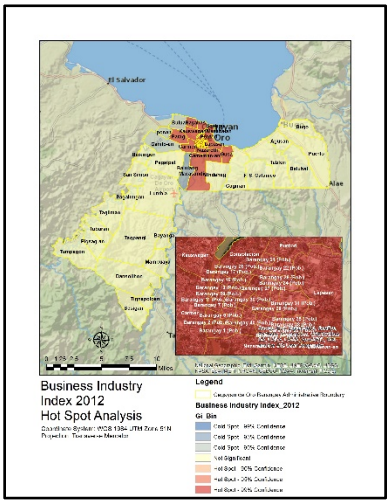
**Map 10. BII HSA 2010**




**Map 11. BII HSA 2011**

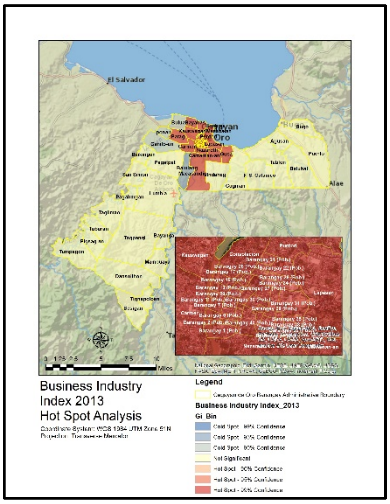



**Map 12. BII HSA 2012**

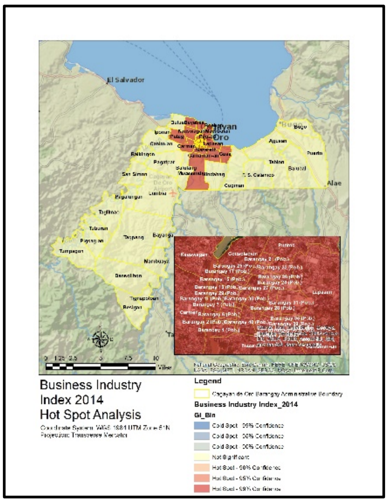



*(Source: Author, 2020)*

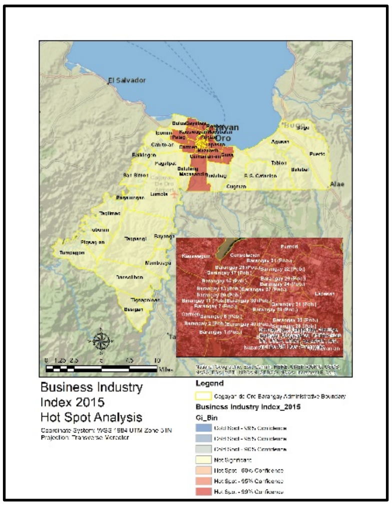
**Map 13. BII HSA 2013**




**Map 14. BII HSA 2014**




**Map 15. BII HSA 2015**




*(Source: Author, 2020)*

### 4.2.3 Correlation Analysis between the Flood Impact Magnitude Index and the Percentage Change of the Business Industy Index

Annual percentage change (PerChange) of the BizIndex was computed from 2011 to 2015. The masterlist of business establishments provided by the local government of Cagayan de Oro both reflects the renewed business permits and the new business applications annually. Thus, in this case the percentage change is used to capture both changes caused by non-renewal and new business permits granted. Percentage change is a mathematical concept that represents the degree of change over time. Positive values indicate a percentage increase whereas negative values indicate percentage decrease. This is calculated using the formula:

**Equation 12. BizIndex Percentage Change Computation**

$$\boldsymbol{Percentage\ Change} = \frac{(\boldsymbol{BizIndex_t} - \boldsymbol{BizIndex_{t-1}})}{\boldsymbol{BizIndex_{t-1}}} * \mathbf{100},$$

where = i refers to the barangay; t refers to the reference year; and t-1 refers to the previous year, and multiplied by 100 to get the percentage.

The inputs for the correlation analysis in Table 14 below can be found in Table 15 which shows the annual number of business establishments and the computed BizIndex for the 80 barangays of Cagayan de Oro city. Afterwards, the computed annual percentage change of the business index as well as the average percentage change from 2011-2015 are then reflected in Table 16.

The results of the correlation analysis conducted between the Flood Impact Magnitude Index (FIMI) and the annual percentage change of the business industry index revealed statistically negative association. The two variables have a negative statistical relationship in the long-term perspective starting from 2013 to 2015 including the average change from 2011-2015. This means that the impact of the flood might started to have significant effects in the number of business establishments in the city in the long-term.

**Table 13. Correlation Analysis of the FIMI and Annual Percentage Change of Business Index**

| **Correlations (bivariate Pearson Correlation)** | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | FIMI | PerChange 2012_2011 | PerChange 2013_2012 | PerChange 2014_2013 | PerChange 2015_2014 | Average Change (2011-2015) |
| FIMI | Pearson Correlation | 1 | -.029 | -.208 | -.311* | -.437** | -.317* |
| | Sig. (2-tailed) | | .859 | .191 | .048 | .004 | .044 |
| | N | 41 | 41 | 41 | 41 | 41 | 41 |
| PerChange 2012_2011 | Pearson Correlation | -.029 | 1 | -.227* | .109 | -.236* | .364** |
| | Sig. (2-tailed) | .859 | | .049 | .345 | .040 | .001 |
| | N | 41 | 78 | 76 | 77 | 76 | 75 |

| Correlations (bivariate Pearson Correlation) | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | FIMI | PerChange 2012_2011 | PerChange 2013_2012 | PerChange 2014_2013 | PerChange 2015_2014 | Average Change (2011-2015) |
| PerChange 2013_2012 | Pearson Correlation | -.208 | -.227* | 1 | .184 | .266* | .583** |
| | Sig. (2-tailed) | .191 | .049 | | .112 | .021 | .000 |
| | N | 41 | 76 | 76 | 76 | 75 | 75 |
| PerChange 2014_2013 | Pearson Correlation | -.311* | .109 | .184 | 1 | .105 | .579** |
| | Sig. (2-tailed) | .048 | .345 | .112 | | .365 | .000 |
| | N | 41 | 77 | 76 | 77 | 76 | 75 |
| PerChange 2015_2014 | Pearson Correlation | -.437** | -.236* | .266* | .105 | 1 | .591** |
| | Sig. (2-tailed) | .004 | .040 | .021 | .365 | | .000 |
| | N | 41 | 76 | 75 | 76 | 77 | 75 |
| Average Change (2011-2015) | Pearson Correlation | -.317* | .364** | .583** | .579** | .591** | 1 |
| | Sig. (2-tailed) | .044 | .001 | .000 | .000 | .000 | |
| | N | 41 | 75 | 75 | 75 | 75 | 75 |

**Table 14. Number of Business Establishments (BE) and BizIndex (BI)**

| Name of Baranggay | 2010 | | 2011 | | 2012 | | 2013 | | 2014 | | 2015 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | BE | BI | BE | BI | BE | BI | BE | BI | BE | BI | BE | BI |
| Agusan | 204 | 0.331 | 239 | 0.369 | 219 | 0.341 | 210 | 0.320 | 235 | 0.304 | 217 | 0.289 |
| Baikingon | 3 | 0.005 | 7 | 0.012 | 7 | 0.012 | 7 | 0.012 | 10 | 0.014 | 14 | 0.020 |
| Balubal | 13 | 0.015 | 15 | 0.016 | 8 | 0.009 | 11 | 0.012 | 8 | 0.007 | 6 | 0.006 |
| Balulang | 423 | 0.484 | 438 | 0.477 | 388 | 0.426 | 405 | 0.436 | 424 | 0.388 | 424 | 0.399 |
| Barangay 1 | 172 | 9.810 | 171 | 9.281 | 154 | 8.431 | 160 | 8.585 | 161 | 7.331 | 164 | 7.680 |
| Barangay 10 | 57 | 10.772 | 70 | 12.590 | 63 | 11.429 | 70 | 12.446 | 80 | 12.071 | 72 | 11.173 |
| Barangay 11 | 202 | 32.427 | 216 | 32.999 | 216 | 33.285 | 201 | 30.355 | 219 | 28.069 | 215 | 28.340 |
| Barangay 12 | 155 | 56.283 | 164 | 56.673 | 156 | 54.376 | 155 | 52.950 | 155 | 44.937 | 143 | 42.637 |
| Barangay 13 | 75 | 9.580 | 65 | 7.901 | 49 | 6.008 | 52 | 6.249 | 56 | 5.711 | 47 | 4.929 |
| Barangay 14 | 196 | 39.273 | 197 | 37.565 | 207 | 39.814 | 208 | 39.209 | 240 | 38.395 | 252 | 41.461 |
| Barangay 15 | 76 | 7.969 | 70 | 6.985 | 71 | 7.147 | 63 | 6.215 | 62 | 5.191 | 61 | 5.252 |
| Barangay 16 | 70 | 22.649 | 64 | 19.707 | 65 | 20.188 | 78 | 23.743 | 77 | 19.891 | 79 | 20.988 |
| Barangay 17 | 37 | 4.770 | 41 | 5.030 | 34 | 4.208 | 30 | 3.639 | 43 | 4.426 | 45 | 4.764 |
| Barangay 18 | 29 | 13.177 | 34 | 14.703 | 31 | 13.522 | 35 | 14.962 | 32 | 11.609 | 27 | 10.074 |
| Barangay 19 | 87 | 27.718 | 81 | 24.559 | 68 | 20.796 | 68 | 20.381 | 68 | 17.297 | 77 | 20.143 |
| Barangay 2 | 125 | 22.745 | 133 | 23.031 | 120 | 20.960 | 121 | 20.713 | 112 | 16.271 | 116 | 17.331 |
| Barangay 20 | 98 | 38.805 | 100 | 37.684 | 98 | 37.250 | 94 | 35.017 | 98 | 30.982 | 94 | 30.563 |
| Barangay 21 | 44 | 7.752 | 44 | 7.377 | 50 | 8.456 | 46 | 7.624 | 44 | 6.189 | 46 | 6.654 |
| Barangay 22 | 115 | 8.111 | 114 | 7.652 | 139 | 9.411 | 142 | 9.422 | 146 | 8.221 | 150 | 8.687 |
| Barangay 23 | 70 | 7.056 | 68 | 6.523 | 70 | 6.773 | 82 | 7.775 | 105 | 8.450 | 112 | 9.269 |
| Barangay 24 | 117 | 8.224 | 122 | 8.161 | 356 | 24.021 | 449 | 29.691 | 509 | 28.565 | 528 | 30.474 |
| Barangay 25 | 146 | 23.213 | 137 | 20.730 | 142 | 21.672 | 153 | 22.885 | 164 | 20.819 | 165 | 21.541 |
| Barangay 26 | 217 | 20.389 | 226 | 20.209 | 213 | 19.211 | 214 | 18.916 | 218 | 16.354 | 235 | 18.130 |
| Barangay 27 | 123 | 10.447 | 124 | 10.023 | 114 | 9.295 | 130 | 10.388 | 150 | 10.172 | 128 | 8.927 |
| Barangay 28 | 136 | 15.599 | 163 | 17.792 | 155 | 17.065 | 153 | 16.509 | 147 | 13.461 | 138 | 12.996 |
| Barangay 29 | 126 | 5.184 | 141 | 5.521 | 164 | 6.477 | 181 | 7.006 | 188 | 6.176 | 204 | 6.892 |
| Barangay 3 | 181 | 19.572 | 202 | 20.787 | 205 | 21.279 | 203 | 20.651 | 187 | 16.144 | 212 | 18.823 |

| Name of Baranggay | 2010 | | 2011 | | 2012 | | 2013 | | 2014 | | 2015 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | BE | BI | BE | BI | BE | BI | BE | BI | BE | BI | BE | BI |
| Barangay 30 | 77 | 10.228 | 83 | 10.492 | 79 | 10.073 | 80 | 9.997 | 75 | 7.954 | 75 | 8.180 |
| Barangay 31 | 283 | 11.964 | 298 | 11.989 | 344 | 13.960 | 408 | 16.226 | 408 | 13.771 | 429 | 14.891 |
| Barangay 32 | 196 | 18.272 | 196 | 17.388 | 194 | 17.360 | 201 | 17.628 | 211 | 15.705 | 211 | 16.151 |
| Barangay 33 | 1019 | 101.478 | 981 | 92.972 | 921 | 88.042 | 849 | 79.540 | 2406 | 191.301 | 2085 | 170.492 |
| Barangay 34 | 134 | 27.445 | 118 | 23.000 | 117 | 23.003 | 114 | 21.966 | 129 | 21.095 | 126 | 21.190 |
| Barangay 35 | 72 | 7.972 | 69 | 7.271 | 53 | 5.633 | 53 | 5.521 | 58 | 5.127 | 57 | 5.182 |
| Barangay 36 | 20 | 2.482 | 24 | 2.835 | 21 | 2.502 | 21 | 2.452 | 24 | 2.378 | 26 | 2.650 |
| Barangay 37 | 79 | 23.545 | 88 | 24.960 | 82 | 23.460 | 86 | 24.114 | 87 | 20.703 | 98 | 23.983 |
| Barangay 38 | 181 | 40.243 | 187 | 39.568 | 170 | 36.282 | 155 | 32.421 | 166 | 29.468 | 158 | 28.845 |
| Barangay 39 | 87 | 31.183 | 84 | 28.652 | 86 | 29.589 | 88 | 29.673 | 106 | 30.334 | 95 | 27.959 |
| Barangay 4 | 158 | 47.776 | 148 | 42.589 | 137 | 39.765 | 137 | 38.972 | 148 | 35.730 | 163 | 40.471 |
| Barangay 40 | 168 | 10.264 | 184 | 10.699 | 203 | 11.906 | 176 | 10.116 | 191 | 9.317 | 176 | 8.830 |
| Barangay 5 | 134 | 43.357 | 146 | 44.956 | 123 | 38.202 | 116 | 35.310 | 132 | 34.100 | 137 | 36.398 |
| Barangay 6 | 51 | 7.987 | 52 | 7.750 | 53 | 7.967 | 44 | 6.482 | 45 | 5.626 | 40 | 5.143 |
| Barangay 7 | 126 | 14.633 | 130 | 14.368 | 127 | 14.158 | 128 | 13.985 | 131 | 12.147 | 122 | 11.634 |
| Barangay 8 | 221 | 43.038 | 226 | 41.884 | 232 | 43.369 | 256 | 46.901 | 267 | 41.514 | 249 | 39.816 |
| Barangay 9 | 211 | 56.417 | 221 | 56.234 | 220 | 56.465 | 219 | 55.087 | 232 | 49.526 | 233 | 51.154 |
| Bayabas | 102 | 0.372 | 106 | 0.368 | 102 | 0.357 | 117 | 0.402 | 126 | 0.367 | 138 | 0.414 |
| Bayanga | 5 | 0.003 | 6 | 0.003 | 5 | 0.003 | 7 | 0.004 | 7 | 0.003 | 6 | 0.003 |
| Besigan | 0 | 0.000 | 0 | 0.000 | 0 | 0.000 | 0 | 0.000 | 0 | 0.000 | 0 | 0.000 |
| Bonbon | 80 | 0.410 | 86 | 0.419 | 81 | 0.399 | 72 | 0.347 | 77 | 0.315 | 71 | 0.299 |
| Bugo | 336 | 0.346 | 376 | 0.369 | 392 | 0.388 | 386 | 0.374 | 390 | 0.321 | 363 | 0.307 |
| Bulua | 730 | 1.274 | 862 | 1.432 | 1064 | 1.783 | 1090 | 1.790 | 1209 | 1.685 | 1216 | 1.743 |
| Camaman-an | 370 | 0.420 | 418 | 0.452 | 405 | 0.442 | 413 | 0.441 | 429 | 0.389 | 439 | 0.410 |
| Canito-an | 264 | 0.205 | 264 | 0.195 | 249 | 0.186 | 260 | 0.190 | 301 | 0.187 | 298 | 0.190 |
| Carmen | 2174 | 5.690 | 2266 | 5.645 | 2141 | 5.379 | 2229 | 5.489 | 2795 | 5.841 | 2625 | 5.642 |
| Consolacion | 116 | 1.781 | 116 | 1.695 | 105 | 1.548 | 114 | 1.647 | 129 | 1.582 | 113 | 1.425 |
| Cugman | 329 | 0.157 | 363 | 0.164 | 359 | 0.164 | 388 | 0.174 | 410 | 0.156 | 403 | 0.157 |

| Name of Baranggay | 2010 | | 2011 | | 2012 | | 2013 | | 2014 | | 2015 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | BE | BI | BE | BI | BE | BI | BE | BI | BE | BI | BE | BI |
| Dansolihon | 11 | 0.001 | 10 | 0.001 | 8 | 0.001 | 10 | 0.001 | 8 | 0.001 | 3 | 0.000 |
| F. S. Catanico | 5 | 0.004 | 4 | 0.003 | 4 | 0.003 | 2 | 0.001 | 3 | 0.002 | 2 | 0.001 |
| Gusa | 601 | 0.718 | 661 | 0.751 | 659 | 0.756 | 656 | 0.737 | 718 | 0.685 | 715 | 0.701 |
| Indahag | 20 | 0.012 | 24 | 0.014 | 23 | 0.013 | 27 | 0.015 | 28 | 0.013 | 30 | 0.015 |
| Iponan | 266 | 0.814 | 310 | 0.903 | 294 | 0.864 | 320 | 0.921 | 357 | 0.872 | 369 | 0.927 |
| Kauswagan | 864 | 2.136 | 912 | 2.145 | 940 | 2.230 | 975 | 2.267 | 1077 | 2.126 | 1056 | 2.143 |
| Lapasan | 1369 | 5.009 | 1442 | 5.021 | 1243 | 4.366 | 1173 | 4.038 | 1160 | 3.389 | 1100 | 3.305 |
| Lumbia | 136 | 0.033 | 133 | 0.031 | 122 | 0.029 | 123 | 0.028 | 158 | 0.031 | 169 | 0.034 |
| Macabalan | 205 | 1.771 | 242 | 1.989 | 211 | 1.749 | 208 | 1.690 | 240 | 1.655 | 207 | 1.468 |
| Macasandig | 408 | 0.252 | 406 | 0.239 | 424 | 0.251 | 443 | 0.257 | 505 | 0.249 | 502 | 0.255 |
| Mambuaya | 8 | 0.006 | 6 | 0.004 | 5 | 0.004 | 4 | 0.003 | 4 | 0.002 | 9 | 0.006 |
| Nazareth | 529 | 2.739 | 545 | 2.685 | 551 | 2.738 | 580 | 2.825 | 645 | 2.666 | 648 | 2.755 |
| Pagalungan | 0 | 0.000 | 0 | 0.000 | 0 | 0.000 | 0 | 0.000 | 1 | 0.001 | 0 | 0.000 |
| Pagatpat | 32 | 0.017 | 29 | 0.014 | 39 | 0.020 | 42 | 0.021 | 55 | 0.023 | 61 | 0.026 |
| Patag | 287 | 0.555 | 294 | 0.541 | 306 | 0.568 | 293 | 0.533 | 310 | 0.479 | 316 | 0.502 |
| Pigsag-an | 1 | 0.001 | 1 | 0.001 | 0 | 0.000 | 0 | 0.000 | 0 | 0.000 | 0 | 0.000 |
| Puerto | 443 | 0.415 | 436 | 0.389 | 418 | 0.376 | 410 | 0.361 | 435 | 0.325 | 441 | 0.339 |
| Puntod | 251 | 1.978 | 264 | 1.980 | 242 | 1.830 | 259 | 1.920 | 294 | 1.850 | 275 | 1.779 |
| San Simon | 2 | 0.002 | 3 | 0.002 | 1 | 0.001 | 3 | 0.002 | 6 | 0.004 | 10 | 0.007 |
| Tablon | 363 | 0.069 | 405 | 0.073 | 407 | 0.074 | 426 | 0.076 | 444 | 0.067 | 457 | 0.071 |
| Taglimao | 3 | 0.002 | 5 | 0.003 | 7 | 0.004 | 4 | 0.002 | 4 | 0.002 | 3 | 0.002 |
| Tagpangi | 4 | 0.002 | 6 | 0.002 | 5 | 0.002 | 5 | 0.002 | 5 | 0.002 | 4 | 0.001 |
| Tignapoloan | 3 | 0.000 | 3 | 0.000 | 2 | 0.000 | 3 | 0.000 | 2 | 0.000 | 2 | 0.000 |
| Tuburan | 5 | 0.004 | 5 | 0.004 | 1 | 0.001 | 1 | 0.001 | 0 | 0.000 | 0 | 0.000 |
| Tumpagon | 0 | 0.000 | 1 | 0.001 | 0 | 0.000 | 1 | 0.001 | 1 | 0.000 | 2 | 0.001 |

**Table 15. BizIndex Annual Percentage Change**

| Name of Baranggay | 2011-2010 | 2012-2011 | 2013-2012 | 2014-2013 | 2015-2014 | Average Change 2010-2015 |
|---|---|---|---|---|---|---|
| Agusan | 0.11 | -7.57 | -6.02 | -5.03 | -5.03 | -4.709 |
| Baikingon | 1.22 | 0.87 | -1.99 | 21.24 | 43.98 | 13.062 |
| Balubal | 0.10 | -46.20 | 34.76 | -38.28 | -22.87 | -14.499 |
| Balulang | -0.01 | -10.65 | 2.30 | -11.15 | 2.84 | -3.334 |
| Barangay 1 | -0.05 | -9.16 | 1.82 | -14.60 | 4.76 | -3.447 |
| Barangay 10 | 0.17 | -9.22 | 8.89 | -3.01 | -7.44 | -2.121 |
| Barangay 11 | 0.02 | 0.87 | -8.80 | -7.53 | 0.96 | -2.897 |
| Barangay 12 | 0.01 | -4.05 | -2.62 | -15.13 | -5.12 | -5.384 |
| Barangay 13 | -0.18 | -23.96 | 4.01 | -8.60 | -13.69 | -8.484 |
| Barangay 14 | -0.04 | 5.99 | -1.52 | -2.08 | 7.99 | 2.066 |
| Barangay 15 | -0.12 | 2.31 | -13.04 | -16.48 | 1.18 | -5.230 |
| Barangay 16 | -0.13 | 2.44 | 17.61 | -16.22 | 5.51 | 1.843 |
| Barangay 17 | 0.05 | -16.35 | -13.52 | 21.64 | 7.63 | -0.111 |
| Barangay 18 | 0.12 | -8.03 | 10.65 | -22.41 | -13.23 | -6.580 |
| Barangay 19 | -0.11 | -15.32 | -1.99 | -15.13 | 16.45 | -3.222 |
| Barangay 2 | 0.01 | -8.99 | -1.18 | -21.45 | 6.52 | -5.017 |
| Barangay 20 | -0.03 | -1.15 | -6.00 | -11.52 | -1.35 | -4.010 |
| Barangay 21 | -0.05 | 14.62 | -9.84 | -18.82 | 7.52 | -1.313 |
| Barangay 22 | -0.06 | 22.99 | 0.12 | -12.74 | 5.66 | 3.194 |
| Barangay 23 | -0.08 | 3.83 | 14.81 | 8.67 | 9.70 | 7.387 |
| Barangay 24 | -0.01 | 194.33 | 23.61 | -3.79 | 6.68 | 44.165 |
| Barangay 25 | -0.11 | 4.55 | 5.60 | -9.03 | 3.47 | 0.895 |
| Barangay 26 | -0.01 | -4.94 | -1.53 | -13.55 | 10.86 | -1.832 |
| Barangay 27 | -0.04 | -7.27 | 11.76 | -2.08 | -12.24 | -1.973 |
| Barangay 28 | 0.14 | -4.08 | -3.26 | -18.46 | -3.45 | -5.823 |
| Barangay 29 | 0.06 | 17.32 | 8.16 | -11.85 | 11.60 | 5.059 |
| Barangay 3 | 0.06 | 2.36 | -2.95 | -21.82 | 16.59 | -1.151 |

| Name of Baranggay | 2011-2010 | 2012-2011 | 2013-2012 | 2014-2013 | 2015-2014 | Average Change 2010-2015 |
|---|---|---|---|---|---|---|
| Barangay 30 | 0.03 | -3.99 | -0.75 | -20.44 | 2.84 | -4.463 |
| Barangay 31 | 0.00 | 16.44 | 16.24 | -15.13 | 8.14 | 5.136 |
| Barangay 32 | -0.05 | -0.16 | 1.54 | -10.91 | 2.84 | -1.347 |
| Barangay 33 | -0.08 | -5.30 | -9.66 | 140.51 | -10.88 | 22.917 |
| Barangay 34 | -0.16 | 0.01 | -4.51 | -3.97 | 0.45 | -1.634 |
| Barangay 35 | -0.09 | -22.52 | -1.99 | -7.13 | 1.07 | -6.132 |
| Barangay 36 | 0.14 | -11.74 | -1.99 | -3.01 | 11.41 | -1.038 |
| Barangay 37 | 0.06 | -6.01 | 2.79 | -14.15 | 15.85 | -0.293 |
| Barangay 38 | -0.02 | -8.30 | -10.64 | -9.11 | -2.11 | -6.037 |
| Barangay 39 | -0.08 | 3.27 | 0.28 | 2.23 | -7.83 | -0.426 |
| Barangay 4 | -0.11 | -6.63 | -1.99 | -8.32 | 13.27 | -0.757 |
| Barangay 40 | 0.04 | 11.28 | -15.03 | -7.90 | -5.23 | -3.368 |
| Barangay 5 | 0.04 | -15.02 | -7.57 | -3.43 | 6.74 | -3.849 |
| Barangay 6 | -0.03 | 2.81 | -18.64 | -13.20 | -8.58 | -7.530 |
| Barangay 7 | -0.02 | -1.46 | -1.22 | -13.14 | -4.22 | -4.014 |
| Barangay 8 | -0.03 | 3.54 | 8.14 | -11.49 | -4.09 | -0.783 |
| Barangay 9 | 0.00 | 0.41 | -2.44 | -10.09 | 3.29 | -1.768 |
| Bayabas | -0.01 | -2.94 | 12.42 | -8.60 | 12.64 | 2.700 |
| Bayanga | 0.14 | -15.94 | 37.21 | -15.13 | -11.85 | -1.115 |
| Besigan | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Bonbon | 0.02 | -5.00 | -12.88 | -9.24 | -5.17 | -6.454 |
| Bugo | 0.06 | 5.16 | -3.49 | -14.25 | -4.28 | -3.360 |
| Bulua | 0.12 | 24.50 | 0.40 | -5.87 | 3.44 | 4.520 |
| Camaman-an | 0.08 | -2.27 | -0.06 | -11.84 | 5.24 | -1.772 |
| Canito-an | -0.05 | -4.86 | 2.33 | -1.75 | 1.82 | -0.502 |
| Carmen | -0.01 | -4.70 | 2.03 | 6.42 | -3.41 | 0.067 |
| Consolacion | -0.05 | -8.70 | 6.41 | -3.97 | -9.91 | -3.244 |
| Cugman | 0.05 | -0.24 | 5.92 | -10.32 | 1.09 | -0.701 |

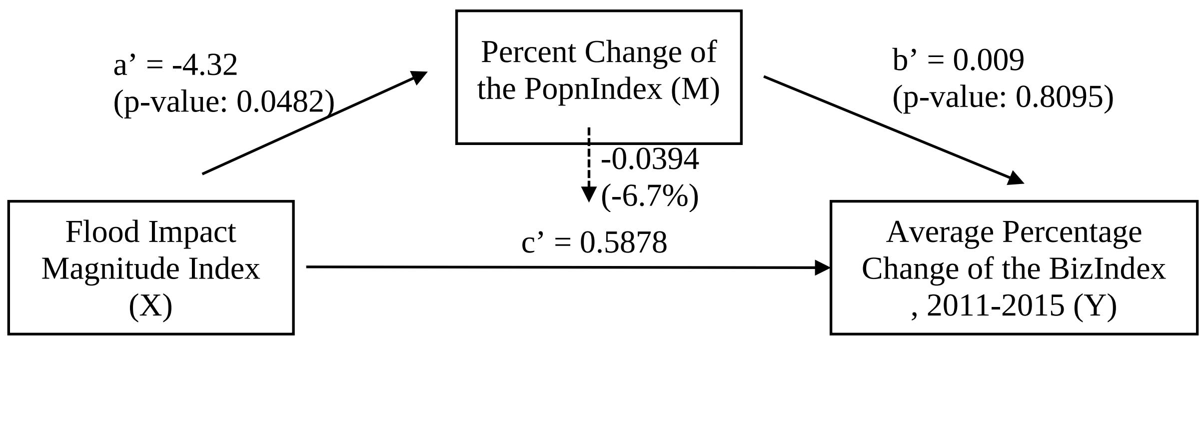
| Name of Baranggay | 2011-2010 | 2012-2011 | 2013-2012 | 2014-2013 | 2015-2014 | Average Change 2010-2015 |
|---|---|---|---|---|---|---|
| Dansolihon | -0.13 | -19.31 | 22.51 | -32.11 | -61.43 | -18.095 |
| F. S. Catanico | -0.24 | 0.87 | -51.00 | 27.30 | -31.44 | -10.901 |
| Gusa | 0.05 | 0.56 | -2.44 | -7.11 | 2.41 | -1.306 |
| Indahag | 0.14 | -3.34 | 15.05 | -11.99 | 10.19 | 2.011 |
| Iponan | 0.11 | -4.34 | 6.67 | -5.32 | 6.30 | 0.684 |
| Kauswagan | 0.00 | 3.96 | 1.65 | -6.25 | 0.84 | 0.041 |
| Lapasan | 0.00 | -13.05 | -7.51 | -16.07 | -2.48 | -7.823 |
| Lumbia | -0.07 | -7.48 | -1.19 | 9.02 | 10.00 | 2.057 |
| Macabalan | 0.12 | -12.05 | -3.39 | -2.08 | -11.30 | -5.739 |
| Macasandig | -0.05 | 5.34 | 2.40 | -3.25 | 2.23 | 1.332 |
| Mambuaya | -0.29 | -15.94 | -21.60 | -15.13 | 131.40 | 15.688 |
| Nazareth | -0.02 | 1.98 | 3.16 | -5.62 | 3.32 | 0.564 |
| Pagalungan | 0.00 | 0.00 | 0.00 | 0.00 | -100.00 | 0.00 |
| Pagatpat | -0.14 | 35.65 | 5.54 | 11.14 | 14.06 | 13.251 |
| Patag | -0.03 | 4.98 | -6.16 | -10.21 | 4.83 | -1.315 |
| Pigsag-an | -0.05 | -100.00 | 0.00 | 0.00 | 0.00 | -20.010 |
| Puerto | -0.06 | -3.30 | -3.87 | -9.96 | 4.26 | -2.585 |
| Puntod | 0.00 | -7.54 | 4.89 | -3.66 | -3.80 | -2.023 |
| San Simon | 0.43 | -66.38 | 194.02 | 69.73 | 71.41 | 53.841 |
| Tablon | 0.06 | 1.36 | 2.58 | -11.55 | 5.85 | -0.337 |
| Taglimao | 0.59 | 41.21 | -44.00 | -15.13 | -22.87 | -8.040 |
| Tagpangi | 0.43 | -15.94 | -1.99 | -15.13 | -17.73 | -10.074 |
| Tignapoloan | -0.05 | -32.76 | 47.01 | -43.42 | 2.84 | -5.275 |
| Tuburan | -0.05 | -79.83 | -1.99 | -100.00 | 0.00 | -36.374 |
| Tumpagon | 0.00 | -100.00 | 0.00 | -15.13 | 105.69 | -1.889 |

### 4.2.4 Mediation Analysis

In the mediation model of the conceptual framework, this research hypothesized that the effects of the flood impact magnitude index (X) towards the number of business establishments (Y) is mediated by the population densification shift (M). To determine the mediation effect, recent development in SPSS allows the regression-based processing of this analysis through the PROCESS methodology. This feature developed by Hayes (2018) incorporates the fundamental methods of mediation analysis as originally introduced by Baron and Kenny (1986) in their joint significant tests. Further, the bootstrapping procedure imbedded in the PROCESS is considered as a robust analysis technique. Bootstrapping is a non-parametric method based on resampling with replacement which is done many times, e.g., 5000 times (Kenny, 2015)

Figure 18 below shows the schematic diagram as well as the coefficient results of the X, M and Y variables. The regression model predicts 22.44% of the variance of the dependent variable with a p-value of 0.0482 which is statistically significant. The dependent variable predicted here is the average percentage change of BizIndex from 2011 to 2015. To see if these mediation coefficients of the variables have significant effects, indirect effect of X on Y through M is examined. Based on the PROCESS results, population density shift has an indirect effect of -0.0394 which indicates partial and statistically significant mediation. For a meaningful interpretation, this number is divided by 0.5878 (c') and multiplied by 100 to get the percentage which gives a value of -6.7%. This means that the percentage change of the population index accounts for -6.7% of the total effect of X to Y. In practical terms, the changes in the population per barangay has a very minor mediating effects to the resulting number of business establishments despite the statistically negative effects of the FIMI to the population per barangay (a: -4.32; p-value=0.0482).

**Figure 18. Diagram and Coefficient Results of the Mediation Analysis in the SPSS PROCESS**



### 4.2.5 Moderation Analysis

The moderation analysis was also done using the PROCESS feature of SPSS. Essentially this is also a regression analysis that includes an interaction effect of the independent variable (X) and the moderator variable (W). Figure 19 below shows the schematic and coefficient results from the SPSS analysis. In this case, the interaction effects happen between the FIMI and Commercial Areas (CA). The moderator variable (CA) is a binary variable holding a value of 1 if a barangay is within the central business district or if it has at least one of the following: Malls, Public Market, Business Park, Commercial Strips and Neighborhood Center. Conversely, it will have a value of 0 if it does not meet any of the aforementioned conditions. All the rest of the variables used in this analysis are continuous. Thus, taking off from Equation 8 from section 3.2.2.6, the regression equation for this moderation test becomes:

$$Y = -4.94 + 2.19X + 4.35W - 1.82XW + \varepsilon$$

**Figure 19. Diagram and Coefficient Results of the Moderation Analysis in the SPSS PROCESS**

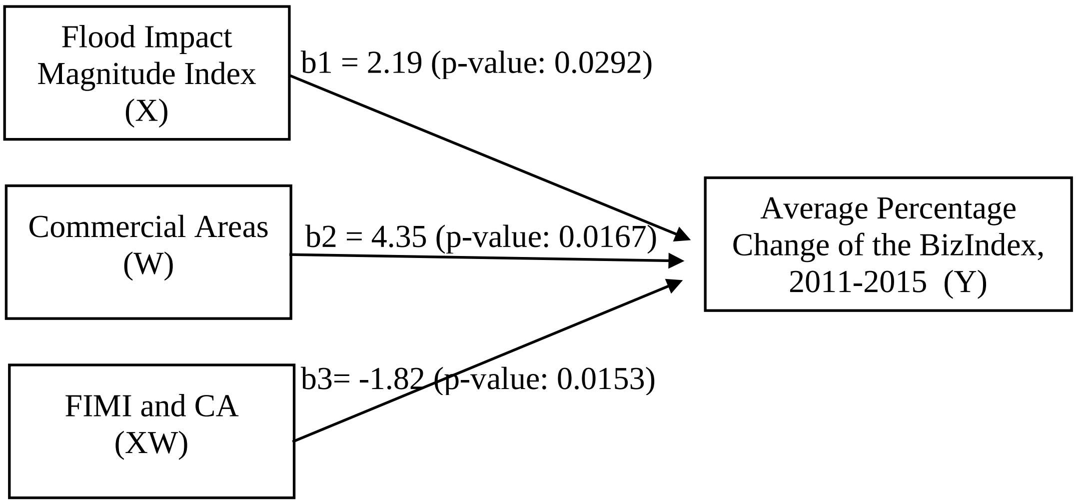
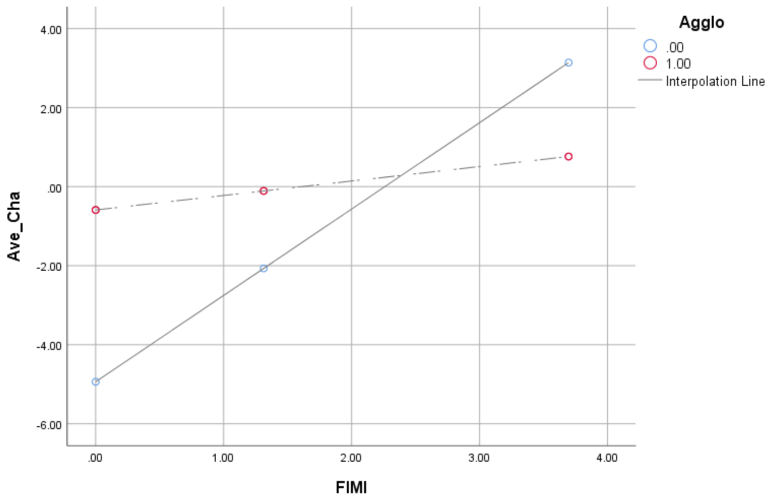



**Figure 20. Interpolation Line between FIMI and Average Percentage Change of BizIndex Moderated by CA**




The regression model for this moderation analysis predicts 29.86% of the variances in the dependent variable with a significant p-value of 0.0674. The FIMI has a coefficient of 2.19

with a significant p-value of 0.0292 while the CA (Agglo) has a statistically significant coefficient of 4.35 (p-value: 0.0167). The interaction effect of X and W has a statistically significant coefficient of -1.82 with p-value of 0.0153.

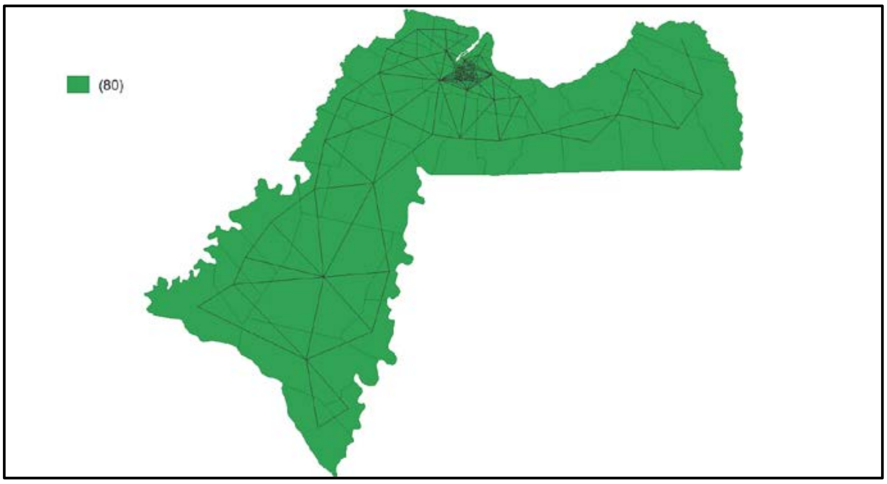
Figure 20 aids in interpreting the interaction effect by plotting the values of the independent variable in the different value of the moderator. To relate the results in practical sense, interestingly, the interaction of the FIMI and the CA have a negative effect to the number of business establishments. This could be due to the FIMI which, to recall, is negatively correlated in the first place with the number of business establishments (Table 12). On the unaffected barangays (those whose FIMI is zero), those which are endowed with commercial areas or are within CBD have relatively lesser average percentage change (-0.5899) at the baseline compared to the other group (-4.9391). As the potential flood effects increases (rise in FIMI), barangays which have commercial areas or are located in the CBD have experienced relatively higher percentage change of business establishments. However as FIMI continue to rise, it is also interesting to note that barangays which do not have commercial areas or are not even located in the CBD, have greater increase in the number of business establishments. This may suggest outlier barangays, which despite of having no commercial areas, are experiencing higher number of business establishments.

### 4.2.6 Spatial Regression Analysis

Spatial regression is conducted to: 1) supplement the non-causality nature of the correlation analysis, and 2) determine the degree of causality of the independent variables to the dependent variable by deriving the individual coefficients of each predictor indicators including values of neighboring barangay.

Prior to conducting the spatial regression, weigh matrix is computed for the study area. In this case, the queen contiguity matrix is used and derived from the GeoDa software. The row stochastic form of this spatial weight matrix will be useful for expressing the spatial regression model later on. The queen contiguity weights simply indicates whether spatial units share a boundary as well as common vertices. Figure 21 below illustrates the parameters of how the queen contiguity weights are derived. The centroid of each polygon (barangay) is determined and connected to the adjacent centroids of its neighboring barangays with an order of 1 which means that it only considers its immediate neighbors. The queen criterion is recommended in practice to manage potential inaccuracies in the polygon file such as rounding errors (Burkey, 2018). It is also the default for contiguity weights.

**Figure 21. Spatial Weights Matrix for Cagayan de Oro**



The spatial regression model deployed in this research is the Spatially Lagged X (SLX) model or also known as the Spatial Cross-regressive Model. This type of regression model adds a spatial lag vector integrating the average values of the predictor variables from neighboring areas into the equation. Intuitively, this model states that the percent change in the number of business establishments per barangay is also related to the average values of the explanatory variables from the neighboring barangays. These are referred as the spatially lagged exogenous regressors. The SLX model presumes that the exploratory variables $X_2$, $X_3$, …, $X_k$ as well as their spatial lags $LX_2$, …, $LX_k$ influence a georeferenced dependent variable Y. In this approach Y is not only affected by values the variables take in the same area but also they can take in neighbouring regions, such that:

$$\boldsymbol{y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots \beta_k X_k + W x_2 + \cdots W x_k + \varepsilon}$$

Where y is an n*1 vector of the endogenous variable Y, $x_j$ an n*1 vector of the exogenous variable Xj (where $x_1$ is a vector of ones for the intercept), W an n*n spatial weight matrix and ε an n*n vector of disturbances. The parameters $\beta_j$j=1, 2,…,k denote the regression coefficients of the exogenous variables $X_1$, $X_2$, …, $X_k$ and the parameters $\gamma_j$ the regression coefficients of the exogeneous spatial lags $Wx_2$,…, $Wx_k$. The disturbances $\varepsilon_i$ are assumed to meet the standard assumptions for a linear regression model which is expected to be zero, constant variance $\sigma^2$ and absence of autocorrelation.

Substantive spatial dependence can be captured by spatial lags in the explanatory variables $X_2$, $X_3$, …, $X_k$ or the endogenous variable Y. The spatial lag variables $Wx_2$, $Wx_3$, …, $Wx_k$ will be incorporated into the standard regression model as additional regressors. Substantive spatial interaction can occur in different applications. Resulting change in the number of business establishments per barangay may not only depend on its own predictor variables but as well on the predictor variables in adjacent barangays. In this case, spillover effects are restricted to neighbourhood areas. Such a restriction may especially hold for spillovers of tacit knowledge which is expected to be exchanged within local areas.

The regression performed in this study is composed of two separate analysis: short-term and long-term flooding disaster impacts. Both equations have different time dimension of the dependent variable, change in the number of business establishments, and one explanatory variable accounting for the barangay population. It is designed as such based on the result of the hotspot analysis trend of business establishments where significant changes started to occur in the later years of 2014-2015. The regression parameters and results are further explained in the next section.

### 4.2.6.1 SLX Regression for Short-term Flood Disaster Impacts

Based on the SLX model, the regression equation looking at the immediate effects of the flooding disaster is defined as follows:

**Equation 13. SLX Regression Model for the Short-term Effects of the Flooding Disaster**

$$y = \beta_0 + \beta_1 \boldsymbol{FIMI} + \beta_2 \boldsymbol{PopnPercChange} + \beta_3 \boldsymbol{Area_{Has}} + \beta_4 \boldsymbol{Flooded} + \beta_5 \boldsymbol{Agglo\_factors} + Wx_2 + \cdots Wx_k + \varepsilon$$

Where:

y – Percentage change in the business index in 2012 from 2011;

FIMI – potential consequences or damages incurred by a barangay based on its flood impact magnitude index value;

PopnPercChange – Percentage change of population index from 2010 (actual census) to 2012 (projected population growth);

Area_Has – land area of the barangay;

Flooded – dummy variable indicating 1 if barangay is flooded and 0 otherwise;

Agglo_factors – dummy variable indicating factors of agglomeration holding a value of 1 if any is true: barangay is within the central business district OR has a mall, OR public market, OR commercial strips, OR business parks, OR neighborhood center; and 0 otherwise;

$\gamma_2 Wx_2 + \cdots \gamma_k Wx_k$ - explanatory 'X' variables of neighbor barangays;

$\varepsilon$ – error/residuals

Diagnostic tests were performed before doing the SLX regression. As a standard procedure, the Ordinary Least Square (OLS) regression model was conducted first to check for autocorrelation effects. Moran's I test is designed for testing regression residuals for spatial dependence. The null hypothesis in this case indicates no spatial correlation of residuals. The p-value of 0.1082 reflected in Table 18 suggests weak evidence against the null hypothesis that there is spatial dependence. Nevertheless, the alternative hypothesis is still greater thus the SLX regression was pursued to further scrutinize the explanatory variables.

**Table 16. OLS Residual Results**

| OLS Residual | Results |
|---|---|
| Residual standard error | 30.49 |
| Mutiple R-squared | 0.1399 |
| Adjusted R-squared | 0.08181 |
| F-statistics | 2.408 |
| p-value | 0.04442 |

**Table 17. Moran's I Spatial Autocorrelation Results based on OLS**

| Moran's I Specification Test | Results |
|---|---|
| standard deviation | 1.2362 |
| p-value | 0.1082 |
| alternative hypothesis | greater |
| Sample estimates | |
| observed Moran's I | 0.04337622 |
| Expectation | -0.04102558 |
| Variance | 0.00466174 |

Another diagnostics to determine the need to run a spatial regression model is through the Lagrange Multiplier (LM) test. While the Moran's I test for spatial error autocorrelation is a general test, the LM tests are more specific (Burkey, 2018). The p-value indicates how the SLX model can improve the regression equation fit. Spatial dependence in regression models may not only be reflected in the error. Instead it may be accounted by entering a spatial lag Wy in the endogenous variable Y. As a rule of thumb, the one with the least p-value is expected to improve the fit of the regression equation (Anselin, 2010). Based on Table 19, the lag model (LMlag and RLMLag) have the least p-value compared to the error model of spatial regression. Thus, the SLX model is pursued.

**Table 18. Lagrange Multiplier Diagnostic Test for the Short-Term SLX Regression**

| LM Test | |
|---|---|
| **LMerr** | 0.34048 |
| df | 1 |
| p-value | 0.5596 |
| **LMlag** | 0.86829 |
| df | 1 |
| p-value | 0.3514 |
| **RLMerr** | 1.3748 |
| df | 1 |
| p-value | 0.241 |
| **RLMlag** | 1.9026 |
| df | 1 |
| p-value | 0.1678 |
| **SARMA** | 2.2431 |
| df | 2 |
| p-value | 0.3258 |

Table 20 below shows the SLX regression results for the short term flood effects on the business establishments. The intercept has a significant negative coefficient of -39.257. This means that when all the effects of the predictor variables are zero, there is already a declining number of the business establishments in the barangays and the flooding disaster could have aggravated the decrease. The regression model predicts 22.37% of the variances in the number of business establishments per barangay with a statistically significant p-value. This R-squared is better than the standard OLS regression which can only predict 13.99%.

Expectedly, the FIMI has a negative effect on the number of business establishments with its negative coefficient of -5.3062. The change in population in a barangay, as a result of the flood, although negative but does not affect significantly the dependent variable. This is consistent with the mediation test conducted in section 4.2.4 wherein there is no mediated path between the dependent and independent variable. The area of the barangay also has almost negligible relationship with the business establishments therein.

The dummy variable both have a positive coefficients. Surprisingly, flood-affected barangays still experienced relatively higher number of business establishments (33.8279% more) compared to the referenced barangay which were not inundated by the flood. The presence of the factors of agglomeration has a positive coefficient as expected which means barangays endowed with the economic infrastructure has 14.1726% more business establishments after the flood. Emphasis is given on the flooded dummy variable which has positive coefficients. Intuitively, this may possibly mean that a barangay that experienced flooding may still have many business establishments in the post-disaster scenario. Looking at the Hot Spot Analysis of the Business Industry Index in 2012 (Map 12), it may be observed that the said map coincides with the hot spot analysis of the flooding impact magnitude index (Map 9) which concentrated in the central business district and its adjacent surrounding areas. Thus, the flooded barangays which also experienced deep flood waters are the areas within and around the central business district that also happen to be the hot spot areas of thriving business establishments.

On the average values of the explanatory variables of the neighboring barangays, the coefficients behave in a similar way as the endogenous predictor variables. However, the presence of agglomeration factors in the neighboring barangays has a statistically significant effect to the georeferenced barangay. This means that barangays who have neighbors endowed with economic infrastructures have relatively higher number of business establishments with (32.8817% more with p-value of 0.0586). This affirms the assumption that business establishments in barangays within the CBD or which has a mall, business parks, etc., will most likely to survive after the flood. The presence of these factors of agglomeration also makes starting a business relatively easier as frequent market activities happen in those areas.

**Table 19. SLX Regression Coefficients for the Short-Term Flood Effects (2011-2012)**

| Coefficients | Estimates | Std. Error | t Value | Pr (<\|t\|) |
|---|---|---|---|---|
| Intercept | -39.256956 | 16.989175 | -2.311 | 0.0238 ** |
| FIMI | -5.306195 | 5.857983 | -0.906 | 0.3682 |
| PopnIndex | -0.065171 | 0.531914 | -0.123 | 0.9028 |
| Area__Has_ | 0.005976 | 0.003973 | 1.504 | 0.1371 |
| Flooded | 33.827876 | 22.486094 | 1.504 | 0.1370 |
| Agglo_factors | 14.172644 | 10.757876 | 1.317 | 0.1921 |
| lag.FIMI | -4.084524 | 10.354547 | -0.394 | 0.6945 |
| lag.PopnIndex | 1.223238 | 1.113338 | 1.099 | 0.2757 |
| lag.Area__Has_ | -0.005582 | 0.005160 | -1.082 | 0.2831 |
| lag.Flooded | 1.173251 | 33.936266 | 0.035 | 0.9725 |
| lag.Agglo_factors | 32.881738 | 17.095238 | 1.923 | 0.0586* |
| *Residual standard error: 29.99*<br>*Multiple R-squared: 0.2237, Adjusted R-squared: 0.1112*<br>*F-statistic: 1.989 on 10 and 69 DF, p-value: 0.04778* | | | | |
| *Significance codes: **** 0.001; ***0.01; **0.5; *0.1* | | | | |

Impact measures of the explanatory variables are shown in Table 21 to show the direct (endogenous) and indirect (exogenous) effects of these predictors. This will also indicate if the overall total effect is significant. A total of 500 simulations/repetition are computed in R to derive the figures. Accordingly, FIMI has a negative direct and indirect effects which increased its negative total effect. Population percentage change (after the flood) and land area of barangay have almost no effect to the number of business establishments based on their small coefficients. Dummy variables both have high total effects but only differ whether the effect comes from within the barangay (flooded indicator) or from its neighbors (presence of agglomeration factors indicator).

**Table 20. Impact measures of the explanatory variables of the SLX Regression for Short-term Flood Effects**

| Impact measures | | | |
|---|---|---|---|
| | **Direct** | **Indirect** | **Total** |
| FIMI | -5.30619529 | -4.084523576 | -9.3907188648 |
| PopnIndex | -0.06517113 | 1.223237918 | 1.1580667923 |
| Area__Has_ | 0.00597606 | -0.005581818 | 0.0003942422 |
| Flooded | 33.82787594 | 1.173250836 | 35.0011267762 |
| Agglo_factors | 14.17264430 | 32.881737643 | 47.0543819393 |

In terms of the significance of the impact measures, only the Agglo_factors shows a significant total p-value of 0.012967. Thus, this indicator variable has a huge influence on the resulting number of business establishments. Barangays which are located within the central business district, or are endowed with economic infrastructure such as malls, public markets, business parks, neighborhood centers and commercial strips are assumed to be better off. These are considered pre-conditions of agglomeration where businesses are more likely to survive, recover or start anew after the flood.

**Table 21. P-values indicating significance of the effects of the impact measures**

| p-values | | | |
|---|---|---|---|
| | **Direct** | **Indirect** | **Total** |
| FIMI | 0.36504 | 0.693237 | 0.264520 |
| PopnIndex | 0.90249 | 0.271893 | 0.293494 |
| Area__Has_ | 0.13258 | 0.279335 | 0.926315 |
| Flooded | 0.13248 | 0.972421 | 0.190058 |
| Agglo_factors | 0.18770 | 0.054424 | 0.012967 |

## 4.2.6.2 SLX Regression for Long-term Flood Disaster Impacts

The spatial regression for the long-term flood disaster impacts looks at the average percentage change of the business index from 2011 to 2015. The average percentage change is basically the mean of the five annual percentage changes taking Equation 1. Percentage Change$_i$ = ((BizIndex$_t$ – BizIndex$_{t-1}$) / BizIndex$_{t-1}$)) * 100 and dividing it by total number of years. Trend in population densification over the years will be considered in the equation through population index percentage change in 2010 and 2015. This is the actual census of the population where changes in population index per barangay is captured. The SLX regression model in determining long-term effects of the flooding disaster is computed with the following equation:

**Equation 14. SLX Regression Model for the Long-term Effects of the Flooding Disaster**

$$y = \beta_0 + \beta_1 \boldsymbol{FIMI} + \beta_2 \boldsymbol{PopnPercChange} + \beta_3 \boldsymbol{Area_{Has}} + \beta_4 \boldsymbol{Flooded} + \beta_5 \boldsymbol{Agglo\_factors} + Wx_2 + \cdots Wx_k + \varepsilon$$

Where:

y – Average percentage change in the business index from 2011 to 2015;

FIMI – potential consequences or damages incurred by a barangay based on its flood impact magnitude index value;

PopnPercChange – Percentage change of population index in 2015 from 2011 (both years are actual census);

Area_Has – land area of the barangay;

Flooded – dummy variable indicating 1 if barangay is flooded and 0 otherwise;

Agglo_factors – dummy variable indicating factors of agglomeration holding a value of 1 if any is true: barangay is within the central business district OR has a mall, OR public market, OR commercial strips, OR business parks, OR neighborhood center; and 0 otherwise;

$\gamma_2 Wx_2 + \cdots \gamma_k Wx_k$ - explanatory 'X' variables of neighbor barangays;

ε – error/residuals

The regression model for the long-term flood impacts was also subjected to diagnostic tests of OLS, Moran's I and Lagrange Multiplier (LM). The residuals from the OLS strongly suggests spatial dependence based on the p-value of 0.03906 (Table 22) revealed by the Moran'I test of spatial autocorrelation. In this case, the null hypothesis is rejected and the alternative hypothesis is accepted that there is spatial autocorrelation in the residuals. The LM test also suggests to conduct a spatial lag regression model based on the LMlag and RLMlag which have the least p-value of 0.2338 and 0.6462, respectively, compared with the p-values of the spatial error model (Table 23).

**Table 22. OLS Residual Results**

| OLS Residual | Results |
|---|---|
| Residual standard error | 10.29 (74 degrees of freedom) |
| Mutiple R-squared | 0.1623 |
| Adjusted R-squared | 0.1057 |
| F-statistics | 2.868 |
| p-value | 0.02018 |

**Table 23. Moran's I Spatial Autocorrelation Results based on OLS**

| Moran's I Specification Test | Results |
|---|---|
| standard deviation | 1.7617 |
| p-value | 0.03906** |
| alternative hypothesis | greater |
| Sample estimates | |
| observed Moran's I | 0.082125101 |
| Expectation | -0.038790904 |
| Variance | 0.004710784 |

**Table 24. Lagrange Multiplier (LM) Diagnostic Test for the Long-Term SLX Regression**

| LM Test | |
|---|---|
| LMerr | 1.2205 |
| df | 1 |
| p-value | 0.2693 |
| LMlag | 1.4175 |
| df | 1 |
| p-value | 0.2338 |
| RLMerr | 0.013742 |
| df | 1 |
| p-value | 0.9067 |
| RLMlag | 0.21074 |
| df | 1 |
| p-value | 0.6462 |
| SARMA | 1.4312 |
| df | 2 |
| p-value | 0.4889 |

Unlike the regression model for the short-term flood impacts, the SLX regression results for the long-term flood impacts reveals more significant findings as shown in Table 26. The regression model predicts 24.17% of the variances in the number of business establishments per barangay with a statistically significant p-value 0.02784. This R-squared is better than the standard OLS regression which can only predict 16.23% and slightly better than the short-term regression model (22.37%).

Looking at the long-term consequences, the intercept coefficient of -16.2518 (with statistically significant p-value of 0.00413) reveals that the city's number of business establishments has declined when all predictors have zero values. However, an important emphasis to make is on the comparative values of the intercepts for the short-term and long-term. The intercept in the short-term is lesser (-39.257) which means that the city's number of business establishments is slowly recovering from and thriving after the flooding disaster in the long-run.

The FIMI has still a negative effect (-3.72884) as expected but this coefficient is now statistically significant (p-value: 0.06892) unlike in the short-term regression model. Both population percentage change from 2010 to 2015 and barangay land area have still almost no effect with very small negative coefficients. Noteworthy to mention is how the coefficients for the dummy variables have now become statistically significant unlike in the short-term model. Flood-affected barangays experienced 20.12% more business establishments than those which are not inundated. Barangays with agglomeration factors also have 6.57% more business establishments compared to those which have none. Emphasis is given on the comparative analysis of the dummy variables in the short- and long-term. The short-term model has greater coefficients for these indicators (flooded: 33.8279 and Agglo: 14.1726) which possibly means that business establishments in the long-run are locating to other areas in the city which are safe from flooding and but may not be endowed with economic infrastructure.

Intuitively, while it is more plausible to assume that flooded barangays should have lesser number of business establishments in the real-world setting, the possible explanation for the positive value of this dummy variable could be that those which experienced flooding are also areas where businesses strongly thrives. In this case, however, the flooded areas also turns-out to be the central business district and its adjacent areas which are the hotspot for business establishments. Thus, this suggests that the flooding disaster of 2011, although considerably catastrophic, did not affect the cluster of hot spot business areas in the city.

On the exogenous explanatory variables, although the neighboring barangays' land area is the only statistically significant value, it may also be observed that this has a very small, almost unfelt, coefficient (0.003399). FIMI still have a negative coefficient (-4.1157) as expected. This implies that the neighboring barangays' susceptibility to flooding affects the dependent variable negatively in terms of inaccessibility and disruption problems. The population density shift per barangay still has very small effect (0.090621) to the dependent variable. The lagged dummy variables 'flooded' and agglomeration factors also have positive coefficients similar with the endogenous predictors but these are not statistically significant. To reiterate, flooded barangays also turned-out to be hot spot area of economic activities. Thus, this logically validates the assumption that flooded neighboring barangays contribute positively (8.863158% more) to the number of business establishments in the georeferenced barangay as these areas are just within the hotspot area where greater economic activities happen.

**Table 25. SLX Regression Coefficients for the Long-Term Flood Effects on 2011-2015**

| Coefficients | Estimates | Std. Error | t Value | Pr (<\|t\|) |
|---|---|---|---|---|
| Intercept | -16.251791 | 5.477410 | -2.967 | 0.00413*** |
| FIMI | -3.728841 | 2.017988 | -1.848 | 0.06892* |
| PopnIndex | -0.009862 | 0.037576 | -0.262 | 0.79375 |
| Area__Has_ | -0.001246 | 0.001342 | -0.928 | 0.35661 |
| Flooded | 20.120011 | 7.654965 | 2.628 | 0.01057** |
| Agglo_factors | 6.569772 | 3.571973 | 1.839 | 0.07018* |
| lag.FIMI | -4.115703 | 3.441847 | -1.196 | 0.23587 |
| lag.PopnIndex | 0.090621 | 0.098686 | 0.918 | 0.36167 |
| lag.Area__Has_ | 0.003399 | 0.001733 | 1.961 | 0.05387* |
| lag.Flooded | 8.863158 | 11.404003 | 0.777 | 0.43970 |
| lag.Agglo_factors | 11.464930 | 5.800359 | 1.977 | 0.05209 |
| Residual standard error: 10.14<br>Multiple R-squared: 0.2417, Adjusted R-squared: 0.1318<br>F-statistic: 2.199 on 10 and 69 DF, p-value: 0.02784 | | | | |
| *Significance codes: **** 0.001; ***0.01; **0.5; *0.1* | | | | |

Table 27 below looks at the direct (endogenous) and indirect (exogenous/neighbor) effects of the predictor variables. On the overall impact, the FIMI and the dummy variables 'flooded' and agglo_factors have statistically significant total impacts with p-values of 0.0067410, 0.0015343 and 0.0043097, respectively (Table 26). The sign of the coefficients of the said variables are also consistent both in the direct and indirect impacts. Endogenous indicator for 'flooded' and exogenous predictor for agglo factors have both greater coefficients than their corresponding counterpart which behaves similarly with the short-term regression model's impact measures.

**Table 26. Impact measures of the explanatory variables of the SLX Regression for Long-term Flood Effects**

| Impact measures | | | |
|---|---|---|---|
| | **Direct** | **Indirect** | **Total** |
| FIMI | -3.728841290 | -4.115703346 | -7.844544636 |
| PercChange | -0.009862358 | 0.090621495 | 0.080759136 |
| Area__Has_ | -0.001245872 | 0.003399138 | 0.002153266 |
| Flooded | 20.120011383 | 8.863157771 | 28.983169154 |
| Agglo_factors | 6.569772310 | 11.464930185 | 18.034702495 |

**Table 27. P-values indicating significance of the effects of the impact measures**

| P-values | | | |
|---|---|---|---|
| | **Direct** | **Indirect** | **Total** |
| FIMI | 0.0646311 | 0.231781 | 0.0067410 |
| PercChange | 0.7929646 | 0.358473 | 0.4666763 |
| Area__Has_ | 0.3533736 | 0.049837 | 0.1287150 |
| Flooded | 0.0085797 | 0.437043 | 0.0015343 |
| Agglo_factors | 0.0658776 | 0.048088 | 0.0043097 |

### 4.2.7 Employment Data

The analysis on the employment data does not involve the spatial dimension yet still included as part of the economic geography discourse. Nevertheless, the discussion delves into the temporal trend of the major sources of employment in the city for 2012-2015. The spatial regression analysis revealed that the business establishments of the city, although it declined, but were slowly recovering indicated by an improved intercept values (from -39.26 in the short-term to -16.25 in the long-term analysis). Together with the bouncing back of the business establishments, the emerging business type is presented below in Tables 29-34. This section supplements as well the effects of the flooding disaster to the economic geography of the city apart from the location and distribution of the business establishments in the city. To avoid overly exhaustive list of all business types, only the top 10 types of business are listed as a major source of employment.

**Table 28. Top 10 sources of employment by business type, 2011**

| Description | Number of Business Establishments | Employees |
|---|---|---|
| SERVICES | 1,196 | 1,321 |
| RETAILER | 2,331 | 743 |
| BANK | 270 | 447 |
| SECURITY | 54 | 404 |

| Description | Number of Business Establishments | Employees |
|---|---|---|
| GEN MDSE | 617 | 347 |
| MANUFACTURE | 173 | 266 |
| CARGO | 236 | 255 |
| AGRICULTURAL | 177 | 235 |
| EATERY | 353 | 195 |
| EDUCATION | 108 | 185 |

**Table 29. Top 10 sources of employment by business type, 2012**

| Description | Number of Business Establishments | Employees |
|---|---|---|
| GEN MDSE | 632 | 8,007 |
| SERVICES | 1,493 | 5,759 |
| RETAILER | 2605 | 4,739 |
| 24-RESTAURANT | 319 | 2,822 |
| BANK | 270 | 1,578 |
| FOOD PROD | 105 | 1,559 |
| EDUCATION | 109 | 1,228 |
| MANUFACTURE | 250 | 1,180 |
| BAKERY | 267 | 1,099 |
| SARI SARI (Mini store) | 1,636 | 1,058 |

**Table 30. Top 10 sources of employment by business type, 2013**

| Description | Number of Business Establishments | Employees |
|---|---|---|
| SARI SARI (Mini store) | 1,512 | 16,564 |
| RETAILER | 2,942 | 8,704 |
| SERVICES | 1,751 | 7,981 |
| EDUCATION | 114 | 5,303 |
| GEN MDSE | 618 | 5,220 |
| RESTAURANT | 305 | 3,424 |
| BANK | 307 | 2,210 |
| MANUFACTURE | 299 | 1,808 |
| FOOD PROD | 86 | 1,607 |
| BEVERAGES | 387 | 1,446 |

**Table 31. Top 10 sources of employment by business type, 2014**

| Description | Number of Business Establishments | Employees |
|---|---|---|
| SARI SARI (Mini store) | 1,856 | 16,509 |
| RETAILER | 5,726 | 9,441 |
| SERVICES | 2,056 | 8,715 |
| GEN MDSE | 571 | 4,789 |
| EDUCATION | 73 | 4,207 |
| RESTAURANT | 377 | 3,782 |
| BANK | 377 | 2,200 |
| MANUFACTURE | 379 | 2,150 |

| Description | Number of Business Establishments | Employees |
|---|---|---|
| FOOD PROD | 69 | 1,476 |
| LESSOR | 1,216 | 1,440 |

**Table 32. Top 10 sources of employment by business type, 2015**

| Description | Number of Business Establishments | Employees |
|---|---|---|
| RETAILER | 5,685 | 9,604 |
| SERVICES | 2,243 | 9,544 |
| GEN MDSE | 521 | 4,879 |
| RESTAURANT | 350 | 3,968 |
| MANUFACTURE | 460 | 2,567 |
| BANK | 336 | 2,343 |
| LESSOR | 1,262 | 1,737 |
| CARGO | 183 | 1,456 |
| SARI SARI (Mini store) | 1,665 | 1,444 |
| CONTRACTOR | 97 | 1,321 |

**Table 33. Annual Percentage Change of the Number of Business Establishments (BE) and Employees from 2011-2015 including the Five-Year Overall Average Change**

| | 2012-2011 | | 2013-2012 | | 2014-2013 | | 2015-2014 | | Average | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Description** | **BE** | **EMP** | **BE** | **EMP** | **BE** | **EMP** | **BE** | **EMP** | **BE** | **EMP** |
| BAKERY | -9.18 | 663.19 | -7.87 | 10.83 | -12.20 | -6.90 | -18.98 | -10.05 | -12.06 | 164.27 |
| FOOD PROD | -10.26 | 2683.93 | -18.10 | 3.08 | 16.28 | -54.76 | -17.39 | -13.14 | -7.37 | 654.78 |
| EDUCATION | 0.93 | 563.78 | 4.59 | 331.84 | -35.96 | -20.67 | 3.43 | 5.82 | -6.76 | 220.19 |
| SECURITY | -3.70 | 120.05 | -7.69 | 28.46 | -4.17 | -16.55 | -2.17 | 20.46 | -4.43 | 38.11 |
| GEN MDSE | 2.43 | 2207.49 | -2.22 | -34.81 | -7.61 | -8.26 | -8.76 | 1.88 | -4.04 | 541.58 |
| EATERY | -24.36 | 463.59 | 2.40 | 26.42 | 2.64 | -4.60 | 3.43 | 5.82 | -3.97 | 122.80 |
| AGRICULTURAL | -4.52 | 76.17 | -5.92 | 11.59 | 6.29 | -1.95 | 11.24 | 30.68 | 1.77 | 29.13 |
| LESSOR | 1.65 | 1308.47 | 3.25 | 72.56 | 6.48 | 0.42 | 3.78 | 20.63 | 3.79 | 350.52 |
| CARGO | 35.17 | 1006.67 | -4.50 | 12.45 | -2.36 | -3.54 | -11.59 | 72.31 | 4.18 | 271.97 |
| SARI SARI (Mini Store) | 15.62 | 6512.50 | -7.58 | 1465.60 | 22.75 | -0.33 | -10.29 | -91.25 | 5.12 | 1971.63 |
| BANK | 0.00 | 253.02 | 13.70 | 40.05 | 22.80 | -0.45 | -10.88 | 6.50 | 6.41 | 74.78 |
| RESTAURANT | 16.42 | 1459.12 | -4.39 | 21.33 | 23.61 | 10.46 | -7.16 | 4.92 | 7.12 | 373.96 |
| BEVERAGES | 34.72 | 3795.24 | 8.40 | 76.77 | 11.11 | -8.71 | -8.84 | -29.32 | 11.35 | 958.49 |
| SERVICES | 24.83 | 335.96 | 17.28 | 38.58 | 17.42 | 9.20 | 9.10 | 9.51 | 17.16 | 98.31 |
| MANUFACTURE | 44.51 | 343.61 | 19.60 | 53.22 | 26.76 | 18.92 | 21.37 | 19.40 | 28.06 | 108.79 |
| RETAILER | 11.75 | 537.82 | 12.94 | 83.67 | 94.63 | 8.47 | -0.72 | 1.73 | 29.65 | 157.92 |
| CONTRACTOR | 5.26 | 1352.00 | 167.50 | 38.84 | 0.00 | 39.88 | -9.35 | 87.38 | 40.85 | 379.52 |

The computation of the percentage change of the number of business establishments and employees as shown in Table 34 also uses Equation 12. Based from the table, contractor-related businesses have the highest percentage change (40.85%) in terms of the number of establishments. This could be attributed to the construction-related activites in the repair and rehabilitation of damaged infrastructure in the city. In terms of employment, Sari-sari (Mini Store) registered the highest percentage change. These results reflect how the economic geography of Cagayan de Oro fared in the post-disaster years.

### 4.2.7 Summary and Salient Discussion of Results

**Table 34. Highlights of the analysis and interpretation of the results as against the hypothesis**

| Hypothesis | Quantitative Results | Spatial Results | Conclusion |
|---|---|---|---|
| 1. Change in the population concentration in a barangay due to the flooding disaster affects the number of business establishments | Mediation Analysis: β = -0.0394 (no p-value but non-zeros BootLLCI and BootULCI which indicates significance) | Short term effect: Endogenous β = -0.065171 (p=0.9028); Exogenous β = 1.223238 (p=0.2757); Long term effect: Endogenous β = -0.009862 (p=0.79375); Exogenous β = 0.090621 (p=0.36167); | Not enough evidence to accept hypothesis. Statistically significant minor coefficient in the mediation analysis but non-significant coefficients in the spatial regression. |
| 2. The presence of commercial areas in a barangay or the location of a barangay within the central business district affects (moderation) the number of business establishments | Moderation Analysis: β = 4.35** (p=0.0167) β = -1.82** (p=0.0153) (Interaction coefficient ) | Short term effect: Endogenous β = 14.172644 (p=0.1921); Exogenous β = 32.881738 (p=0.0586*); Long term effect: Endogenous β = 6.569772 (p=0.07018*); Exogenous β = 11.46493 (p=0.05209); | Hypothesis is supported. Significant coefficients in the moderation and spatial regression. |
| 3. Flooding disaster affects negatively the economic geography in terms of the number of business establishments in the city. | Correlation analysis using the Flood Impact Magnitude Index (FIMI): 2012-2011: β = -.029 (p=0.859) | Short term effect: Endogenous FIMI β = -5.306195 (p=0.3682); Exogenous FIMI β = | Supported in the long-term effects. |

| Hypothesis | Quantitative Results | Spatial Results | Conclusion |
|---|---|---|---|
| | <u>2013-2012:</u><br>β = -.208<br>(p=0.191)<br><br><u>2014-2013</u><br>β = -.311*<br>(p=0.048)<br><br><u>2015-2014</u><br>β = -.437**<br>(p=.004)<br><br><u>Average Change 2011-2015</u><br>β = -.317*<br>(p=0.044) | -4.084524<br>(p=0.6945);<br><br><u>Long term effect:</u><br>Endogenous<br>FIMI β =<br>-3.728841<br>(p=0.06892*);<br><br>Exogenous<br>FIMI β =<br>-4.115703<br>(p=0.23587); | |
| *Significance codes: **** 0.001; ***0.01; **0.5; *0.1* | | | |

Table 36 provides a summary of all the statistical examinations done in this research. The results are categorized into two parts: 1) the purely quantitative and 2) spatial statistic results. The corresponding concluding statements are then given to answer the hypothesis based on the outcome of each statistical test. On the first hypothesis, both the mediation test and spatial regression coefficients reveal weak and non-significant relationship of the population concentration changes to the number of business establishments per barangay. On the other hand, the moderation test for the presence of commercial areas produced statistically significant regression coefficients. This means that the availability of economic infrastructure and the CBD proximity affects the survival and/or creation of new business establishments after the flooding disaster in the short- and long-run respectively. Lastly, there is a strong evidence supporting the third hypothesis in the long-run perspective. The correlation and spatial regression analysis both revealed significant negative effects of the FIMI to the business establishments in the city. A barangay which had high flooding impacts most probably experienced a declining number of business establishments in their area 3-4 years after the flooding disaster of TS Sendong. All these findings including their potential implications are further elaborated in the next chapter.

# Chapter 5: Conclusions

Using the statistical and spatial results from the previous chapter as springboard, this chapter synthesized all the major significant findings through which the conclusions hinge upon. Each of the research sub-question is answered which altogether form part of the main research question and shed light on this explanatory case-study research. Implications of the result from this study are presented positioning its significance to the academic literature and denoting its importance to the urban spatial planning in the disaster context. Lastly, recommendation for further research is laid out in the finale section as denouement of this research.

The advent of climate change requires more studies on its catastrophic effects. Countries in the global south are among those which are heavily affected by disasters especially the coastal cities. Hence, the city of Cagayan de Oro, Philippines is chosen as the study area being a coastal city with two river systems and most especially because of the immense flood damages incurred from TS Sendong. The impact of the increasing frequency and magnitude of natural disasters calls for a different approach in determining the spatial consequences of disasters in urban areas. The massive urban flooding resulted in heavy damages and fatalities (RDC, 2012, RDRRMC, 2012), as well as population displacement and resettlement (Carrasco et al., 2016; Franta, 2016) as some hazard-prone areas were declared no-build zones. These negative changes affected as well the economic geography of Cagayan de Oro City.

Various studies on the economics of disasters have their focus on the larger geographical scale. Scholars often cover cross-country, regional or provincial scopes and use measure like GDP, GDP per capita, labor, employment, among other macroeconomic measures (Imaizumi, 2016; Noy, 2009; Noy and Vu, 2010). Most of the literature are also inclined towards the economic costs (Kousky, 2014) such as monetization of damages, quantification of fatalities (Mediodia et al., 2013), implications to economic growth (Akao and Sakamoto, 2018; Noy and Vu, 2010) and the assessment of the vulnerability as well as adaptive capacity of affected areas to recover (Chang and Huang, 2015; Noy and Yonson, 2018). Literature is scant on examining the impacts of disasters at the city level looking at the spatial analysis on the effects to the location and distribution of human economic activities. Thus, this is also one of the rationale of this study.

## 5.1 Answering the Research Questions

To explain how flooding disaster affects the economic geography of Cagayan de Oro City in terms of the spatial and temporal distribution of human economic activities, the following research questions were formulated:

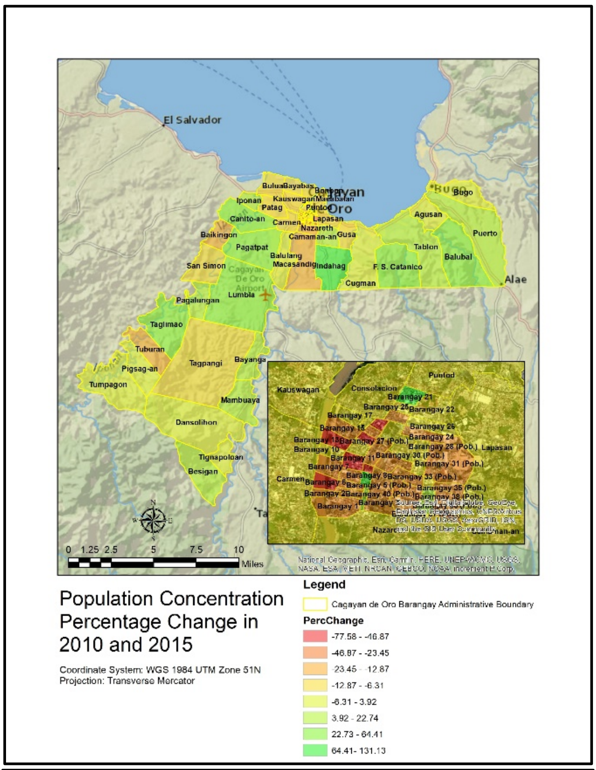
**What are the spatio-temporal effects of a flooding disaster to the economic geography of Cagayan de Oro City?**

1. How does the shift in the population concentration (as a result of the flooding disaster) affect the number of business establishments per sub-area (barangay) in the city?
2. How does the availability of commercial areas and the barangay land area influence the concentration of business establishments after the flood?
3. Is there a correlation between the varying levels of flood impact to the resulting number of business establishments in a barangay in the short- and long-term perspectives?

4. How does a major catastrophe like a flooding disaster affect the post-spatial cluster and number of business establishments in a barangay?

### 5.1.1. The first sub-question

The first sub-question is answered first by the mediation analysis conducted. It revealed a minor partial significant mediation of the population between the flood impact and the number of business establishments in a barangay. A key finding in the analysis also shows that the flood impact magnitude index has a statistically significant negative effect to the population index shifts. Although this means that the flood contributed to the reduced number of people in a barangay, this reduction did not have much influence on the number of the business establishments. The second answer comes from the spatial regression analysis. The results of the short-term and long-term regressions also reveal a weak influence of the population to the number of business establishments in the barangay. The population predictors have very small and non-significant coefficients including the values of the neighboring areas. The population density change is assumed to have an effect on the work force (Peterson, 2017) or in the engagement into entrepreneurial activities, thus, increasing economic activities in an area. However, in this case, shift in population densification does not have significant effects to the clusters of high-performing barangays.




**Map 16. Population Concentration Percentage Change in 2010 and 2015**

Map 16 shows the visual presentation of population concentration changes from 2010 to 2015. The darker red in color symbolizes higher negative change in population while the lighter green indicates otherwise. Notable are the seemingly decreasing population in the Central Business District and the movement of the population towards south and east. On a spatial lens, despite this observation the hotspot of business areas is still in the CBD and its adjacent areas as shown in Map 15 (p.46). This further supports the result in the mediation and spatial regression analysis that the changes in the population index of a barangay do not have significant effects to the post-disaster cluster (spatial) of thriving business areas in the city. Secondly, there were no long-term closure of affected areas in the CBD after the flood which could have a huge effect on the location of economic activities per finding of Faisal et al., (2020). This finding is also not supportive with the study of Lam et al. (2012) which posited that population affects the re-opening of the business establishments in inundated areas. The result herein illustrates that despite negative population concentration shift in the CBD, the said area is still thriving with many economic activities.

### 5.1.2. The second sub-question

The moderation analysis conducted revealed that the presence of commercial areas or the within-CBD conditionality has significant moderation effects to the number of business establishment in a barangay after flooding disaster. This is further supported by the statistically significant coefficients from the spatial regression analysis. These results suggest complementation of and consistency in the statistical tests conducted on the effect of the presence of such economic infrastructure. Linking this to the location theories, business establishments therefore spatially cluster and thrive in areas where factors of production and other growth-facilitating environment, such as transportation infrastructure support that enables accessibility, business networks, and related services, are available. The concepts of agglomeration and economies of scale are indeed gripping forces that explain the spatial clustering of these business activities as economic agents seeks the benefits thereof (Fujita and Thisse, 2002; Helbing et al., 2007). However, these imply that the impact of the flooding disaster in this case is not strong enough to shape and influence post-spatial cluster of the business establishments in Cagayan de Oro.

### 5.1.3 The third sub-question

The correlation analysis between the flood impact magnitude index and the annual percentage change of business industry index revealed a negative statistically significant relationship especially in the long term perspective (2013-2015). In fact, all the correlation coefficients are negative including the average total change in the business industry index for the five-year period after the flood (2011-2015). The flood indeed had significant negative effects in terms of the quantity of the number of business establishments in a barangay. This finding supports the conclusion of related literature that disasters lower the average growth rate in the affected areas (Raddatz, 2007; Noy, 2009; Hsiang and Jina, 2014, 2015, in Akao and Sakamoto, 2018). However, although the disaster had a negative effect on the number of business establishments, the hot spot maps indicate that the flood inundation did not change the spatial concentration of the business establishments in the city.

**Photo 1. Unfinished mall beside the Cagayan river (abandoned because it submerged during TS Sendong)**

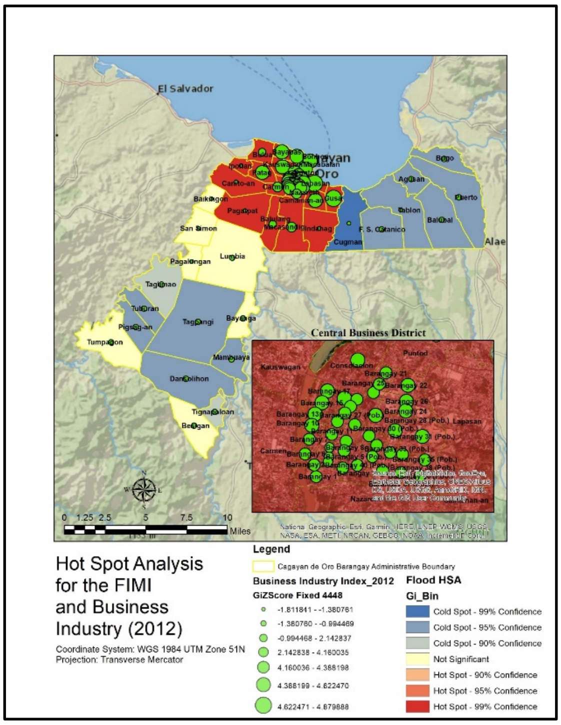
The city could have experienced higher growth trajectory without the disaster scenario. Case in point, Photo 1 shows an unfinished mall construction which was abandoned already as it was heavily affected by the flood. This is just one among the many disruptions of the floods. It is noteworthy to mention however that the decline in the number of business establishments cannot be attributed solely to TS Sendong as there could be other myriad of potential causes such as other disaster occurrences or unconducive business climate that affected flow investments after the flood.

### 5.1.4 The fourth sub-question

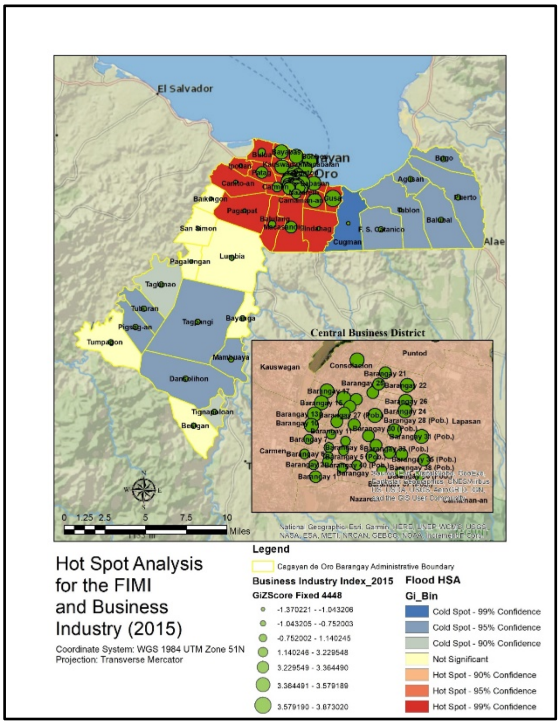
The hotspot analyses done for both the flood impact magnitude index (Map 9) and the business industry index (Maps 10-15) revealed almost similar concentration of both phenomena. This means that the flood-affected areas are also places where business establishments concentrate. In other words, despite the flooding disaster brought by TS Sendong the cluster of thriving business areas in the city of Cagayan de Oro did not change. For visualization purposes, Maps 17 and 18 depicts an overlay of the Hot Spot Analysis of the FIMI and the business establishments in the city in the immediate and long-term perspectives. The symbology of the BizIndex is modified to hierarchical circles to illustrate how the two phenomena coincide.

This strongly posits that there is still a high concentration of human economic activities in the central business district (Barangays 1-40) and its adjacent areas that include barangays Gusa, Lapasan, Camaman-an, Macasandig, Nazareth, Carmen, Patag, Kauswagan, Macabalan, Puntod, Bonbon and Bayabas despite being hotspot areas for flood. The number of business establishments may have been reduced by the flood and tried to slowly recover over the years but the disaster did not affect the areas of high concentration of business establishments in the city.

**Map 17. Overlay of FIMI and BizIndex 2012**




**Map 18. Overlay of FIMI and BizIndex, 2015**




### 5.1.5 The main research question

The articulation of the results in the four sub-questions essentially answers altogether the main research question. The approach to answer the main research question has two lenses: Spatial and Temporal. Generally, the flood disaster of TS Sendong had negative effects on the number of business establishments in the city focusing on a purely quantitative perspective (supportive to the findings of Raddatz (2007), Noy, 2009, and Hsiang and Jina (2014, 2015), in Akao and Sakamoto (2018)). The spatial regression analyses revealed that the city was slowly recovering from the flood marked by an improved intercept values (from -39.26 in the short-term to -16.25 in the long-term analysis). Looking at the flooding's spatial effect, the hot spot analysis produced by the HSA of ArcGIS have almost the same concentration of the potentially high flood impact and the location of business establishments.

Many of the significant changes happen in the long-term perspective. The correlation analysis and the SLX regression analysis both have statistically significant coefficients when looking at the effects of the flood in the long run. The FIMI are negatively correlated with the business industry index and its causal strength are statistically significant negative coefficients. Although, the increase/decrease of the flood's causal relationship toward the business establishment cannot be sufficiently explained by the density shifts of the population concentration as caused by the flood, the presence of commercial areas in a barangay or its location in the CBD moderated the resulting number of business establishments after the flood. The moderation test revealed that the endowments of economic infrastructure support the survival, creation and thriving of business establishments in the city after the flooding disaster.

Although looking more closely on the hotspot trend over the period of five years, the areas of Bulua, Iponan, Canitoan and Balulang became no longer cold spot areas. This means that the business index in those barangays have somehow increased in the span of three years and that those are no longer statistically low based on the Gi* statistics. Connecting this with the moderation test, the interpolation line implies that there are affected barangays with higher number of business establishments despite having no commercial areas or not being within the CBD. In relation as well to the comparative analysis of the spatial regression coefficients of the dummy variables 'flooded' and 'agglo_factors', the short-term model has greater coefficients for these indicators compared to the long-term model which possibly means that business establishments in the long-run are locating to other areas in the city despite being flood-prone and not endowed with economic infrastructure. Barangays Balulang and Canitoan fit these findings with high probability marking them as no longer cold spots in the long-run.

On a temporal perspective, what this suggests is that although the flood have decreased the number of business establishments, other businesses might have relocated, spurred or spilled over from neighboring barangays towards the aforementioned four barangays. In the span of five years, the concentration of business establishments may not have changed, but if the spill-over effect continues, the city's development could potentially occur in the city peripheral areas.

## 5.2 Implications of the research in the context of Climate Change Adaptation

Although this research is a case study, highly contextualized and cannot be generalized, the findings and spatial statistical methods employed herein can be used and replicated, respectively, to other research. There are increasing evidences of the impacts of climate change to the countries in global south (Alfieri et al., 2017; Pachauri et al., 2014; Peduzzi et al., 2012). There are also a growing number of literatures which strongly suggest negative effects of disasters to economic growth, people and assets such as the empirical studies of Kousky (2014), Noy and Vu (2010), Kellenberg and Mobarak (2008), Hammond et al. (2015), and Toya and Skidmore (2007). While it is equally important to examine and/or compare disaster effects on the larger macroeconomic scale (cross-country, national, regional, provincial), this research demonstrated how looking closely at the city/urban- and firm-level can produce equally insightful results on the short-term and long-term impacts of flooding disaster. Delving deeper into the urban level of analysis using the spatial lens in examining flood impacts can produce meaningful results that could guide policy- and decision-makers on how to better plan for resilient cities. The implications are further discussed below including recommendations for further research when using this study as a springboard.

### 5.2.1 Contribution to the Economics of Disaster Literature

An increasing number of empirical studies have investigated the economic consequences of disasters. However, the scholarly articles are dominated by studies which quantify and estimate economic damages and costs and use country-level datasets. For instance, the research papers of Hammond et al. (2015), Kousky (2014) and Mediodia et al. (2013), provided a review of the damage estimation to the economy looking at economic growth trend in terms of GDP. Based on empirical evidences, disasters affect economic growth negatively. However, despite its potential importance, little is known about the formal mechanisms underlying these empirical observations (Akao and Sakamoto, 2018). This research has demonstrated how zooming into the urban level of human economic activities can contribute to an improved understanding of how disasters disrupts/alters the economic landscape of the affected area. The findings herein shed light to the question on 'what and how many business activity happens where?' in the post-disaster scenario. Hence, this study's approach using the economic geography lens complements as well the studies of Faisal et al. (2020), Lam et al. (2012) and Imaizumi (2016) who also utilized the spatial elements in investigating disaster effects. Such studies including this research bridge the gap in the economics of disaster literature in terms of providing a cluster-based analysis that can connect the city-level consequences to the economic performance of a larger geographical context.

### 5.2.2 Implications on Urban Spatial Planning in terms of Exposure Management

This research has shown that although the flood had negative impacts on the number of business establishments, the concentration of businesses (BizIndex) is still clustered in the flood-inundated areas composed of the CBD and its surrounding barangays. The trend and pattern still include those barangays within the CBD adjacent to the river which are highly susceptible to flooding. To safeguard economic growth and protect the people, urban managers need to either: 1) steer development away from flood-prone areas to relatively safer areas or 2) establish flood risk mitigation project such as dike and/or expand urban drainage systems, among other hard infrastructure interventions. To recall, *Disaster Risk = f (Hazard, Exposure, Vulnerability, Capacity)*, therefore, to reduce risk damages it is necessary to reduce exposure of people and assets by re-directing them out of harm's way (Yonson, 2016). Nature-based solutions are also gaining popularity such as the mangrove forest to protect coastal communities (Hochard et al., 2019), increasing the room-for-the-river interventions, sponge cities, and green roof initiatives, among other innovations. A growing number of climate change projections have provided evidences of the flooding threats for coastal cities (Peduzzi et al., 2012) as well as from riverine flooding (Alfieri et al., 2017), thus it is more imperative for urban managers to learn the catastrophic lessons of the past like TS Sendong and use evidence-based decision-making to create climate change adaptive cities.

### 5.2.3 Recommendations for Further Research

The mediation and moderation tests performed in this research are done in simple models. Thus, it is recommended for other research to take off from the findings of this study and explore other variables that could potentially shed more light on the causality relationships between the flood impact and the business establishments. There are also other spatial regression analysis to use such as the spatially lag Y or spatially lag error models which could produce equally insightful results. This research was also limited to the number and location of business establishments and the major source of employment as indicators of economic geography and performance. The city government was not able to provide the barangay financial statement which could have indicated also the economic dynamism in an area. It could also have captured investment flow especially fund transfer from governments or foreign aids for reconstruction and rehabilitation activities that will have an effect to the local economy. Hence, it is also recommended for future studies to use other economic indicators disaggregated at the sub-area unit of a city.

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# Annex 1: Research Instruments and Time schedule

Figure 22 below shows the excerpt of the questions contained in the Climate Exposure Database (ClimEx.Db). Particularly, codes H29 and H31 are extracted to derive the flood duration and flood depth, respectively. The responses of the households acquired in 2014 include the flooding experienced from TS Sendong in 2011 since the questions cover three-years time.

**Figure 22. Questionnaire of the Climate Exposure Database (ClimEx.Db)**

| CATEGORY | TYPE | QUESTION | ClimEx Code |
|---|---|---|---|
| Household | Climate Change | Three years ago, how long did it usually take for the flood to subside? | H29 |
| Household | Climate Change | During the past 12 months, how long did it usually take for the flood to subside? | H30 |
| Household | Climate Change | Up to what extent have floods reached the household? | H31 |
| | | Compared to 3 years ago, does drought occur more often in | |

This research utilized the shapefiles used in Map 19 below to perform the geo-imputation and derive the flood extent of the barangays not covered in the GIS analysis of the local government. The data herein are also used to reinforce the flood depth value to those barangays with very few household data/observations in the ClimEx.DB.

**Map 19. Flood Inundation Map of Cagayan de Oro (left) and Iponan Rivers (right): 1 in 100 Year Rainfall Return Period (Source: River Basin Flood Modelling Study)**

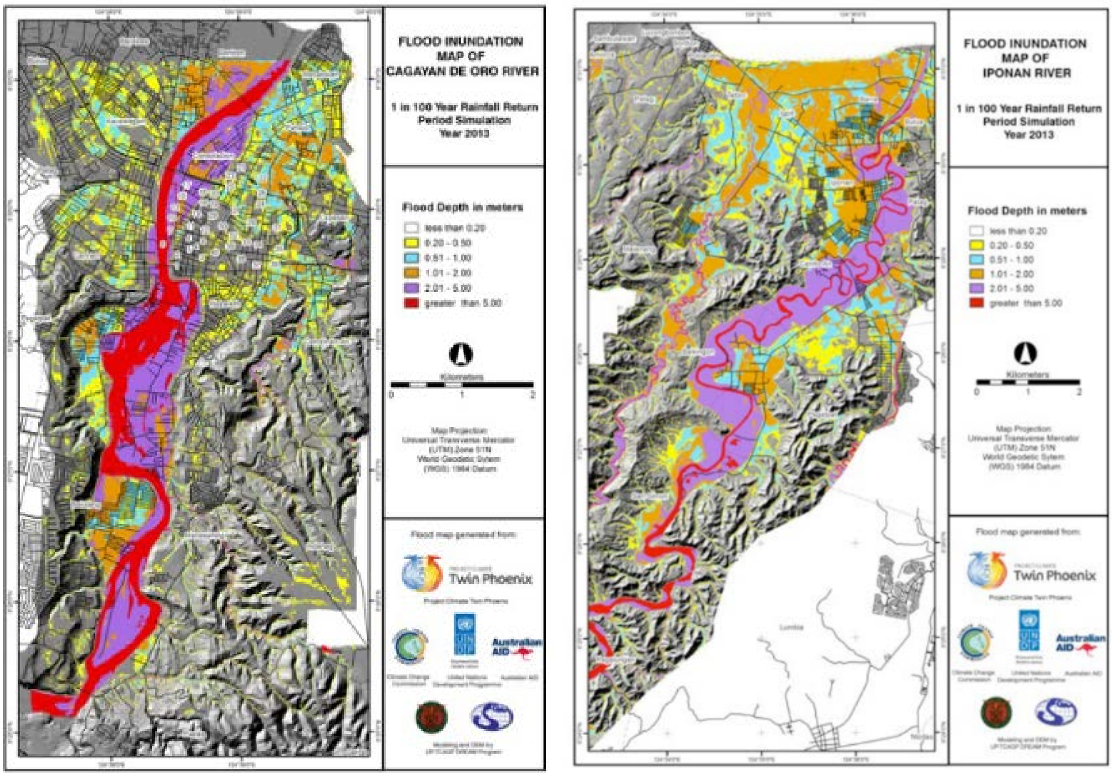


**Figure 23. Estimated Extent of Flooding in Barangays in Cagayan de Oro for the 100 Year Rainfall Event, 2013 Land Cover (Source: River Basin Flood Modelling Study)**

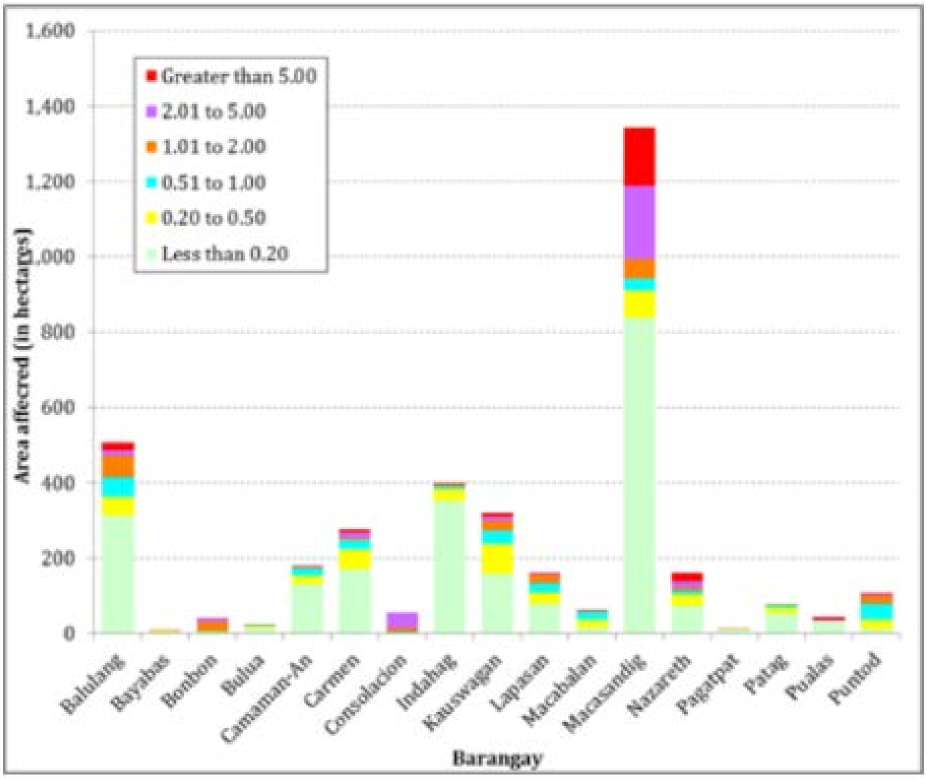



**Figure 24. Estimated Extent of Flooding in Barangays in Iponan River, Cagayan de Oro City for the 100 Year Rainfall Event, 2013 Land Cover (Source: River Basin Flood Modelling Study)**

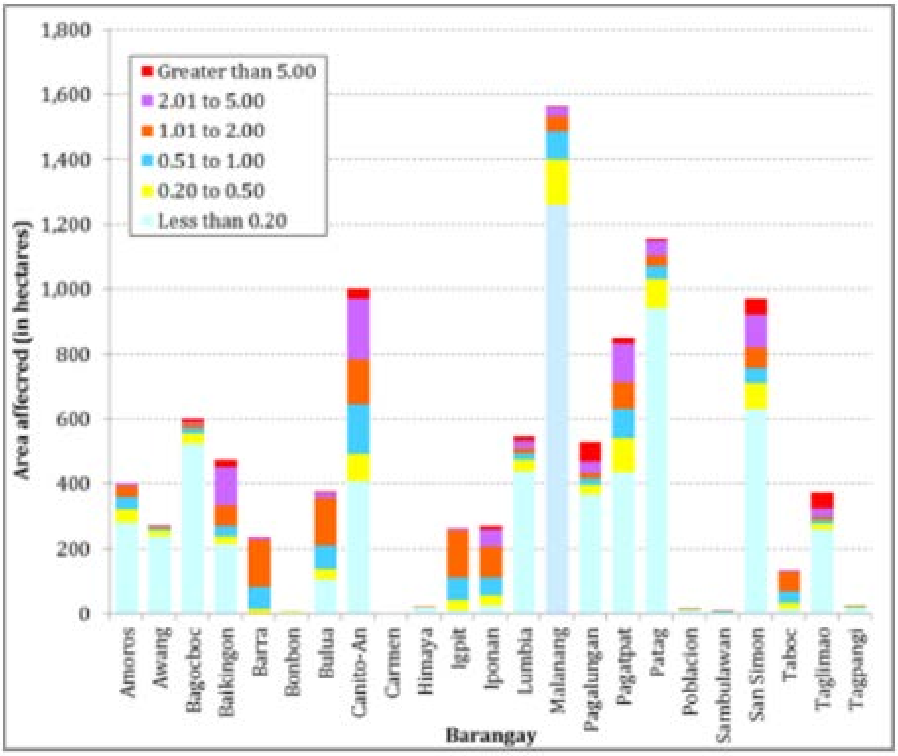
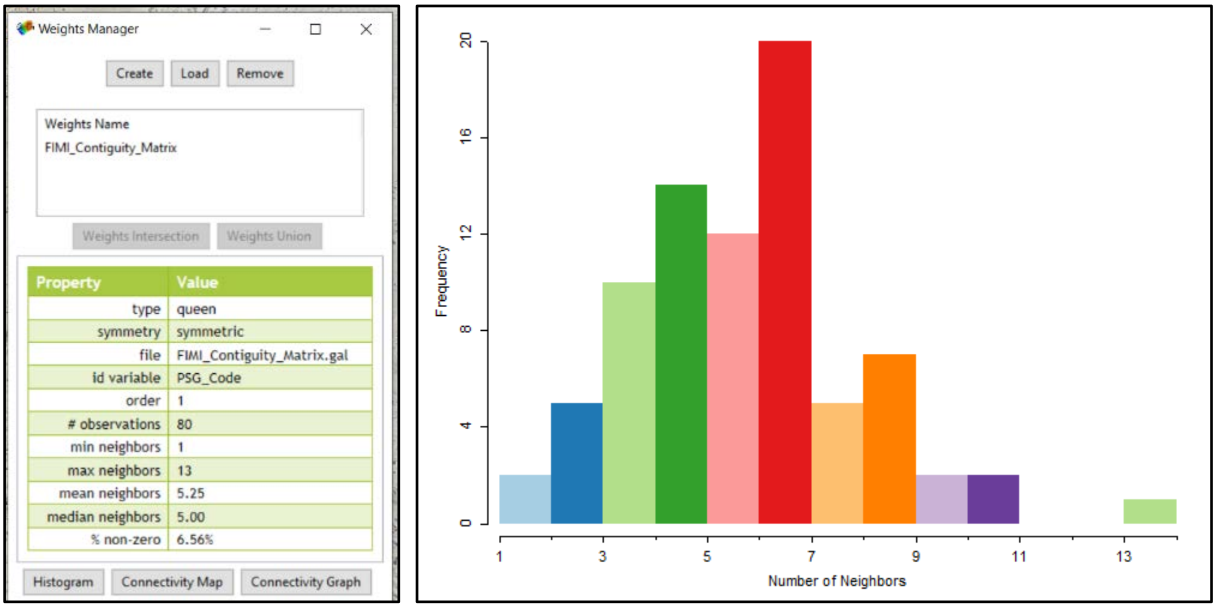


**Figure 25. Creation of the Spatial Weight Matrix Using Queen Contiguity in GeoDa**




| Table 35. Hot Spot Analysis Table of the 2011 Business Industry Index with Z-Score and P-values | | | | |
|---|---|---|---|---|
| **Barangay** | **BII_2011** | **Z-Score** | **P-Value** | **Gi_Bin** |
| Agusan | 0.368904 | -1.17051368467 | 0.24179433078 | 0 |
| Baikingon | 0.011646 | -1.53725845610 | 0.12423003050 | 0 |
| Balubal | 0.016456 | -1.18207128283 | 0.23717743886 | 0 |
| Balulang | 0.477251 | 2.25058686210 | 0.02441171630 | -2 |
| Barangay 1 | 9.281310 | 4.26804021378 | 0.00001971978 | 3 |
| Barangay 10 | 12.589719 | 4.40030355770 | 0.00001080995 | 3 |
| Barangay 11 | 32.998537 | 4.17086531505 | 0.00003034452 | 3 |
| Barangay 12 | 56.673372 | 4.17086531505 | 0.00003034452 | 3 |
| Barangay 13 | 7.901382 | 4.40030355770 | 0.00001080995 | 3 |
| Barangay 14 | 37.565469 | 4.28853260018 | 0.00001798574 | 3 |
| Barangay 15 | 6.985469 | 4.40030355770 | 0.00001080995 | 3 |
| Barangay 16 | 19.706865 | 4.28853260018 | 0.00001798574 | 3 |
| Barangay 17 | 5.030311 | 4.40030355770 | 0.00001080995 | 3 |
| Barangay 18 | 14.702748 | 4.40030355770 | 0.00001080995 | 3 |
| Barangay 19 | 24.559256 | 4.28853260018 | 0.00001798574 | 3 |
| Barangay 2 | 23.030647 | 4.16700008779 | 0.00003086344 | 3 |
| Barangay 20 | 37.683514 | 4.28853260018 | 0.00001798574 | 3 |
| Barangay 21 | 7.377027 | 4.28853260018 | 0.00001798574 | 3 |
| Barangay 22 | 7.651767 | 4.39088230305 | 0.00001128916 | 3 |
| Barangay 23 | 6.522674 | 4.28853260018 | 0.00001798574 | 3 |
| Barangay 24 | 8.161045 | 4.39088230305 | 0.00001128916 | 3 |
| Barangay 25 | 20.729535 | 4.28853260018 | 0.00001798574 | 3 |
| Barangay 26 | 20.208583 | 4.39088230305 | 0.00001128916 | 3 |
| Barangay 27 | 10.023276 | 4.39088230305 | 0.00001128916 | 3 |
| Barangay 28 | 17.791816 | 4.39088230305 | 0.00001128916 | 3 |
| Barangay 29 | 5.521073 | 4.28853260018 | 0.00001798574 | 3 |

| Table 35. Hot Spot Analysis Table of the 2011 Business Industry Index with Z-Score and P-values | | | | |
|---|---|---|---|---|
| **Barangay** | **BII_2011** | **Z-Score** | **P-Value** | **Gi_Bin** |
| Barangay 3 | 20.787187 | 4.15740595167 | 0.00003218817 | 3 |
| Barangay 30 | 10.492391 | 4.27186880299 | 0.00001938416 | 3 |
| Barangay 31 | 11.988990 | 4.39088230305 | 0.00001128916 | 3 |
| Barangay 32 | 17.388491 | 4.27186880299 | 0.00001938416 | 3 |
| Barangay 33 | 92.972224 | 4.27186880299 | 0.00001938416 | 3 |
| Barangay 34 | 22.999938 | 4.27186880299 | 0.00001938416 | 3 |
| Barangay 35 | 7.270761 | 4.27186880299 | 0.00001938416 | 3 |
| Barangay 36 | 2.834700 | 4.15086686416 | 0.00003312184 | 3 |
| Barangay 37 | 24.960263 | 4.15086686416 | 0.00003312184 | 3 |
| Barangay 38 | 39.567690 | 4.15740595167 | 0.00003218817 | 3 |
| Barangay 39 | 28.652465 | 4.27186880299 | 0.00001938416 | 3 |
| Barangay 4 | 42.589222 | 4.05764696163 | 0.00004956962 | 3 |
| Barangay 40 | 10.698685 | 4.15740595167 | 0.00003218817 | 3 |
| Barangay 5 | 44.956286 | 4.05764696163 | 0.00004956962 | 3 |
| Barangay 6 | 7.749604 | 4.16700008779 | 0.00003086344 | 3 |
| Barangay 7 | 14.368156 | 4.16700008779 | 0.00003086344 | 3 |
| Barangay 8 | 41.884299 | 4.05764696163 | 0.00004956962 | 3 |
| Barangay 9 | 56.234466 | 4.15740595167 | 0.00003218817 | 3 |
| Bayabas | 0.368120 | 4.46107653846 | 0.00000815490 | 3 |
| Bayanga | 0.003445 | -1.19834878516 | 0.23078128345 | 0 |
| Bonbon | 0.419480 | 4.51765548189 | 0.00000625281 | 3 |
| Bugo | 0.368568 | -1.15954942921 | 0.24623232063 | 0 |
| Bulua | 1.431758 | 1.90519394474 | 0.05675486504 | -1 |
| Camaman-An | 0.451943 | 4.47251079849 | 0.00000773065 | 3 |
| Canito-An | 0.195352 | -1.67620761260 | 0.09369753360 | -1 |
| Carmen | 5.644520 | 3.82533821793 | 0.00013059267 | 3 |
| Consolacion | 1.695236 | 4.40030355770 | 0.00001080995 | 3 |
| Cugman | 0.164374 | -1.53024144438 | 0.12595697630 | 0 |
| Dansolihon | 0.001089 | -0.97237636928 | 0.33086335593 | 0 |
| F. S. Catanico | 0.002875 | -1.19033660775 | 0.23391413927 | 0 |
| Gusa | 0.751364 | 4.68073508225 | 0.00000285848 | 3 |
| Indahag | 0.013514 | -1.31760582527 | 0.18763563456 | 0 |
| Iponan | 0.903039 | -1.77681730669 | 0.07559830344 | -1 |
| Kauswagan | 2.145406 | 4.40654977722 | 0.00001050302 | 3 |
| Lapasan | 5.021263 | 4.62720091993 | 0.00000370641 | 3 |
| Lumbia | 0.030845 | -1.19753657173 | 0.23109750351 | 0 |
| Macabalan | 1.989070 | 4.50708317263 | 0.00000657249 | 3 |
| Macasandig | 0.238691 | 4.29587336301 | 0.00001740069 | 3 |
| Mambuaya | 0.004300 | -0.97210770571 | 0.33099698144 | 0 |
| Nazareth | 2.685144 | 4.03743871839 | 0.00005403795 | 3 |
| Pagalungan | 0.000000 | -1.39210459881 | 0.16389072587 | 0 |
| Pagalungan | 0.000000 | -0.97242243676 | 0.33084044680 | 0 |
| Pagatpat | 0.014405 | -1.55660892233 | 0.11956336415 | 0 |
| Patag | 0.541078 | 4.31238381126 | 0.00001615038 | 3 |

| Table 35. Hot Spot Analysis Table of the 2011 Business Industry Index with Z-Score and P-values | | | | |
|---|---|---|---|---|
| **Barangay** | **BII_2011** | **Z-Score** | **P-Value** | **Gi_Bin** |
| Pigsag-An | 0.000744 | -1.19851641455 | 0.23071605839 | 0 |
| Puerto | 0.388552 | -1.17180174030 | 0.24127668434 | 0 |
| Puntod | 1.979697 | 4.39088230305 | 0.00001128916 | 3 |
| San Simon | 0.002447 | -1.39184711034 | 0.16396870063 | 0 |
| Tablon | 0.073156 | -1.37922714512 | 0.16782473112 | 0 |
| Taglimao | 0.003149 | -1.19845185881 | 0.23074117566 | 0 |
| Tagpangi | 0.002183 | -0.97219726023 | 0.33095243573 | 0 |
| Tignapoloan | 0.000305 | -1.19864545650 | 0.23066585674 | 0 |
| Tuburan | 0.003814 | -1.19842599480 | 0.23075123934 | 0 |
| Tumpagon | 0.000548 | -0.97238068414 | 0.33086121013 | 0 |

| Table 36. Hot Spot Analysis Table of the 2012 Business Industry Index with Z-Score and P-values | | | | |
|---|---|---|---|---|
| **Barangay** | **BII_2012** | **Z-Score** | **P-Value** | **Gi_Bin** |
| Agusan | 0.340963 | -1.19736522883 | 0.23116425196 | 0 |
| Baikingon | 0.011747 | -1.57348615658 | 0.11560629128 | 0 |
| Balubal | 0.008853 | -1.20972270771 | 0.22638533571 | 0 |
| Balulang | 0.426434 | 2.14283731407 | 0.03212616393 | -2 |
| Barangay 1 | 8.431046 | 4.36134428241 | 0.00001292658 | 3 |
| Barangay 10 | 11.428944 | 4.50235320392 | 0.00000672052 | 3 |
| Barangay 11 | 33.284515 | 4.26806307833 | 0.00001971776 | 3 |
| Barangay 12 | 54.376013 | 4.26806307833 | 0.00001971776 | 3 |
| Barangay 13 | 6.008047 | 4.50235320392 | 0.00000672052 | 3 |
| Barangay 14 | 39.814429 | 4.38819782385 | 0.00001142938 | 3 |
| Barangay 15 | 7.146665 | 4.50235320392 | 0.00000672052 | 3 |
| Barangay 16 | 20.188241 | 4.38819782385 | 0.00001142938 | 3 |
| Barangay 17 | 4.207629 | 4.50235320392 | 0.00000672052 | 3 |
| Barangay 18 | 13.521624 | 4.50235320392 | 0.00000672052 | 3 |
| Barangay 19 | 20.796328 | 4.38819782385 | 0.00001142938 | 3 |
| Barangay 2 | 20.959614 | 4.26326634306 | 0.00002014601 | 3 |
| Barangay 20 | 37.249893 | 4.38819782385 | 0.00001142938 | 3 |
| Barangay 21 | 8.455635 | 4.38819782385 | 0.00001142938 | 3 |
| Barangay 22 | 9.410642 | 4.48765616297 | 0.00000720110 | 3 |
| Barangay 23 | 6.772708 | 4.38819782385 | 0.00001142938 | 3 |
| Barangay 24 | 24.020580 | 4.48765616297 | 0.00000720110 | 3 |
| Barangay 25 | 21.672295 | 4.38819782385 | 0.00001142938 | 3 |
| Barangay 26 | 19.211204 | 4.48765616297 | 0.00000720110 | 3 |
| Barangay 27 | 9.294808 | 4.48765616297 | 0.00000720110 | 3 |
| Barangay 28 | 17.065222 | 4.48765616297 | 0.00000720110 | 3 |
| Barangay 29 | 6.477326 | 4.38819782385 | 0.00001142938 | 3 |
| Barangay 3 | 21.278733 | 4.24829960914 | 0.00002153992 | 3 |
| Barangay 30 | 10.073282 | 4.36609554997 | 0.00001264872 | 3 |
| Barangay 31 | 13.959579 | 4.48765616297 | 0.00000720110 | 3 |
| Barangay 32 | 17.360216 | 4.36609554997 | 0.00001264872 | 3 |

| Table 36. Hot Spot Analysis Table of the 2012 Business Industry Index with Z-Score and P-values | | | | |
|---|---|---|---|---|
| **Barangay** | **BII_2012** | **Z-Score** | **P-Value** | **Gi_Bin** |
| Barangay 33 | 88.042304 | 4.36609554997 | 0.00001264872 | 3 |
| Barangay 34 | 23.0026610 | 4.36609554997 | 0.00001264872 | 3 |
| Barangay 35 | 5.633187 | 4.36609554997 | 0.00001264872 | 3 |
| Barangay 36 | 2.501858 | 4.24227549465 | 0.00002212648 | 3 |
| Barangay 37 | 23.459994 | 4.24227549465 | 0.00002212648 | 3 |
| Barangay 38 | 36.282363 | 4.24829960914 | 0.00002153992 | 3 |
| Barangay 39 | 29.588893 | 4.36609554997 | 0.00001264872 | 3 |
| Barangay 4 | 39.765470 | 4.15158514494 | 0.00003301804 | 3 |
| Barangay 40 | 11.905733 | 4.24829960914 | 0.00002153992 | 3 |
| Barangay 5 | 38.202363 | 4.15158514494 | 0.00003301804 | 3 |
| Barangay 6 | 7.967088 | 4.26326634306 | 0.00002014601 | 3 |
| Barangay 7 | 14.158229 | 4.26326634306 | 0.00002014601 | 3 |
| Barangay 8 | 43.368895 | 4.15158514494 | 0.00003301804 | 3 |
| Barangay 9 | 56.465156 | 4.24829960914 | 0.00002153992 | 3 |
| Bayabas | 0.357299 | 4.57274643991 | 0.00000481373 | 3 |
| Bayanga | 0.002896 | -1.22590466630 | 0.22023457568 | 0 |
| Bonbon | 0.398516 | 4.62247035859 | 0.00000379197 | 3 |
| Bugo | 0.387582 | -1.18652997543 | 0.23541309221 | 0 |
| Bulua | 1.782591 | 1.80241322151 | 0.07148041656 | -1 |
| Camaman-An | 0.441682 | 4.56977628525 | 0.00000488245 | 3 |
| Canito-An | 0.185849 | -1.71085165290 | 0.08710850151 | -1 |
| Carmen | 5.379369 | 3.91329956024 | 0.00009104348 | 3 |
| Consolacion | 1.547779 | 4.50235320392 | 0.00000672052 | 3 |
| Cugman | 0.163971 | -1.56515677977 | 0.11754615279 | 0 |
| Dansolihon | 0.000879 | -0.99470577770 | 0.31987939680 | 0 |
| F. S. Catanico | 0.002900 | -1.21754494697 | 0.22339696880 | 0 |
| Gusa | 0.755583 | 4.87988768658 | 0.00000106146 | 3 |
| Indahag | 0.013063 | -1.38076144133 | 0.16735232281 | 0 |
| Iponan | 0.863853 | -1.81184099914 | 0.07001076808 | -1 |
| Kauswagan | 2.230438 | 4.50839469968 | 0.00000653200 | 3 |
| Lapasan | 4.365825 | 4.72909909809 | 0.00000225518 | 3 |
| Lumbia | 0.028539 | -1.22514957147 | 0.22051889374 | 0 |
| Macabalan | 1.749301 | 4.60609386376 | 0.00000410303 | 3 |
| Macasandig | 0.251433 | 4.16003530919 | 0.00003181984 | 3 |
| Mambuaya | 0.003614 | -0.99446855609 | 0.31999481955 | 0 |
| Nazareth | 2.738232 | 4.12552703841 | 0.00003698867 | 3 |
| Pagalungan | 0.00000 | -1.42412481588 | 0.15441034395 | 0 |
| Pagatpat | 0.01954 | -1.59811380986 | 0.11001765075 | 0 |
| Patag | 0.568043 | 4.42382316110 | 0.00000969694 | 3 |
| Puerto | 0.375739 | -1.19846196123 | 0.23073724489 | 0 |
| Puntod | 1.830449 | 4.48765616297 | 0.00000720110 | 3 |
| San Simon | 0.000823 | -1.42389619135 | 0.15447652451 | 0 |
| Tablon | 0.074155 | -1.41181473142 | 0.15800451971 | 0 |
| Taglimao | 0.004447 | -1.22601708443 | 0.22019226906 | 0 |

| Table 36. Hot Spot Analysis Table of the 2012 Business Industry Index with Z-Score and P-values | | | | |
|---|---|---|---|---|
| **Barangay** | **BII_2012** | **Z-Score** | **P-Value** | **Gi_Bin** |
| Tagpangi | 0.001835 | -0.99454633295 | 0.31995697337 | 0 |
| Tignapoloan | 0.000205 | -1.22616553815 | 0.22013640999 | 0 |
| Tuburan | 0.000769 | -1.22601708443 | 0.22019226906 | 0 |

| Table 37. Hot Spot Analysis Table of the 2013 Business Industry Index with Z-Score and P-values | | | | |
|---|---|---|---|---|
| **Barangay** | **BII_2013** | **Z-Score** | **P-Value** | **Gi_Bin** |
| Agusan | 0.320429 | -1.23053313999 | 0.21849754823 | 0 |
| Baikingon | 0.011513 | -1.61369883339 | 0.10659276713 | 0 |
| Balubal | 0.011930 | -1.24253580553 | 0.21403896216 | 0 |
| Balulang | 0.436239 | 2.10116390150 | 0.03562658103 | -2 |
| Barangay 1 | 8.584788 | 4.47791331117 | 0.00000753762 | 3 |
| Barangay 10 | 12.445503 | 4.62281031386 | 0.00000378576 | 3 |
| Barangay 11 | 30.355221 | 4.38217083516 | 0.00001175026 | 3 |
| Barangay 12 | 52.949677 | 4.38217083516 | 0.00001175026 | 3 |
| Barangay 13 | 6.248697 | 4.62281031386 | 0.00000378576 | 3 |
| Barangay 14 | 39.208691 | 4.50542388805 | 0.00000662406 | 3 |
| Barangay 15 | 6.214905 | 4.62281031386 | 0.00000378576 | 3 |
| Barangay 16 | 23.742617 | 4.50542388805 | 0.00000662406 | 3 |
| Barangay 17 | 3.638552 | 4.62281031386 | 0.00000378576 | 3 |
| Barangay 18 | 14.961807 | 4.62281031386 | 0.00000378576 | 3 |
| Barangay 19 | 20.381470 | 4.50542388805 | 0.00000662406 | 3 |
| Barangay 2 | 20.712679 | 4.37761196169 | 0.00001199867 | 3 |
| Barangay 20 | 35.016736 | 4.50542388805 | 0.00000662406 | 3 |
| Barangay 21 | 7.624001 | 4.50542388805 | 0.00000662406 | 3 |
| Barangay 22 | 9.421968 | 4.60715022737 | 0.00000408225 | 3 |
| Barangay 23 | 7.775476 | 4.50542388805 | 0.00000662406 | 3 |
| Barangay 24 | 29.691265 | 4.60715022737 | 0.00000408225 | 3 |
| Barangay 25 | 22.885312 | 4.50542388805 | 0.00000662406 | 3 |
| Barangay 26 | 18.916361 | 4.60715022737 | 0.00000408225 | 3 |
| Barangay 27 | 10.387900 | 4.60715022737 | 0.00000408225 | 3 |
| Barangay 28 | 16.508991 | 4.60715022737 | 0.00000408225 | 3 |
| Barangay 29 | 7.006149 | 4.50542388805 | 0.00000662406 | 3 |
| Barangay 3 | 20.650796 | 4.36166451019 | 0.00001290767 | 3 |

| Table 37. Hot Spot Analysis Table of the 2013 Business Industry Index with Z-Score and P-values | | | | |
|---|---|---|---|---|
| **Barangay** | **BII_2013** | **Z-Score** | **P-Value** | **Gi_Bin** |
| Barangay 30 | 9.997301 | 4.48242897160 | 0.00000737982 | 3 |
| Barangay 31 | 16.226427 | 4.60715022737 | 0.00000408225 | 3 |
| Barangay 32 | 17.627808 | 4.48242897160 | 0.00000737982 | 3 |
| Barangay 33 | 79.540500 | 4.48242897160 | 0.00000737982 | 3 |
| Barangay 34 | 21.965744 | 4.48242897160 | 0.00000737982 | 3 |
| Barangay 35 | 5.520813 | 4.48242897160 | 0.00000737982 | 3 |
| Barangay 36 | 2.451950 | 4.35528284487 | 0.00001328952 | 3 |
| Barangay 37 | 24.113561 | 4.35528284487 | 0.00001328952 | 3 |
| Barangay 38 | 32.421059 | 4.36166451019 | 0.00001290767 | 3 |
| Barangay 39 | 29.673023 | 4.48242897160 | 0.00000737982 | 3 |
| Barangay 4 | 38.972205 | 4.26276533710 | 0.00002019125 | 3 |
| Barangay 40 | 10.116299 | 4.36166451019 | 0.00001290767 | 3 |
| Barangay 5 | 35.309532 | 4.26276533710 | 0.00002019125 | 3 |
| Barangay 6 | 6.482242 | 4.37761196169 | 0.00001199867 | 3 |
| Barangay 7 | 13.985051 | 4.37761196169 | 0.00001199867 | 3 |
| Barangay 8 | 46.900686 | 4.26276533710 | 0.00002019125 | 3 |
| Barangay 9 | 55.087216 | 4.36166451019 | 0.00001290767 | 3 |
| Bayabas | 0.401667 | 4.70010265031 | 0.00000260031 | 3 |
| Bayanga | 0.003973 | -1.25899265002 | 0.20803301140 | 0 |
| Bonbon | 0.347170 | 4.74610412015 | 0.00000207372 | 3 |
| Bugo | 0.374037 | -1.21988306213 | 0.22250923039 | 0 |
| Bulua | 1.789721 | 1.89461482823 | 0.05814344886 | -1 |
| Camaman-An | 0.441422 | 4.69127610058 | 0.00000271506 | 3 |
| Canito-An | 0.190188 | -1.75073270092 | 0.07999196382 | -1 |
| Carmen | 5.488752 | 4.01936115198 | 0.00005835616 | 3 |
| Consolacion | 1.646924 | 4.62281031386 | 0.00000378576 | 3 |
| Cugman | 0.173682 | -1.60717727631 | 0.10801548533 | 0 |
| Dansolihon | 0.001076 | -1.02155058702 | 0.30699366902 | 0 |
| F. S. Catanico | 0.001421 | -1.24993234452 | 0.21132428707 | 0 |
| Gusa | 0.737139 | 4.99723232684 | 0.00000058159 | 3 |
| Indahag | 0.015029 | -1.39302118999 | 0.16361338300 | 0 |
| Iponan | 0.921492 | -1.85218088799 | 0.06399985226 | -1 |

| Table 37. Hot Spot Analysis Table of the 2013 Business Industry Index with Z-Score and P-values | | | | |
|---|---|---|---|---|
| **Barangay** | **BII_2013** | **Z-Score** | **P-Value** | **Gi_Bin** |
| Kauswagan | 2.267335 | 4.62995269111 | 0.00000365749 | 3 |
| Lapasan | 4.037775 | 4.85483492890 | 0.00000120487 | 3 |
| Lumbia | 0.028199 | -1.25817042224 | 0.20833015403 | 0 |
| Macabalan | 1.690030 | 4.72921354833 | 0.00000225391 | 3 |
| Macasandig | 0.257460 | 4.04365939709 | 0.00005262335 | 3 |
| Mambuaya | 0.002834 | -1.02130378061 | 0.30711055000 | 0 |
| Nazareth | 2.824851 | 4.23559528023 | 0.00002279470 | 3 |
| Pagalungan | 0.000000 | -1.46258798845 | 0.14358015194 | 0 |
| Pagalungan | 0.000000 | -1.25926565519 | 0.20793441881 | 0 |
| Pagalungan | 0.000000 | -1.02159949378 | 0.30697051158 | 0 |
| Pagatpat | 0.020623 | -1.63669883346 | 0.10169341285 | 0 |
| Patag | 0.533060 | 4.54787205203 | 0.00000541911 | 3 |
| Puerto | 0.361196 | -1.23140609169 | 0.21817104310 | 0 |
| Puntod | 1.919954 | 4.60715022737 | 0.00000408225 | 3 |
| San Simon | 0.002419 | -1.46229423368 | 0.14366059801 | 0 |
| Tablon | 0.076068 | -1.45032143110 | 0.14696890547 | 0 |
| Taglimao | 0.002491 | -1.25919285631 | 0.20796070595 | 0 |
| Tagpangi | 0.001798 | -1.02135086927 | 0.30708824778 | 0 |
| Tignapoloan | 0.000301 | -1.25926262969 | 0.20793551125 | 0 |
| Tuburan | 0.000754 | -1.25919285631 | 0.20796070595 | 0 |
| Tumpagon | 0.000542 | -1.02158853975 | 0.30697569823 | 0 |

| Table 38. Hot Spot Analysis Table of the 2014 Business Industry Index with Z-Score and P-values | | | | |
|---|---|---|---|---|
| **Barangay** | **BII_2014** | **Z-Score** | **P-Value** | **Gi_Bin** |
| Agusan | 0.304314 | -0.84283366265 | 0.39932148682 | 0 |
| Baikingon | 0.013958 | -1.10354415861 | 0.26979094345 | 0 |
| Balubal | 0.007363 | -0.85005609583 | 0.39529390796 | 0 |
| Balulang | 0.387593 | 0.94583618805 | 0.34423215625 | 0 |
| Barangay 1 | 7.331226 | 3.06280357577 | 0.00219273939 | 3 |
| Barangay 10 | 12.071065 | 3.16087882089 | 0.00157293922 | 3 |
| Barangay 11 | 28.068721 | 2.99569709630 | 0.00273818281 | 3 |
| Barangay 12 | 44.937043 | 2.99569709630 | 0.00273818281 | 3 |

| Table 38. Hot Spot Analysis Table of the 2014 Business Industry Index with Z-Score and P-values | | | | |
|---|---|---|---|---|
| **Barangay** | **BII_2014** | **Z-Score** | **P-Value** | **Gi_Bin** |
| Barangay 13 | 5.711041 | 3.16087882089 | 0.00157293922 | 3 |
| Barangay 14 | 38.394712 | 3.07999693347 | 0.00207002726 | 3 |
| Barangay 15 | 5.190710 | 3.16087882089 | 0.00157293922 | 3 |
| Barangay 16 | 19.891424 | 3.07999693347 | 0.00207002726 | 3 |
| Barangay 17 | 4.426057 | 3.16087882089 | 0.00157293922 | 3 |
| Barangay 18 | 11.609330 | 3.16087882089 | 0.00157293922 | 3 |
| Barangay 19 | 17.297235 | 3.07999693347 | 0.00207002726 | 3 |
| Barangay 2 | 16.270845 | 2.99272066042 | 0.00276502701 | 3 |
| Barangay 20 | 30.982400 | 3.07999693347 | 0.00207002726 | 3 |
| Barangay 21 | 6.188978 | 3.07999693347 | 0.00207002726 | 3 |
| Barangay 22 | 8.221429 | 3.15104186337 | 0.00162689170 | 3 |
| Barangay 23 | 8.449745 | 3.07999693347 | 0.00207002726 | 3 |
| Barangay 24 | 28.565466 | 3.15104186337 | 0.00162689170 | 3 |
| Barangay 25 | 20.818548 | 3.07999693347 | 0.00207002726 | 3 |
| Barangay 26 | 16.353906 | 3.15104186337 | 0.00162689170 | 3 |
| Barangay 27 | 10.172246 | 3.15104186337 | 0.00162689170 | 3 |
| Barangay 28 | 13.461319 | 3.15104186337 | 0.00162689170 | 3 |
| Barangay 29 | 6.175894 | 3.07999693347 | 0.00207002726 | 3 |
| Barangay 3 | 16.144461 | 2.98270319321 | 0.00285714923 | 3 |
| Barangay 30 | 7.954176 | 3.06575179835 | 0.00217123471 | 3 |
| Barangay 31 | 13.770956 | 3.15104186337 | 0.00162689170 | 3 |
| Barangay 32 | 15.704564 | 3.06575179835 | 0.00217123471 | 3 |
| Barangay 33 | 191.301080 | 3.06575179835 | 0.00217123471 | 3 |
| Barangay 34 | 21.094632 | 3.06575179835 | 0.00217123471 | 3 |
| Barangay 35 | 5.127390 | 3.06575179835 | 0.00217123471 | 3 |
| Barangay 36 | 2.378180 | 2.97895298658 | 0.00289235153 | 3 |
| Barangay 37 | 20.702525 | 2.97895298658 | 0.00289235153 | 3 |
| Barangay 38 | 29.467600 | 2.98270319321 | 0.00285714923 | 3 |
| Barangay 39 | 30.333754 | 3.06575179835 | 0.00217123471 | 3 |
| Barangay 4 | 35.730352 | 2.91355765169 | 0.00357335849 | 3 |
| Barangay 40 | 9.317159 | 2.98270319321 | 0.00285714923 | 3 |
| Barangay 5 | 34.099584 | 2.91355765169 | 0.00357335849 | 3 |
| Barangay 6 | 5.626344 | 2.99272066042 | 0.00276502701 | 3 |

| Table 38. Hot Spot Analysis Table of the 2014 Business Industry Index with Z-Score and P-values | | | | |
|---|---|---|---|---|
| **Barangay** | **BII_2014** | **Z-Score** | **P-Value** | **Gi_Bin** |
| Barangay 7 | 12.146931 | 2.99272066042 | 0.00276502701 | 3 |
| Barangay 8 | 41.513721 | 2.91355765169 | 0.00357335849 | 3 |
| Barangay 9 | 49.526298 | 2.98270319321 | 0.00285714923 | 3 |
| Bayabas | 0.367106 | 3.22113030728 | 0.00127686078 | 3 |
| Bayanga | 0.003372 | -0.85975132089 | 0.38992614699 | 0 |
| Bonbon | 0.315095 | 3.24568995106 | 0.00117166370 | 3 |
| Bugo | 0.320725 | -0.83646333467 | 0.40289430344 | 0 |
| Bulua | 1.684715 | 0.68669691033 | 0.49227374905 | 0 |
| Camaman-An | 0.389136 | 3.21173253281 | 0.00131937148 | 3 |
| Canito-An | 0.186861 | -1.19796320322 | 0.23093136418 | 0 |
| Carmen | 5.840991 | 2.74730271990 | 0.00600876457 | 3 |
| Consolacion | 1.581610 | 3.16087882089 | 0.00157293922 | 3 |
| Cugman | 0.155757 | -1.10074657336 | 0.27100698755 | 0 |
| Dansolihon | 0.000731 | -0.69758883863 | 0.48543436857 | 0 |
| F. S. Catanico | 0.001809 | -0.85437863492 | 0.39289523861 | 0 |
| Gusa | 0.684717 | 3.56970085458 | 0.00035738911 | 3 |
| Indahag | 0.013227 | -1.02619603361 | 0.30479920498 | 0 |
| Iponan | 0.872471 | -1.27124651863 | 0.20364098739 | 0 |
| Kauswagan | 2.125534 | 3.16563337626 | 0.00154745700 | 3 |
| Lapasan | 3.388779 | 3.32126029539 | 0.00089611921 | 3 |
| Lumbia | 0.030741 | -0.85905584123 | 0.39030971737 | 0 |
| Macabalan | 1.654945 | 3.23505617542 | 0.00121618800 | 3 |
| Macasandig | 0.249080 | 3.18457249169 | 0.00144967996 | 3 |
| Mambuaya | 0.002405 | -0.69744230283 | 0.48552604034 | 0 |
| Nazareth | 2.666050 | 2.89663788906 | 0.00377184844 | 3 |
| Pagalungan | 0.000617 | -0.99866589730 | 0.31795657947 | 0 |
| Pagatpat | 0.022920 | -1.11706814410 | 0.26396520794 | 0 |
| Patag | 0.478643 | 3.11808198921 | 0.00182032157 | 3 |
| Puerto | 0.325229 | -0.84379700114 | 0.39878285996 | 0 |
| Puntod | 1.849608 | 3.15104186337 | 0.00162689170 | 3 |
| San Simon | 0.004106 | -0.99841091857 | 0.31808015459 | 0 |
| Tablon | 0.067285 | -0.99127760649 | 0.32155005763 | 0 |
| Taglimao | 0.002114 | -0.85986423354 | 0.38986389514 | 0 |

| Table 38. Hot Spot Analysis Table of the 2014 Business Industry Index with Z-Score and P-values | | | | |
|---|---|---|---|---|
| **Barangay** | **BII_2014** | **Z-Score** | **P-Value** | **Gi_Bin** |
| Tagpangi | 0.001526 | -0.69746871894 | 0.48550951391 | 0 |
| Tignapoloan | 0.000170 | -0.85990942823 | 0.38983897975 | 0 |
| Tuburan | 0.000000 | -0.85987947131 | 0.38985549460 | 0 |
| Tuburan | 0.000000 | -0.85992031941 | 0.38983297569 | 0 |
| Tuburan | 0.000000 | -0.69761080698 | 0.48542062614 | 0 |
| Tumpagon | 0.000460 | -0.69760209177 | 0.48542607797 | 0 |

| Table 39. Hot Spot Analysis Table of the 2015 Business Industry Index with Z-Score and P-values | | | | |
|---|---|---|---|---|
| **Barangay** | **BII_2015** | **Z-Score** | **P-Value** | **Gi_Bin** |
| Agusan | 0.288994 | -0.90950382640 | 0.36308424928 | 0 |
| Baikingon | 0.020097 | -1.18848221821 | 0.23464350263 | 0 |
| Balubal | 0.005679 | -0.91621045901 | 0.35955653138 | 0 |
| Balulang | 0.398614 | 1.14024458788 | 0.25418443528 | 0 |
| Barangay 1 | 7.680169 | 3.30119067385 | 0.00096275430 | 3 |
| Barangay 10 | 11.172859 | 3.40743092606 | 0.00065577504 | 3 |
| Barangay 11 | 28.339565 | 3.22954793320 | 0.00123986095 | 3 |
| Barangay 12 | 42.636842 | 3.22954793320 | 0.00123986095 | 3 |
| Barangay 13 | 4.929483 | 3.40743092606 | 0.00065577504 | 3 |
| Barangay 14 | 41.460728 | 3.32039593937 | 0.00089889863 | 3 |
| Barangay 15 | 5.252198 | 3.40743092606 | 0.00065577504 | 3 |
| Barangay 16 | 20.988357 | 3.32039593937 | 0.00089889863 | 3 |
| Barangay 17 | 4.763622 | 3.40743092606 | 0.00065577504 | 3 |
| Barangay 18 | 10.073889 | 3.40743092606 | 0.00065577504 | 3 |
| Barangay 19 | 20.143489 | 3.32039593937 | 0.00089889863 | 3 |
| Barangay 2 | 17.331106 | 3.22627105335 | 0.00125414524 | 3 |
| Barangay 20 | 30.562793 | 3.32039593937 | 0.00089889863 | 3 |
| Barangay 21 | 6.654268 | 3.32039593937 | 0.00089889863 | 3 |
| Barangay 22 | 8.686842 | 3.39635777908 | 0.00068289035 | 3 |
| Barangay 23 | 9.269334 | 3.32039593937 | 0.00089889863 | 3 |
| Barangay 24 | 30.474294 | 3.39635777908 | 0.00068289035 | 3 |
| Barangay 25 | 21.541043 | 3.32039593937 | 0.00089889863 | 3 |
| Barangay 26 | 18.130470 | 3.39635777908 | 0.00068289035 | 3 |

| Table 39. Hot Spot Analysis Table of the 2015 Business Industry Index with Z-Score and P-values | | | | |
|---|---|---|---|---|
| **Barangay** | **BII_2015** | **Z-Score** | **P-Value** | **Gi_Bin** |
| Barangay 27 | 8.927128 | 3.39635777908 | 0.00068289035 | 3 |
| Barangay 28 | 12.996474 | 3.39635777908 | 0.00068289035 | 3 |
| Barangay 29 | 6.892049 | 3.32039593937 | 0.00089889863 | 3 |
| Barangay 3 | 18.823224 | 3.21499471242 | 0.00130446925 | 3 |
| Barangay 30 | 8.180341 | 3.30443649252 | 0.00095167535 | 3 |
| Barangay 31 | 14.891465 | 3.39635777908 | 0.00068289035 | 3 |
| Barangay 32 | 16.151099 | 3.30443649252 | 0.00095167535 | 3 |
| Barangay 33 | 170.492023 | 3.30443649252 | 0.00095167535 | 3 |
| Barangay 34 | 21.189904 | 3.30443649252 | 0.00095167535 | 3 |
| Barangay 35 | 5.182262 | 3.30443649252 | 0.00095167535 | 3 |
| Barangay 36 | 2.649617 | 3.21083633532 | 0.00132349289 | 3 |
| Barangay 37 | 23.983157 | 3.21083633532 | 0.00132349289 | 3 |
| Barangay 38 | 28.844962 | 3.21499471242 | 0.00130446925 | 3 |
| Barangay 39 | 27.958901 | 3.30443649252 | 0.00095167535 | 3 |
| Barangay 4 | 40.470576 | 3.14109336483 | 0.00168318365 | 3 |
| Barangay 40 | 8.829559 | 3.21499471242 | 0.00130446925 | 3 |
| Barangay 5 | 36.397531 | 3.14109336483 | 0.00168318365 | 3 |
| Barangay 6 | 5.143396 | 3.22627105335 | 0.00125414524 | 3 |
| Barangay 7 | 11.634060 | 3.22627105335 | 0.00125414524 | 3 |
| Barangay 8 | 39.815846 | 3.14109336483 | 0.00168318365 | 3 |
| Barangay 9 | 51.154049 | 3.21499471242 | 0.00130446925 | 3 |
| Bayabas | 0.413501 | 3.47359016772 | 0.00051354478 | 3 |
| Bayanga | 0.002972 | -0.92705387259 | 0.35389857493 | 0 |
| Bonbon | 0.298803 | 3.49867178649 | 0.00046758177 | 3 |
| Bugo | 0.307009 | -0.90235320645 | 0.36686928009 | 0 |
| Bulua | 1.742649 | 0.85252065904 | 0.39392518635 | 0 |
| Camaman-An | 0.409530 | 3.46108631988 | 0.00053800027 | 3 |
| Canito-An | 0.190259 | -1.29235538252 | 0.19623410062 | 0 |
| Carmen | 5.641703 | 2.96230773919 | 0.00305342435 | 3 |
| Consolacion | 1.424835 | 3.40743092606 | 0.00065577504 | 3 |
| Cugman | 0.157451 | -1.18611335051 | 0.23557756009 | 0 |
| Dansolihon | 0.000282 | -0.75226574130 | 0.45189127172 | 0 |
| F. S. Catanico | 0.001240 | -0.92117776751 | 0.35695763436 | 0 |

| Table 39. Hot Spot Analysis Table of the 2015 Business Industry Index with Z-Score and P-values | | | | |
|---|---|---|---|---|
| **Barangay** | **BII_2015** | **Z-Score** | **P-Value** | **Gi_Bin** |
| Gusa | 0.701244 | 3.87302010374 | 0.00010749496 | 3 |
| Indahag | 0.014575 | -1.04320596963 | 0.29685292430 | 0 |
| Iponan | 0.927439 | -1.37022135860 | 0.17061781296 | 0 |
| Kauswagan | 2.143347 | 3.41293779656 | 0.00064266609 | 3 |
| Lapasan | 3.304868 | 3.57918869154 | 0.00034466255 | 3 |
| Lumbia | 0.033817 | -0.92622467980 | 0.35432924018 | 0 |
| Macabalan | 1.467975 | 3.48671184888 | 0.00048899792 | 3 |
| Macasandig | 0.254640 | 3.32188699289 | 0.00089410898 | 3 |
| Mambuaya | 0.005565 | -0.75200327040 | 0.45204909812 | 0 |
| Nazareth | 2.754608 | 3.12218547425 | 0.00179513806 | 3 |
| Pagatpat | 0.026143 | -1.20721965720 | 0.22734758429 | 0 |
| Patag | 0.501780 | 3.36448965113 | 0.00076685360 | 3 |
| Puerto | 0.339090 | -0.90991623382 | 0.36286669809 | 0 |
| Puntod | 1.779267 | 3.39635777908 | 0.00068289035 | 3 |
| San Simon | 0.007038 | -1.07637464771 | 0.28175975234 | 0 |
| Tablon | 0.071224 | -1.06924974050 | 0.28495716704 | 0 |
| Taglimao | 0.001630 | -0.92727178196 | 0.35378545231 | 0 |
| Tagpangi | 0.001256 | -0.75214324405 | 0.45196492668 | 0 |
| Tignapoloan | 0.000175 | -0.92730309492 | 0.35376919879 | 0 |
| Tuburan | 0.000000 | -0.92727178196 | 0.35378545231 | 0 |
| Tumpagon | 0.000946 | -0.75224985661 | 0.45190082246 | 0 |

**Table 40. Cagayan de Oro Population Data and PopnIndex for 2010, 2012 and 2015**

| **Barangay** | **2010 (Actual Census)** | | **2012 (Projection)** | | **2015 (Actual Census)** | |
|---|---|---|---|---|---|---|
| | **Count** | **PopnIndex** | **Count** | **PopnIndex** | **Count** | **PopnIndex** |
| Agusan | 14,812 | 0.67 | 15,378 | 0.66 | 16,261 | 0.66 |
| Baikingon | 2,342 | 0.11 | 2,420 | 0.11 | 2,291 | 0.10 |
| Balubal | 2,893 | 0.09 | 3,014 | 0.09 | 4,718 | 0.14 |
| Balulang | 32,531 | 1.04 | 35,543 | 1.07 | 34,793 | 0.99 |
| Barangay 1 | 453 | 0.72 | 438 | 0.66 | 349 | 0.50 |
| Barangay 10 | 616 | 3.26 | 568 | 2.83 | 786 | 3.70 |
| Barangay 11 | 342 | 1.54 | 330 | 1.40 | 204 | 0.82 |
| Barangay 12 | 469 | 4.76 | 466 | 4.46 | 257 | 2.32 |
| Barangay 13 | 2,330 | 8.32 | 2,321 | 7.82 | 1156 | 3.68 |
| Barangay 14 | 479 | 2.68 | 452 | 2.39 | 526 | 2.63 |

| Barangay | 2010 (Actual Census) | | 2012 (Projection) | | 2015 (Actual Census) | |
|---|---|---|---|---|---|---|
| | **Count** | **PopnIndex** | **Count** | **PopnIndex** | **Count** | **PopnIndex** |
| Barangay 15 | 2,966 | 8.70 | 3,200 | 8.85 | 2,049 | 5.35 |
| Barangay 16 | 143 | 1.29 | 139 | 1.19 | 36 | 0.29 |
| Barangay 17 | 2,342 | 8.44 | 2,345 | 7.97 | 2,280 | 7.32 |
| Barangay 18 | 1,496 | 19.01 | 1,448 | 17.35 | 1,561 | 17.67 |
| Barangay 19 | 419 | 3.73 | 412 | 3.46 | 352 | 2.79 |
| Barangay 2 | 84 | 0.43 | 71 | 0.34 | 71 | 0.32 |
| Barangay 20 | 121 | 1.34 | 112 | 1.17 | 69 | 0.68 |
| Barangay 21 | 254 | 1.25 | 235 | 1.09 | 535 | 2.35 |
| Barangay 22 | 1,944 | 3.83 | 1,896 | 3.53 | 2,192 | 3.85 |
| Barangay 23 | 916 | 2.58 | 894 | 2.38 | 928 | 2.33 |
| Barangay 24 | 929 | 1.83 | 942 | 1.75 | 795 | 1.39 |
| Barangay 25 | 1,295 | 5.76 | 1,347 | 5.65 | 1,113 | 4.41 |
| Barangay 26 | 2,383 | 6.26 | 2,364 | 5.86 | 2,621 | 6.13 |
| Barangay 27 | 1,380 | 3.28 | 1,368 | 3.06 | 1,610 | 3.41 |
| Barangay 28 | 541 | 1.74 | 595 | 1.80 | 536 | 1.53 |
| Barangay 29 | 485 | 0.56 | 446 | 0.48 | 448 | 0.46 |
| Barangay 3 | 177 | 0.54 | 165 | 0.47 | 271 | 0.73 |
| Barangay 30 | 875 | 3.25 | 919 | 3.22 | 822 | 2.72 |
| Barangay 31 | 1,506 | 1.78 | 1,478 | 1.65 | 1,170 | 1.23 |
| Barangay 32 | 1,410 | 3.68 | 1,438 | 3.54 | 1,166 | 2.71 |
| Barangay 33 | 86 | 0.24 | 85 | 0.22 | 67 | 0.17 |
| Barangay 34 | 621 | 3.56 | 630 | 3.40 | 634 | 3.23 |
| Barangay 35 | 2,395 | 7.42 | 2,477 | 7.23 | 2,239 | 6.17 |
| Barangay 36 | 791 | 2.75 | 783 | 2.56 | 679 | 2.10 |
| Barangay 37 | 77 | 0.64 | 57 | 0.45 | 141 | 1.05 |
| Barangay 38 | 94 | 0.58 | 83 | 0.49 | 67 | 0.37 |
| Barangay 39 | 46 | 0.46 | 45 | 0.43 | 36 | 0.32 |
| Barangay 4 | 108 | 0.91 | 96 | 0.77 | 80 | 0.60 |
| Barangay 40 | 830 | 1.42 | 910 | 1.47 | 791 | 1.20 |
| Barangay 5 | 83 | 0.75 | 87 | 0.74 | 78 | 0.63 |
| Barangay 6 | 212 | 0.93 | 163 | 0.67 | 110 | 0.43 |
| Barangay 7 | 542 | 1.76 | 531 | 1.63 | 511 | 1.48 |
| Barangay 8 | 157 | 0.85 | 148 | 0.76 | 129 | 0.63 |
| Barangay 9 | 132 | 0.99 | 119 | 0.84 | 315 | 2.10 |
| Bayabas | 12,999 | 1.33 | 15,400 | 1.48 | 13,670 | 1.24 |
| Bayanga | 2,769 | 0.05 | 2,930 | 0.05 | 3,289 | 0.05 |
| Besigan | 1,404 | 0.01 | 1,572 | 0.01 | 1,673 | 0.01 |
| Bonbon | 9,195 | 1.32 | 9,459 | 1.28 | 9,573 | 1.22 |
| Bugo | 27,122 | 0.78 | 28,169 | 0.77 | 30,893 | 0.79 |
| Bulua | 31,345 | 1.53 | 33,237 | 1.53 | 32,348 | 1.41 |
| Camaman-an | 24,651 | 0.78 | 25,424 | 0.76 | 30,927 | 0.88 |
| Canito-an | 15,069 | 0.33 | 16,440 | 0.34 | 27,815 | 0.54 |
| Carmen | 67,583 | 4.95 | 72,617 | 5.01 | 70,492 | 4.60 |

| Barangay | 2010 (Actual Census) | | 2012 (Projection) | | 2015 (Actual Census) | |
|---|---|---|---|---|---|---|
| | Count | PopnIndex | Count | PopnIndex | Count | PopnIndex |
| Consolacion | 9,919 | 4.26 | 10,163 | 4.12 | 10,433 | 3.99 |
| Cugman | 20,531 | 0.27 | 21,688 | 0.27 | 22,383 | 0.27 |
| Dansolihon | 4,811 | 0.02 | 5,187 | 0.02 | 5,550 | 0.02 |
| F. S. Catanico | 1,710 | 0.04 | 1,789 | 0.04 | 2,502 | 0.05 |
| Gusa | 26,117 | 0.87 | 27,982 | 0.88 | 26,815 | 0.80 |
| Indahag | 6,235 | 0.10 | 7,359 | 0.11 | 16,179 | 0.24 |
| Iponan | 20,707 | 1.77 | 24,192 | 1.95 | 26,340 | 2.01 |
| Kauswagan | 34,541 | 2.39 | 35,830 | 2.34 | 35,069 | 2.16 |
| Lapasan | 41,903 | 4.29 | 43,443 | 4.19 | 43,611 | 3.97 |
| Lumbia | 14,079 | 0.10 | 16,090 | 0.10 | 22,429 | 0.14 |
| Macabalan | 20,303 | 4.90 | 20,601 | 4.69 | 20,721 | 4.46 |
| Macasandig | 23,310 | 0.40 | 24,632 | 0.40 | 20,738 | 0.32 |
| Mambuaya | 2,490 | 0.05 | 2,774 | 0.06 | 3,431 | 0.06 |
| Nazareth | 10,658 | 1.54 | 10,643 | 1.45 | 10,395 | 1.34 |
| Pagalungan | 1,806 | 0.04 | 1,804 | 0.04 | 2,290 | 0.04 |
| Pagatpat | 5,178 | 0.08 | 5,986 | 0.08 | 8,456 | 0.11 |
| Patag | 17,219 | 0.93 | 17,027 | 0.87 | 17,742 | 0.85 |
| Pigsag-an | 1,256 | 0.03 | 1,353 | 0.03 | 1,347 | 0.03 |
| Puerto | 11,475 | 0.30 | 12,549 | 0.31 | 14,318 | 0.33 |
| Puntod | 18,399 | 4.05 | 19,013 | 3.95 | 18,796 | 3.69 |
| San Simon | 1,346 | 0.03 | 1,405 | 0.03 | 1,391 | 0.03 |
| Tablon | 18,608 | 0.10 | 19,750 | 0.10 | 23,004 | 0.11 |
| Taglimao | 1,418 | 0.03 | 1,505 | 0.03 | 2,249 | 0.04 |
| Tagpangi | 2,684 | 0.03 | 2,674 | 0.03 | 2,649 | 0.03 |
| Tignapoloan | 4,514 | 0.01 | 4,681 | 0.01 | 4,866 | 0.01 |
| Tuburan | 1,395 | 0.03 | 1,536 | 0.03 | 1,290 | 0.03 |
| Tumpagon | 2,232 | 0.04 | 2,500 | 0.04 | 2,433 | 0.03 |

**Table 41. Population Index Percentage Change in the Short-Term (2010-2012) and Long-Term (2010-2015)**

| Barangay | 2010-2012 Percentage Change | 2010-2015 Percentage Change |
|---|---|---|
| Agusan | -2.08 | -2.21 |
| Baikingon | -2.54 | -12.87 |
| Balubal | -1.74 | 45.26 |
| Balulang | 3.05 | -4.73 |
| Barangay 1 | -8.81 | -31.38 |
| Barangay 10 | -13.03 | 13.65 |
| Barangay 11 | -8.99 | -46.87 |
| Barangay 12 | -6.29 | -51.19 |
| Barangay 13 | -6.05 | -55.81 |
| Barangay 14 | -11.00 | -2.19 |
| Barangay 15 | 1.76 | -38.47 |
| Barangay 16 | -8.32 | -77.58 |

| Barangay | 2010-2012 Percentage Change | 2010-2015 Percentage Change |
|---|---:|---:|
| Barangay 17 | -5.56 | -13.29 |
| Barangay 18 | -8.71 | -7.06 |
| Barangay 19 | -7.26 | -25.17 |
| Barangay 2 | -20.28 | -24.71 |
| Barangay 20 | -12.70 | -49.21 |
| Barangay 21 | -12.74 | 87.61 |
| Barangay 22 | -8.01 | 0.44 |
| Barangay 23 | -7.95 | -9.76 |
| Barangay 24 | -4.36 | -23.78 |
| Barangay 25 | -1.90 | -23.45 |
| Barangay 26 | -6.43 | -2.03 |
| Barangay 27 | -6.50 | 3.92 |
| Barangay 28 | 3.73 | -11.75 |
| Barangay 29 | -13.27 | -17.72 |
| Barangay 3 | -12.08 | 36.38 |
| Barangay 30 | -0.94 | -16.32 |
| Barangay 31 | -7.44 | -30.80 |
| Barangay 32 | -3.81 | -26.34 |
| Barangay 33 | -6.78 | -30.61 |
| Barangay 34 | -4.32 | -9.06 |
| Barangay 35 | -2.45 | -16.73 |
| Barangay 36 | -6.64 | -23.54 |
| Barangay 37 | -30.18 | 63.11 |
| Barangay 38 | -16.72 | -36.51 |
| Barangay 39 | -7.73 | -30.29 |
| Barangay 4 | -16.16 | -34.02 |
| Barangay 40 | 3.41 | -15.11 |
| Barangay 5 | -1.14 | -16.29 |
| Barangay 6 | -27.48 | -53.78 |
| Barangay 7 | -7.60 | -16.02 |
| Barangay 8 | -11.09 | -26.81 |
| Barangay 9 | -14.97 | 112.56 |
| Bayabas | 11.74 | -6.33 |
| Bayanga | -0.20 | 5.80 |
| Besigan | 5.60 | 6.14 |
| Bonbon | -2.97 | -7.27 |
| Bugo | -2.04 | 1.46 |
| Bulua | 0.01 | -8.08 |
| Camaman-an | -2.72 | 11.75 |
| Canito-an | 2.90 | 64.41 |
| Carmen | 1.34 | -7.09 |
| Consolacion | -3.36 | -6.31 |
| Cugman | -0.37 | -2.89 |
| Dansolihon | 1.69 | 2.76 |

| Barangay | 2010-2012 Percentage Change | 2010-2015 Percentage Change |
|---|---|---|
| F. S. Catanico | -1.32 | 30.33 |
| Gusa | 1.05 | -8.55 |
| Indahag | 11.32 | 131.13 |
| Iponan | 10.19 | 13.30 |
| Kauswagan | -2.16 | -9.57 |
| Lapasan | -2.22 | -7.30 |
| Lumbia | 7.79 | 41.90 |
| Macabalan | -4.30 | -9.09 |
| Macasandig | -0.33 | -20.76 |
| Mambuaya | 5.08 | 22.73 |
| Nazareth | -5.82 | -13.13 |
| Pagalungan | -5.79 | 12.94 |
| Pagatpat | 9.04 | 45.46 |
| Patag | -6.73 | -8.22 |
| Pigsag-an | 1.60 | -4.47 |
| Puerto | 3.15 | 11.14 |
| Puntod | -2.53 | -9.01 |
| San Simon | -1.55 | -7.95 |
| Tablon | 0.11 | 10.12 |
| Taglimao | 0.10 | 41.27 |
| Tagpangi | -6.03 | -12.09 |
| Tignapoloan | -2.19 | -3.98 |
| Tuburan | 3.85 | -17.63 |
| Tumpagon | 5.64 | -2.91 |

**Table 42. Correlation result between the FIMI and the Percentage Change of PopIndex from 2010 to 2015**

| Correlations | | | |
|---|---|---|---|
| | | FIMI | PercChange_POPN |
| FIMI | Pearson Correlation | 1 | -.230* |
| | Sig. (2-tailed) | | .040 |
| | N | 80 | 80 |
| PercChange_POPN | Pearson Correlation | -.230* | 1 |
| | Sig. (2-tailed) | .040 | |
| | N | 80 | 80 |

*. Correlation is significant at the 0.05 level (2-tailed).

**-------------------------------------Mediation Analysis-----------------------------------------------**

***************** PROCESS Procedure for SPSS Version 3.5 *****************

Written by Andrew F. Hayes, Ph.D. www.afhayes.com

Documentation available in Hayes (2018). www.guilford.com/p/hayes3
**************************************************************************

Model : 4
Y : AveCh
X : FIMI
M : Popn_Ave

Sample
Size: 80

**************************************************************************

| OUTCOME VARIABLE: | | | | | | |
|---|---|---|---|---|---|---|
| Popn_Ave | | | | | | |
| | | | | | | |
| Model Summary | | | | | | |
| R | R-sq | MSE | F | df1 | df2 | p |
| .2244 | .0504 | 1140.7374 | 4.0314 | 1.0000 | 76.0000 | .0482 |
| | | | | | | |
| Model | | | | | | |
| | coeff | se | t | p | LLCI | ULCI |
| constant | 3.3092 | 5.1821 | .6386 | .5250 | -7.0119 | 13.6303 |
| FIMI | -4.3174 | 2.1503 | -2.0078 | .0482 | -8.6000 | -.0347 |

| OUTCOME VARIABLE: | | | | | | |
|---|---|---|---|---|---|---|
| AveCh | | | | | | |
| | | | | | | |
| Model Summary | | | | | | |
| R | R-sq | MSE | F | df1 | df2 | p |
| .0933 | .0087 | 123.5690 | .3294 | 2.0000 | 75.0000 | .7204 |
| | | | | | | |
| Model | | | | | | |
| | coeff | se | t | p | LLCI | ULCI |
| constant | -1.8326 | 1.7101 | -1.0716 | .2873 | -5.2394 | 1.5742 |
| FIMI | .5878 | .7262 | .8093 | .4209 | -.8590 | 2.0345 |
| Popn_Ave | .0091 | .0378 | .2420 | .8095 | -.0661 | .0843 |

TOTAL EFFECT MODEL
OUTCOME VARIABLE:
AveCh

| Model Summary | | | | | | |
|---|---|---|---|---|---|---|
| R | R-sq | MSE | F | df1 | df2 | p |
| .0891 | .0079 | 122.0383 | .6078 | 1.0000 | 76.0000 | .4380 |
| | | | | | | |
| Model | | | | | | |
| | coeff | se | t | p | LLCI | ULCI |
| constant | -1.8024 | 1.6950 | -1.0634 | .2910 | -5.1782 | 1.5734 |
| FIMI | .5483 | .7033 | .7796 | .4380 | -.8524 | 1.9491 |

| TOTAL, DIRECT, AND INDIRECT EFFECTS OF X ON Y | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | | | | |
| Total effect of X on Y | | | | | | | |
| Effect | se | t | p | LLCI | ULCI | c_ps | c_cs |
| .5483 | .7033 | .7796 | .4380 | -.8524 | 1.9491 | .0498 | .0891 |
| | | | | | | | |
| Direct effect of X on Y | | | | | | | |
| Effect | se | t | p | LLCI | ULCI | c'_ps | c'_cs |
| .5878 | .7262 | .8093 | .4209 | -.8590 | 2.0345 | .0533 | .0955 |
| | | | | | | | |
| Indirect effect(s) of X on Y: | | | | | | | |
| | Effect | BootSE | BootLLCI | BootULCI | | | |
| Popn_Ave | -.0394 | .1058 | -.2670 | .1784 | | | |
| | | | | | | | |
| Partially standardized indirect effect(s) of X on Y: | | | | | | | |
| | Effect | BootSE | BootLLCI | BootULCI | | | |
| Popn_Ave | -.0036 | .0105 | -.0283 | .0159 | | | |
| | | | | | | | |
| Completely standardized indirect effect(s) of X on Y: | | | | | | | |

| | Effect | BootSE | BootLLCI | BootULCI |
|---|---|---|---|---|
| Popn_Ave | -.0064 | .0189 | -.0508 | .0283 |

ANALYSIS NOTES AND ERRORS

Level of confidence for all confidence intervals in output:
95.0000

Number of bootstrap samples for percentile bootstrap confidence intervals:
5000

------------------------------ End Matrix for Mediation Analysis -------------------------------------

**-------------------------------------Moderation Analysis-----------------------------------------------**

***************** PROCESS Procedure for SPSS Version 3.5 *****************

Written by Andrew F. Hayes, Ph.D. www.afhayes.com
Documentation available in Hayes (2018). www.guilford.com/p/hayes3

**************************************************************************

Model : 1
Y : Ave_Cha
X : FIMI
W : Agglo

Sample
Size: 80

**************************************************************************

OUTCOME VARIABLE:
Ave_Cha

| Model Summary | | | | | | |
|---|---|---|---|---|---|---|
| R | R-sq | MSE | F | df1 | df2 | p |
| .2986 | .0892 | 112.0630 | 2.4805 | 3.0000 | 76.0000 | .0674 |

| Model | | | | | | |
|---|---|---|---|---|---|---|
| | coeff | se | t | p | LLCI | ULCI |
| constant | -4.9391 | 2.0443 | -2.4161 | .0181 | -9.0107 | -.8675 |
| FIMI | 2.1858 | .9831 | 2.2233 | .0292 | .2277 | 4.1439 |
| Agglo | 4.3493 | 1.7779 | 2.4462 | .0167 | .8082 | 7.8904 |
| Int_1 | -1.8198 | .7333 | -2.4816 | .0153 | -3.2803 | -.3593 |

Product terms key:

Int_1 : FIMI x Agglo

Test(s) of highest order unconditional interaction(s):

| | R2-chng | F | df1 | df2 | p |
|---|---|---|---|---|---|
| X*W | .0738 | 6.1584 | 1.0000 | 76.0000 | .0153 |

----------

Focal predict: FIMI (X)

Mod var: Agglo (W)

Conditional effects of the focal predictor at values of the moderator(s):

| Agglo | Effect | se | t | p | LLCI | ULCI |
|---|---|---|---|---|---|---|
| .0000 | 2.1858 | .9831 | 2.2233 | .0292 | .2277 | 4.1439 |
| 1.0000 | .3660 | .6795 | .5387 | .5917 | -.9873 | 1.7194 |
| 1.0000 | .3660 | .6795 | .5387 | .5917 | -.9873 | 1.7194 |

Data for visualizing the conditional effect of the focal predictor:

Paste text below into a SPSS syntax window and execute to produce plot.

DATA LIST FREE/

FIMI Agglo Ave_Cha .

BEGIN DATA.

| | | |
|---|---|---|
| .0000 | .0000 | -4.9391 |
| 1.3130 | .0000 | -2.0691 |
| 3.6953 | .0000 | 3.1380 |

| | | |
|---|---|---|
| .0000 | 1.0000 | -.5899 |
| 1.3130 | 1.0000 | -.1093 |
| 3.6953 | 1.0000 | .7627 |
| .0000 | 1.0000 | -.5899 |
| 1.3130 | 1.0000 | -.1093 |
| 3.6953 | 1.0000 | .7627 |

END DATA.

GRAPH/SCATTERPLOT=

FIMI WITH Ave_Cha BY Agglo .

********** ANALYSIS NOTES AND ERRORS ***********

Level of confidence for all confidence intervals in output:

95.0000

W values in conditional tables are the 16th, 50th, and 84th percentiles.

------------------------------ End Matrix for Moderation Analysis --------------------------------

**Table 43. Inventory of Commercial Areas Cagayan de Oro City**

| Type of Commercial Areas | Location | Area (in sq.m.) |
|---|---|---|
| **Malls** | | |
| ·Gaisano City Mall | Recto Avenue – Corrales, Lapasan | 23,877.84 |
| ·Limketkai Mall | Lapasan | 46,320.70 |
| ·SM City | Upper Carmen | 50,442.78 |
| · Ororama Supercenter | Cogon, Barangay 33 | 13,588.96 |
| -Ayala Centrio Mall | Lapasan | 51,232.36 |
| **Central Business District** | | |
| · Commercial Business District (CBD) | Barangays 1 to 40 | |
| **Business Park** | | |
| · Alwana Business Park | Cugman | 330,000 |
| ·Pueblo de Oro Business Park | Upper Carmen | 3,600,000 |
| ·Pride Rock Business Park | Gusa | |
| · Limketkai Center | Lapasan | |
| · Agora Square | Lapasan | |
| · Westbound Market/ Terminal Square CBD | Bulua | |
| · Georgetown Cybermall | R.N. Pelaez Blvd, Carmen | 2,000.00 |

| Type of Commercial Areas | Location | Area (in sq.m.) |
|---|---|---|
| **Public Market** | | |
| · Cogon Market | Cogon District, Barangay 33 | |
| · Carmen Market | Carmen | |
| · Agora/Market City | Lapasan | |
| · Puerto Market | Puerto | |
| · Eastbound Terminal & Market | Gusa | |
| · Westbound Terminal & Market | Bulua | |
| **Commercial Strips** | | |
| · Along J.R. Borja Extension | Camaman-an | |
| · Along R.N. Pelaez Boulevard | Carmen to Kauswagan | |
| **Neighborhood Center** | | |
| · Ororama Superstore | Carmen | |
| · Gaisano Superstore | Cogon | |
| | Carmen | |
| | Bulua | |
| · Savemore Market | Lapasan | |
| | Capistrano | |
| | Kauswagan | |
| · Robinsons Supercenter | Gusa | |
| · -Puregold | Lapasan | |

**Photo 2. Damages of TS Sendong in Cagayan de Oro City**


Sources: Upper right (http://www.unladkabayan.org/reliefops_dec2011.html); Lower right (https://www.pinaymommyonline.com/a-tragic-day-for-cagayan-de-oro-city/); Left: (Susan R. Espinueva et al., 2012).
For aerial footage:
https://www.youtube.com/watch?time_continue=268&v=xivpP7qVrEU&feature=emb _logo

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