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CLIMATE CHANGE ADAPTATION: THE CASE OF COASTAL COMMUNITIES IN THE PHILIPPINES

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Abstract: Climate change poses challenges and risks to coastal communities, and the adaptation of local residents is a critically relevant issue that needs to be addressed in the policymaking process. The main purpose of this paper is to determine the perceptions and experiences of climate change among coastal community residents in the Philippines. This study used a combination of methods, such as participatory mapping exercises, focus group discussions, key informant interviews, and document analyses. The data, which were primarily collected from three coastal villages in the province of Bulacan, were subjected to a thematic network analysis. The findings revealed four dominant themes pertaining to climate change adaptation in a coastal community setting: vulnerability conditions, risk awareness, risk perceptions, and climate change awareness and perceptions. In particular, it was found out that the communities were exposed to the threats of natural hazards like flood and storm surge. Such exposure highlighted the residents' concerns over the risks of hazards on their livelihoods and properties. The residents also observed the unpredictability and the worsening effects of climate change. With their direct experiences of the natural hazards' impacts and awareness of the presence of risks, residents had undertaken actions to build their adaptive capacity. This study then highlights the value of integrating local knowledge into the mapping exercises, revealing crucial information regarding vulnerabilities, risks, and adaptation practices.

Keywords: climate change adaptation; coastal communities; local knowledge; thematic network analysis; participatory GIS

Introduction

Geographic variation in climate change causes and impacts exists, and the extent by which this difference is encountered in different parts of the world is shaped mainly by context-specific conditions (Reichel & Frömming, 2014). In the Philippines, where a series of devastating natural disasters annually occur, the rapid population growth and economic development have serious implications on risk reduction and management efforts (Lagmay, Racoma, Aracan, Alconis-Ayco, & Saddi, 2017). Moreover, the Philippines has been consistently identified as one of the countries most affected by disasters. The Global Climate Risk Index emphasized how the country has remained in the list of the affected countries

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that are frequently exposed to catastrophes, such as those resulting from typhoons (Eckstein, Künzel, Schäfer, & Winges, 2020). Projections also suggest that extreme weather conditions in the country are likely to occur more frequently. The Philippine Atmospheric, Geophysical and Astronomical Services Administration (2011) projects that between 2020 and 2060, increased temperatures, extreme rainfall, and dry days are to be the most climatic conditions expected to happen locally.

The frequency of extreme weather events in recent years has called for a more proactive and integrated approach to responding to adverse climate change impacts on lives, livelihood, and properties (Raza, 2018). However, in developing countries, the provision for cost-effective, reliable, and suitable interventions geared toward reducing vulnerability levels remains a challenging task (Osti, Tanaka, & Tokioka, 2008). Addressing efforts aimed at vulnerability reduction requires the effective formulation and implementation of climate change adaptation interventions specific to the needs of the people at a local level (Khadka et al., 2018). The crafting of adaptation plans becomes more locally relevant when climate-related information is readily available to the public (Minano, Johnson, & Wandel, 2018). This bottom-up approach entails the local people to actively partake in developing such plans through the integration of their knowledge. However, when the bottom-up nature of planning is merged with a top-down approach, achieving a more substantial level of adaptive capacity is likely to happen (Minano et al., 2018).

The integration of top-down and bottom-up approaches can then be realized through the use of Participatory Geographic Information Systems (PGIS). As a geospatial approach to participatory action research, PGIS is characterized by the visualization of spatial information communicated by community residents, which then influences the decision-making processes involved in utilizing geographic information for planning (Dunn, 2007). Throughout the years, PGIS has evolved into an indispensable tool for tapping the potential of local spatial knowledge, which allows for a more detailed and data-driven visualization (Ahmed et al., 2019). Because of its cost-effectiveness, PGIS has become an emerging alternative to the traditional yet costly means of mapping that experts usually carry out (Cheung et al., 2016). Through PGIS, access to scientific data becomes even more relevant when residents merge their indigenous knowledge with science-based knowledge and actively participate in the mapping process (Levine & Feinholz, 2015).

The inputs that people can offer concerning the changes that exist in their natural environment, specifically how the occurrence of disasters has transformed it, are vital to creating maps in a participatory manner (Klonner, Usón, Marx, Mocnik, & Höfle, 2018). A practical case in point is how mapping serves as a tool for encouraging them to identify hazard-prone areas and document environmental risks (Cadag & Gaillard, 2012; Meyer et al., 2018). Given their familiarity with the geographic features of their village, residents can quickly mark areas on their map that are vulnerable to hazards such as flooding and storm surge. In the context of vulnerability assessment, local knowledge becomes a necessary means to uncover vulnerabilities in natural and social environments where multiple hazards commonly occur (Sullivan-Wiley, Short Gianotti, & Casellas Connors, 2019). On the part of the local planners, utilizing vulnerability-based maps would make it easier for them to implement interventions that minimize people's exposure to risks and increase their adaptive capacity (Preston, Yuen, & Westaway, 2011).

Although science-based knowledge remains an indispensable tool in understanding climate-related hazards, reliance on not only expert knowledge but also on local knowledge has become a critical component of developing maps because local knowledge reflects how community residents utilize strategies to cope with the changing climate conditions (Onencan, Meesters, & Van De Walle, 2018). Bridging the gap between the lay public knowledge, which relevance cannot be taken for granted, and

the experts knowledge, thus emerges as a primary concern in minimizing disaster risks (Cadag & Gaillard, 2012). Hence, a significant consideration of PGIS is how the process of mapping is carried out in a manner that provides equal representation among stakeholders who contribute to the process regardless of their profile, background, and expertise (Burdon et al., 2019). After all, the primary concern of PGIS is to examine the structure and extent of an area, but in other respects, PGIS is bound to stimulate human empowerment on account of inclusivity (Merschdorf & Blaschke, 2018). Giving equal value to expert and non-expert opinions creates a venue for a more inclusive decision-making.

Within a participatory setting, non-experts are empowered to voice out their opinions without being influenced or dominated by experts (Cinderby, 1999; McCall & Minang, 2005). Since both experts and non-experts are expected to contribute to a shared decision-making, assessing the relevance and quality of data also becomes a collaborative undertaking. Although conflicting views are likely to arise, the discussion between the two groups can still be geared towards consensus building (Giuffrida, Le Pira, Inturri, & Ignaccolo, 2019). It is in this context that even non-experts can be involved in scientific research, in which they can conduct the gathering, evaluation, and analysis of data (Kar, Sieber, Haklay, & Ghose, 2016). Furthermore, while incompatibility exists between expert knowledge and experiential knowledge of non-experts, meaningful conversations are still possible especially when mapping exercises are used as a platform for dialogue (Cinderby, Snell, & Forrester, 2008). Such conversations allow both parties to deal with the challenges in using local knowledge (Brown & Kyttä, 2018; Haworth, Bruce, Whittaker, & Read, 2018).

Previous studies on the applications based on geographic information system (GIS) have focused on landscape and urban planning (Bijker & Sijstma, 2017; Brown, Schebella, & Weber, 2014), ecosystem services assessment (Damastuti & de Groot, 2019; Lopes & Videria, 2015), land use planning (Hessel et al., 2009; Ioki et al., 2019), analysis of land use perceptions (Mapedza, Wright, & Fawcett, 2003), integrated coastal management (Käyhkö et al., 2019), and natural resource management in indigenous settlements (Smith, 2003). Moreover, the applications of either GIS technology or GIS in the Philippines context have mostly focused on assessing and monitoring land use (Endo et al., 2017; Mialhe et al., 2015) and landslide hazard (Alejandrino, Lagmay, & Eco, 2016; Oh & Lee, 2011; Opiso, Puno, Alburo, & Detalla, 2016). In this regard, the potential of PGIS in mapping flood and storm surge has not been sufficiently addressed. Hence, this study aims to integrate both community mapping and open-source GIS to maximize people's knowledge in determining hazards and reducing their vulnerabilities as a coastal municipality. Reliable findings can be obtained by ensuring that the data collected through PGIS represent the technical knowledge of carefully selected research participants from the community (Akbar, Flacke, Martinez, Aguilar, & van Maarseveen, 2020; Haklay & Francis, 2018). Moreover, the reliability of local spatial knowledge as basis for generating rich and valuable information cannot be put into question since this type of knowledge "embodies generations of practical essential knowledge, and it operates in interactive, holistic systems" (McCall & Minang, 2005, p. 343).

As the study considers the preceding statements, objectives were laid out to explore the coastal village residents' perceptions of climate change impacts and integrate these perceptions to GIS-based information. The information includes qualitative data such as participatory mapping data and interview responses concerning the residents' perceptions and experiences of natural hazards. These data are then incorporated into a GIS. Specifically, this study seeks to describe the climate-related hazards experienced by the residents, identify how they perceive their vulnerabilities toward climate-related hazards, identify the adaptation strategies they use in responding to climatic impacts, and map each village based on their experiences and perceptions of their PGIS facilitates equitable participation and engagement of local people in the conduct of scientific research. It also contributes to the limited body

of literature concerning the qualitative study of climate change adaptation by employing both participatory GIS and thematic network analysis. Moreover, the maps that will be generated from this study will further facilitate appropriate actions from the residents to address their vulnerabilities and exposures to natural hazards. These maps can also help local government units and even the private sector and non-government organizations in terms of enhancing their operations as regards the provision of services during and immediately after the occurrences of hazards.

Study area

This study was carried out in three coastal barangays or villages, namely, Taliptip, Bambang, and Perez, in the municipality of Bulakan (Figure 1a), province of Bulacan, Philippines (Figure 1b). The villages are situated in the southern part of the Central Luzon region, comprising a total land area of 43 km^2, i.e., 27 km^2 in Taliptip (Office of the Barangay Council of Taliptip, 2016), 15 km^2 in Bambang (Office of the Barangay Council of Bambang, 2016), and 1 km^2 in Perez (Office of the Barangay Council of Perez, 2019). These coastal areas border the northeastern coast of Manila Bay. Each village is subdivided into *purok* or *sitio*, which are small administrative units or districts. Majority of the land areas are devoted to agriculture, livestock, and aquaculture. The villages' total population was 21,475 in 2015, accounting for about 28% of the municipality's population (Philippine Statistics Authority, 2015).

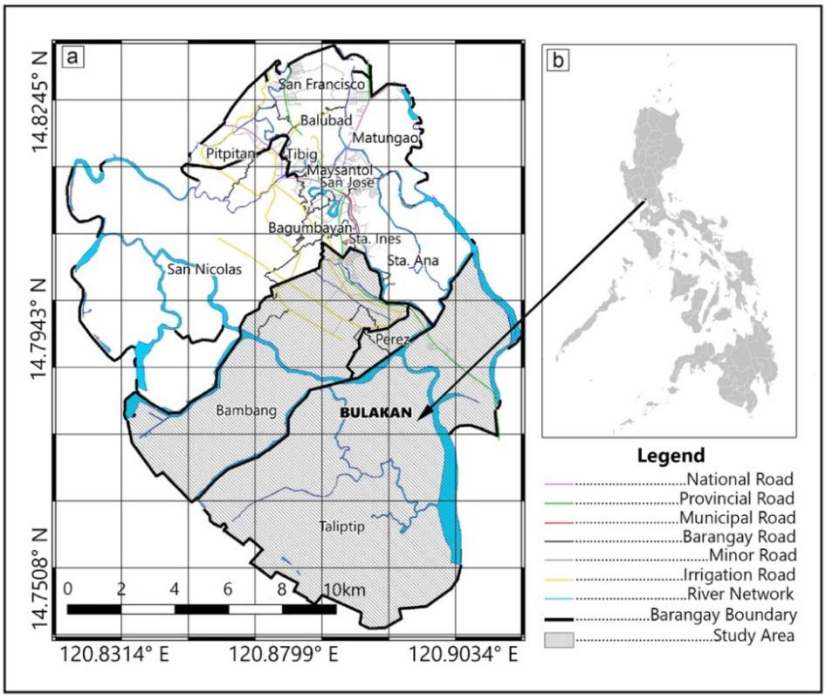

Figure 1. Map of the study area (a). From "Road Network Map: Municipality of Bulakan," by Municipal Planning and Development Office, Province of Bulacan, 2019. Copyright 2019 by the Municipal Planning and Development Office. Map of the provinces of the Philippines (b). From "Blank Map - Philippines," by M. Gonzalez, 2009 (https://commons.wikimedia.org/wiki/File:BlankMap-Philippines.png). In the public domain.

According to the Provincial Government of Bulacan (2014), the villages experience extended periods of tidal flooding caused by an estimated 7 mm rise in sea level annually. The villages are also identified as the coastal areas in the province that are most prone to the high level of susceptibility to flooding and storm surges. Furthermore, the report states that seasonal temperature in the villages and throughout the province is likely to increase by 0.9 °C – 1.0 °C by 2020 and 1.7 °C – 2.1 °C by 2050. Seasonal rainfall change is also likely to increase by 12.8% in 2020 and 23.6% in 2050 during the rainfall during the southwest monsoon (June–July–August) season.

Within the last two decades, the villages have been hit by extreme weather events. The coastal communities were severely affected by the onsets of typhoons Ketsana (locally known as Ondoy) in 2009, Nesat (Pedring) in 2011, Haiyan (Yolanda) in 2013, and Rammasun (Glenda) in 2014 (Catane et al., 2019; Office of the Barangay Council of Bambang, 2016; Office of the Barangay Council of Perez, 2019; Office of the Barangay Council of Taliptip, 2016). The typhoons caused massive flooding and storm surge, damaging housing and agricultural properties. The reports also stated the occurrence of torrential rainfall brought by the southwest monsoon in 2012, which also resulted in severe flooding and even storm surge in the villages.

Materials and methods

This study utilized a combination of methods to explore the residents' perceptions of climate-related risks (Figure 2). Results drawn from the participatory mapping exercises were triangulated with those from focus group discussions (FGDs), key informant interviews, and document analyses. Purposive sampling was utilized in selecting the participants for both participatory mapping exercises and FGDs. A total of 33 participants were recruited, and they were composed of village council leaders, women health workers, parent leaders, disaster risk reduction and management members, agriculture group leaders, farmers, and elderly members of the community.

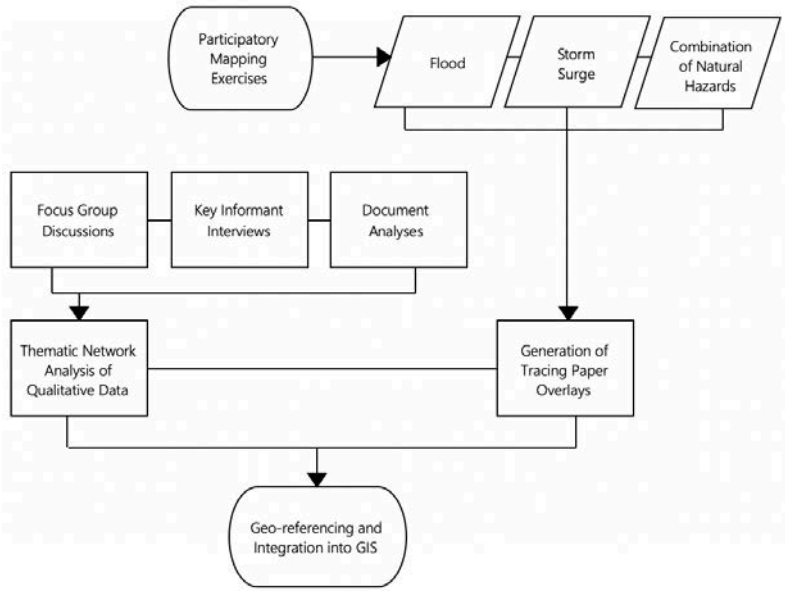

Figure 2. Flow chart of methodology.

For each mapping exercise, the participants were tasked to work on an enlarged copy of the village map (i.e., base map) generated from Google Earth. Moreover, an image of the map was projected on the wall and zoomed in so that the participants would have a more accurate and detailed view of the villages' geographic features. Each of the participants was given coloring materials, which they utilized for marking specific climate-related hazards that occur in their village. In this regard, they were asked to put markings on a tracing paper overlaid on top of a base map. Three overlays were each assigned a hazard, namely, flood, storm surge, and other natural hazards (a combination of hazards). These hazards were initially identified by the Municipal Planning and Development Office of Bulakan as the foremost risks experienced by the residents.

Immediately after conducting the mapping activity, an FGD was carried out with the participants from each village. Two researchers facilitated the discussion. One served as the FGD facilitator, and the other one acted as the assistant facilitator. The FGD started with a brief discussion of the objectives and setting of expectations. The whole discussion, which was recorded using a smartphone, was organized around a semi-structured interview guide consisting of open-ended questions that focused on the following: (1) climate-related hazards they commonly experience, (2) specific populations in their village that are most vulnerable to climate change, (3) adaptation practices that should be carried out by the village's residents, and (4) observations and perceptions of climate change and its effects. The whole discussion was recorded using a smartphone and took approximately one hour.

Key informant interviews were also conducted with village, municipal, and provincial officers. These included interviews with village council members, municipal agriculturists, planning and development heads, and provincial environment and natural resources officers. Each interview was facilitated using a semi-structured interview guide consisting of the same open-ended questions used in the FGD. This was done to triangulate the collected information from the participatory mapping exercises and FGDs. Prior to the study's formal conduct, permission was sought and obtained from the municipal and village authorities. Participation in every phase of this study was voluntary. All participants gave their written and verbal consent after the details of the research objectives, data gathering procedures, and ethical issues had been explained to them.

This study employed document analyses of the Barangay Disaster Risk Reduction and Management (BDRRM) plans of the three villages to supplement the qualitative data obtained from the FGDs. Among the crucial information included in the plans were the identified natural hazards in the community, major issues concerning vulnerable sectors of the community (e.g., children, elderly, persons with disabilities), and the village's risk reduction and management plan (Office of the Barangay Council of Bambang, 2016; Office of the Barangay Council of Perez, 2019; Office of the Barangay Council of Taliptip, 2016). The village's administrative council formulated the plans after undergoing series of trainings organized by the Municipal DRRM Council of Bulakan.

The digital recordings of the FGDs and key informant interviews were transcribed. As a preliminary phase in the analysis of the research participants' responses, transcripts were imported into NVivo software. Excerpts obtained from the BDRRM plans were also imported directly into NVivo. The qualitative data obtained from the responses and documents were subjected to coding and thematic network analysis. Following the analytic steps proposed by Attride-Stirling (2001), the construction of a thematic network begins with the organization of themes to determine a specific global theme. A direct outcome of this arrangement is the selection of basic themes that are extracted from the text. Reorganizing the basic themes would then result in the formulation of organizing themes. When organizing themes are clustered together, a global theme finally emerges. All together, these themes can be illustrated as a thematic network. After further exploring

the resulting thematic network, the patterns established through the emerging themes were then interpreted.

In conducting the GIS analysis, the tracing paper overlays were photographed, digitized, and loaded into the open-source software QGIS. Information regarding the locations and the extent of the occurrences of hazards, which were drawn from the thematic network analysis of qualitative data, were also integrated into QGIS. The aim was to triangulate the data obtained from different sources and translate them into hazard-related values that can be georeferenced to the maps.

Results

Participatory GIS for climate change adaptation: a thematic network

As a final thematic network, the global theme comprises seven basic themes and four organizing themes, as illustrated in Figure 3. The dominant organizing themes, which will be discussed in the succeeding paragraphs, are the following: vulnerability conditions, climate change awareness and perceptions, risk awareness, and risk perceptions.

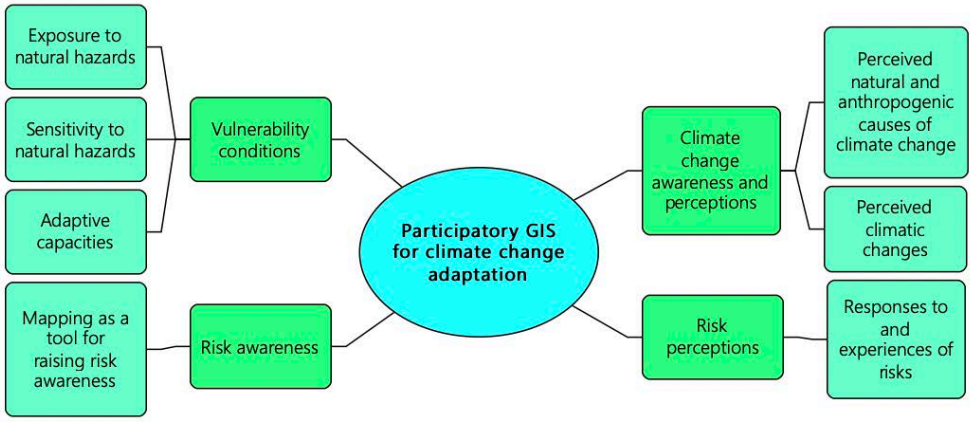

Figure 3. The thematic network of participatory geographic information system for climate change adaptation.

The analysis of vulnerability conditions revealed three basic themes, namely exposure to natural hazards, sensitivity to natural hazards, and adaptive capacities.

Exposure to natural hazards

All participants reported that they were exposed to natural hazards such as flooding caused by typhoon, storm surge, and high tide. They mentioned that when typhoon-driven flooding coincided with high tide, flooding became severe in most areas in their villages. Floods would usually last from days to weeks. They recall that during the onset of typhoons Ketsana in 2009 and Haiyan in 2013, low-lying areas in their villages were inundated by floodwater that lasted two weeks. One participant recalled: "Our house was included among those that were submerged in floodwater. Inside our house, floodwater reached knee-depth during typhoons Ondoy and Yolanda" (Participant 3, Bambang).

During the typhoon season (June to November), residents would typically expect flooding after heavy rainfall, with water levels reaching neck-depth. In the mapping activity, the villages' low-lying areas were colored with a darker shade by the participants to indicate the worst flooding level. A case in point is shared by the participants who reside in Umbuyan, a zone located in Perez. They noted that the torrential flooding that came from the nearby fish ponds and river reached the residential areas and forced people to leave their houses.

As echoed by the key informants, flooding was a commonly occurring hazard in the three villages. High tide flooding was particularly perceived as the primary cause of inconvenience for the residents for a short period. Another source of frustration was high-level flooding, which resulted from heavy rains spawned by typhoons and combined with high tide flooding.

The connection of the municipality to the river channel also inundated villages lying in high-elevation areas. Hence, flooding outcomes could become even worse in areas located in flood plains. The municipal planning and development head explained that flooding could occur in 10 of Bulakan's 14 villages because of the proximity to the river network. He added that floodwater could also originate from nearby towns. An informant from the provincial environment and natural resources office also identified the opening of dams' spillway gates when having to release excess water as another key reason for extreme flooding: "Excessive flooding contributes to the release of water from Angat Dam or Ipo Dam, which causes the spillover of flooding in lowland areas."

An examination of the maps shows differences in identifying hazard-prone areas as perceived by each group of participants. The mapping activities revealed that almost all areas of Bambang and Taliptip were perceived to be exposed to flood risk (Figure 4). This observation was expected because the two villages are the only coastal areas in the municipality that border the Manila Bay. Hence, the mapping activities indicated that the high-risk, flood-prone zones were mostly located in both villages' southernmost and northernmost parts. However, the participants from Perez perceived that only the northernmost part of their village, where the residential areas are mostly located, was prone to flood.

In terms of the areas highly affected by the storm surge (Figure 5), the participants from Bambang and Taliptip recognized their storm surge exposure. The map for Taliptip indicated that a vast majority of the areas were at high risk of storm surge. However, the participants from Perez did not indicate actual risks associated with storm surge. During the participatory mapping activity, they mentioned that their village did not experience the storm surge reaching far inland from the coast. They added that they had already elevated the roads and upgraded fishpond dikes in order to reduce the storm surge and tidal flooding risks. The mapping activities also revealed the threats caused by the combination of flooding brought by typhoons and high tide (Figure 6). This observation was further reiterated in the FGDs, where the participants from Bambang and Taliptip indicated the high risk of experiencing such a combined form of natural hazard. Moreover, the participants from Perez consistently stressed the exposure of the northernmost areas of their village to the said hazards' threats.

The participants' observations were aligned to those identified in the BDRRM plans. The natural hazards were categorized in extreme weather events, flooding, and storm surge. The plans also recorded typhoons Nesat in 2011 and Rammasun in 2014 as among the most destructive natural events to hit the villages in the past decade (Office of the Barangay Council of Bambang, 2016; Office of the Barangay Council of Taliptip, 2016). The southwest monsoon that occurred in 2012 was also identified as a prominent disastrous event.

Sensitivity to natural hazards

The majority of the participants cited that the natural hazards they experienced in their villages had disproportionately affected children, daily wage earners, and the elderly. In particular, children were perceived as the most vulnerable segment of the villages' population that were most likely to suffer from adverse impacts such as getting infected with water-borne diseases and experiencing the disruption of their schooling. As shared by a participant: "Sometimes, we experience prolonged flooding. This situation is frightening, especially knowing that children are prone to water-borne diseases like leptospirosis" (Participant 8, Perez). Natural hazards were perceived to have a detrimental impact on the livelihood of daily wage earners. The participants noted that individuals who work in the agriculture, construction, and transport sectors could not provide for their families because of their inability to go to work when faced with natural hazards. The well-being of the elderly during the onset of disasters was also highlighted by a few participants, who noted that they should be prioritized during rescue operations.

The participants identified the proximity to water bodies and housing quality as factors affecting the vulnerability of specific population segments in their villages, with some participants admitting that their families belong to such groups. Most of the hazard-sensitive residents live in low-lying areas located near water bodies. Poor-quality housing, coupled with the house's low-lying elevation, also contributed to hazard sensitivity. Dwellings, particularly those located in the coastal wetlands, were made with either lightweight construction materials or concrete bricks.

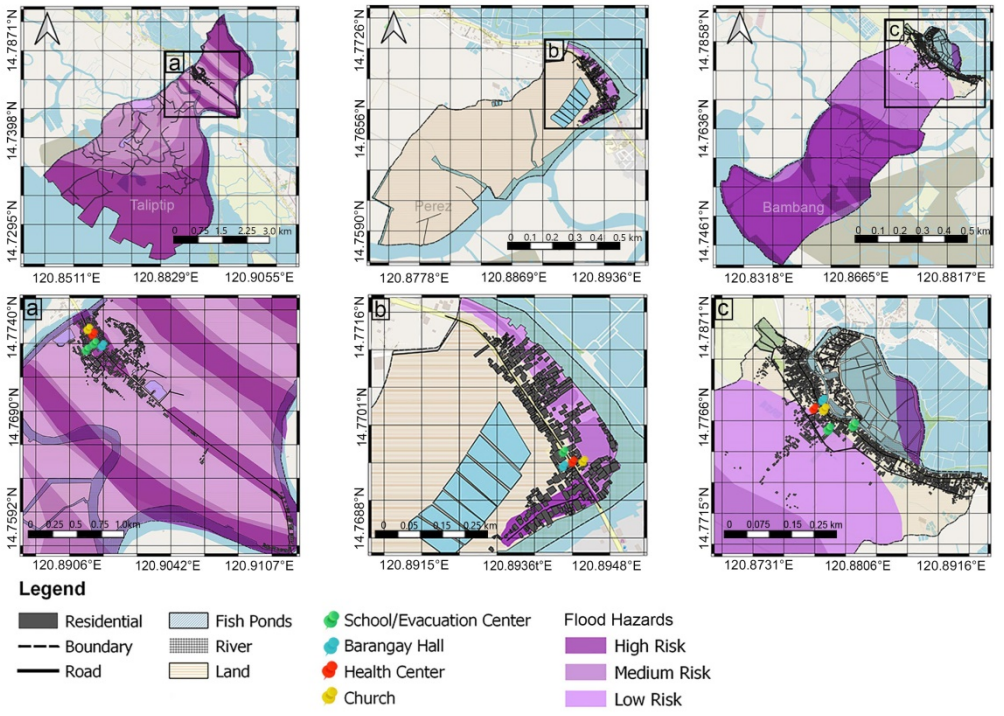

Figure 4. Exposure of Taliptip (a), Perez (b), and Bambang (c) to flood hazards according to the mapping exercise.

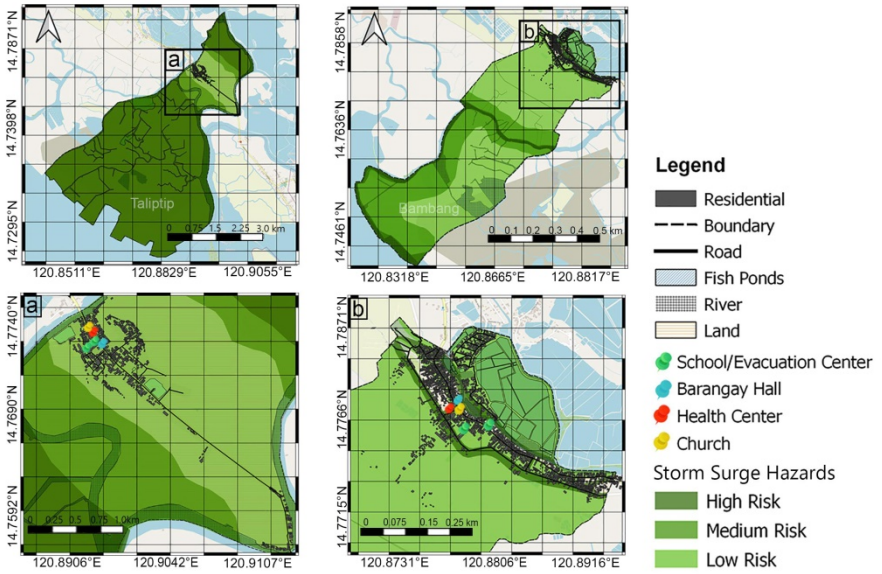

Figure 5. Exposure of Taliptip (a) and Bambang (b) to storm surge hazards according to the mapping exercise.

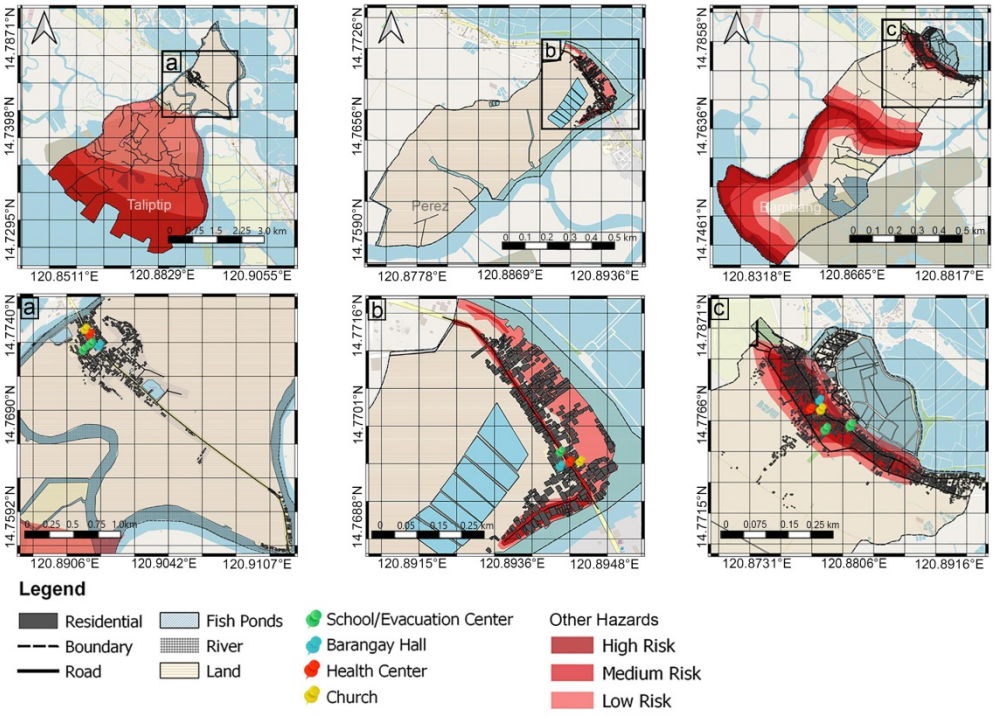

Figure 6. Exposure of Taliptip (a), Perez (b), and Bambang (c) to combination of flooding due to typhoons and high tide according to the mapping exercise.

The informants also highlighted the contribution of the villages' low elevation and their proximity to water bodies to resident vulnerability. They noted that the villages' geographic features created vulnerability to flooding, which mainly affects families who are dependent on farming and fishing practices for subsistence. These families had been living near hazard-prone areas for a long period and, thus, were left with no choice but to bear the adverse impacts of the hazards on their livelihood. A village official from Bambang shared: "Residents who live a hand-to-mouth existence, especially those who live in the coastal area and till land near the river, are mostly affected. These are the only places they know where they could reside because they could not afford rent."

The proximity to water bodies, particularly to the bay, river, or ponds, was perceived to be a significant factor for the villages' sensitivity to natural hazards. For instance, Taliptip's participants pointed out in the mapping exercises that most of the residential areas were near water bodies that turned out to be sources of floodwater (Figure 4, 5, and 6). In their mapping outputs, the participants from Bambang highlighted the proximity of their village to coastal and inland water bodies as the foremost contributing factor to their vulnerability (Figure 4, 5, and 6). Based on the maps they produced, the participants from Perez still recognized the negative consequence of residing near the river and fish ponds despite acknowledging that only the northern portion of their village was vulnerable to natural hazards (Figure 4, 5, and 6).

Similarly, as identified in the BDRRM plans, sensitivity to natural hazards could be attributed to the vulnerable population, proximity to water bodies, and low-lying areas in the village. Aside from the children and elderly, persons with disabilities and agricultural households were specified as high risk to natural hazards. The plans also marked shallow river channels, drainage canals, and poor soil quality (i.e., loose and saturated soil) as the villages' key vulnerable geographic features (Office of the Barangay Council of Bambang, 2016; Office of the Barangay Council of Perez, 2019; Office of the Barangay Council of Taliptip, 2016).

Adaptive capacities

Several adaptive capacity measures were highlighted by the participants as preparation and response to climate-related hazards. Each village has a well-organized DRRM unit composed of local officials and volunteers. The participants noted that the DRRM unit had been responsive to natural hazards' impacts, from alerting the village of evacuation and disaster preparedness orders to providing relief assistance. A sense of preparedness was perceived to have been created among the residents with the implementation of a disaster risk reduction plan. As illustrated in this narrative: "As a volunteer and member of the village council, we really stay alert whenever we hear news about a typhoon. Even with just a few drops of rain, the village councilor, chairman, and volunteers do the village rounds to prepare the residents. We then must raise the first alarm. We also evacuate them from their houses and bring them to the school (which serves as the village's evacuation center). The volunteers also serve as guards in the evacuation area. We are responsible for getting the list of evacuated families" (Participant 5, Perez).

At the household level, some participants reported that there were families who had their houses elevated. This was a common adaptation strategy among families living in areas that are prone to seasonal flooding. It had become an inevitable response after road elevation projects were implemented to address the rise of flood levels. Houses which were once above the road level became inundated by water overflowing from the elevated roadways. To protect their properties from being damaged by floods, some households had no choice but to spend for the elevation of their houses, making sure that the lowest floor would be above the flood level.

The informants confirmed the local village councils' measures in responding to community needs during and after the occurrence of hazards. Concrete measures ranged from implementing an evacuation plan to delivering immediate relief assistance. As shared by a village official from Bambang: "When our area is placed under typhoon signal no. 1 (weather disturbance expected in 36 hours) or 2 (weather disturbance expected in 24 hours), we immediately call for a meeting that would also include our front liners, like mother leaders, health workers, and village-based police officers. We determine the need for relief goods and evacuate the residents to our elementary school."

Most of the strategies indicated in the BDRMM plans and implemented by the villages in responding to the impacts of climate-related hazards were highlighted by the participants and key informants. These village-based measures included the implementation of disaster risk reduction plans, a sense of preparedness among residents, clean-up drives, access to local authorities' services, implementation of a community evacuation plan, availability of a team of volunteers, and provision for relief assistance.

Risk awareness

The mapping activity served as an avenue for the participants to be more familiar with their villages' geographical features. A common observation of each focus group during the activity was that each of their villages covers an area much more significant than expected. This observation was reiterated by five participants who noted that it was their first time to see where particular areas in their village were located, specifically those near the coast. One of them shared: "We were able to learn about the extent of flooding in each area of our village. We were also able to see that fish ponds and farmlands occupy a larger portion than the residential areas" (Participant 11, Bambang).

Six participants acknowledged that the mapping exercise contributed to raising awareness of the present and future risks, and they suggested prioritizing the coastal areas, which were mostly affected by hazards in their villages. They highlighted the importance of prioritizing the welfare of vulnerable populations living in such areas and explicitly noted the provision of help from the local government. According to five participants, hazard maps are beneficial in planning for risk reduction. They agreed that village officials and residents could quickly determine safe areas for evacuation and prioritize specific areas for rescue operations by utilizing the maps. As one participant said: "The importance of mapping is that we saw the particular areas in our village that should be given priority, especially those households that should be given help and evacuated when flooding occurs" (Participant 1, Bambang).

When asked about the significance of carrying out a mapping activity in each village, the informants shared most of the participants' views. They perceived the production of maps as a tool to determine hazard-prone areas that residents should avoid. Maps were also perceived to be beneficial for emergency evacuation planning. An informant said the following: "In doing each map, we can determine the area that poses a danger. We can identify that a particular area is low-lying. We can then give precautionary measures to residents living there to evacuate to higher ground, especially during the onset of heavy rainfall and flooding" (Municipal agriculture officer).

Risk perceptions

The participants' exposure to natural hazards such as floods and storm surges brought serious concerns to their livelihoods. Significant reasons for concern revolved around the probability of losing their properties and livelihood, contracting infectious diseases, and experiencing injuries and deaths following such hazards.

More than half of them reported that earning a livelihood was difficult and most often impossible during hazards, especially among families that rely on members who were daily wage earners. Nine of them were aware of how natural disasters could result in outbreaks of water-borne diseases. Seventeen participants answered that they were concerned about their well-being, noting that lives and properties could be put at risk during increased flooding. These concerns were evident in the following statements: "I fear that my husband would lose his job. He is a construction worker. Whenever there is a typhoon, he could not go to work, and we would not be able to eat. I also worry about my children getting sick. I am also unable to work as a seamstress because my sewing machine is submerged in floodwater. There is no source of income" (Participant 3, Bambang).

The informants also stressed the risks experienced by vulnerable community segments. They noted that families who merely relied on agriculture-based activities experience lost productivity and financial losses during disasters. For instance, some fisherfolk would attempt to brave the typhoon. However, the risk of the impending danger would force them to stop their fishing activities. Meanwhile, fish pond or farmland owners and workers had to endure the losses arising from the washing out of agricultural resources during massive flooding.

Another concern is centered around the predicament of public transport workers who had to halt their operations because of flooded streets. For tricycle and jeepney drivers, who serve as the only transport service providers in the villages, this would only mean that they could not provide for their families' daily needs. As explained by a village official from Bambang, flooded and impassable roads caused by typhoons would already have a detrimental effect on their only livelihood source.

Natural hazards were also perceived to pose a danger to families residing near water bodies. The informants specified that children and the elderly were most likely to contract diseases such as dengue, cholera, and skin infections. Two informants mentioned that residents were also at high risk of drowning and snake bites, and they noted that such incidents had already been recorded.

Climate change awareness and perceptions

Most of the participants shared that they had been observing and experiencing the worsening effects of climate change. They noted that the severe flooding occurring in their coastal villages had been caused by climate change. They also believed that increased occurrences of extreme weather events are likely to exist in the future. Such adverse effects were perceived to be of great concern, especially for participants who were living in low-lying areas: "In the past, we did not experience severe flooding. When we were still kids, we would usually play in dried fish ponds. Now, children could no longer play there because the fish ponds are always submerged. The river is also overflowing with water, and that is because of climate change." (Participant 8, Perez).

The participants also observed the occurrence of shifting seasons. The unusual increase in rainfall during the dry season and less rainfall during the wet season were the significant changes that they believed to have been caused by climate change. This observation was captured in these verbalizations: "For the longest time, we have been aware of the changes happening in our climate. The wet season becomes dry season. The dry season becomes wet season. We no longer know when rainfall would occur. Even if it is the dry season, there are still typhoons" (Participant 7, Bambang).

The informants had the same observations as those of the participants. The unpredictability and uncertainty of climate conditions were their critical perceptions of climate change. Increased temperature, sudden rainfall, grass fires, high-level flooding, and the frequency of severe typhoons were what they recognized as climate change manifestations. Hence, a municipal agriculture officer

remarked: "We cannot prevent climate change. What we can only do is to take actions to slow it down. Extreme heat is affecting animals and humans. Crops are also affected. Due to the uncontrollable rise of sea levels caused by climate change, our communities are slowly being submerged, causing damages to our properties and livelihood."

Less than half of the participants also pointed out that open-waste burning is to be blamed for exacerbating the effects of climate change. Because of improper waste disposal, this household practice had become widespread in every village. Three participants even identified open-waste burning as responsible for the depletion of the ozone layer. Hence, one of them argued: "We have to stop burning our waste because it is a factor of the depletion of the ozone layer" (Participant 8, Perez). For the informants, human activities such as improper waste disposal and deforestation should also be blamed for climate change. As remarked by an environmental officer: "Our lack of compassion for the environment prevented us from seeing the effects of our actions, which have resulted in the increased amount of gases or what we call the 'greenhouse effect'."

Discussion

The results of this study indicate that residents are vulnerable to climate-related hazards. Their exposure to natural hazards was inevitable because of the proximity of the villages to water bodies. In particular, the findings show that residents from Bambang and Taliptip were mostly affected by natural hazards. Consistent with Catane et al. (2019) hazard assessment of the coastal communities of Bulakan, locals from both villages were found to be prone to repeated exposure to flooding and storm surges. Moreover, historical occurrences of typhoons and the southwest monsoon are parallel with the hazard assessment findings, in which these extreme weather events further exacerbated the occurrence of hazards (e.g., the southwest monsoon in 2011, Nesat in 2011, and Haiyan in 2013). As previously found out by Esteban et al. (2017), residents in coastal settlements are exposed to high incidents of hazards such as coastal flooding and flash flood, which caused areas to be submerged in meters of floodwater. Evidently, the residents' coastal location directly contributes to a higher chance of encountering hazard-related events, which have become common (Kellens, Zaalberg, Neutens, Vanneuville, & De Maeyer, 2011; Mukhopadhyay, Dasgupta, Hazra, & Mitra, 2012).

The sensitivity of specific populations to natural hazards was also well recognized by the participants within the context of social vulnerability. In this study, children and elderly residents comprised the villages' vulnerable population mainly because of health risks. As a result of their exposure to flooding, they had to live in unsafe conditions that adversely affected their livelihood and living conditions. As observed by Tauzer et al. (2019), sensitive populations are most likely to suffer from increased risk of infectious diseases caused by mobility limitations and lower immunity levels. Low-wage income earners were also perceived to be socially vulnerable because of limited opportunities for labor during disasters. Mavhura (2019) noted that these earners further encounter problems in accessing basic needs and services because of the threats of natural hazards.

As they had recognized their exposure and sensitivity to natural hazards, the residents undertook measures to strengthen their adaptive capacity. The village council, particularly its BDRRM unit, played an integral role in providing disaster response services and mobilizing community volunteers. The implementation of a local ordinance was another indication of a local-level ability to improve adaptation. These measures identified in the study reveal that adaptive capacity can be shaped by an enabling environment facilitated by institutions and governance (Adger et al., 2007; Bukvic, Rohat, Apotsos, & de Sherbinin, 2020; Engle & Lemos, 2010). They highlight the role of community-level

governance in influencing adaptation actions. As argued by Tauzer et al. (2019), the empowerment of both the coastal community leaders and the residents to utilize their knowledge and skills is crucial in enhancing their local capacities to respond to natural hazards.

With the generation of hazard maps by the participants themselves, it becomes apparent that they acknowledged the presence of risks in their immediate environment. This finding indicates that personal experience can be a basis of risk perception. As revealed in their accounts, the participants associated risk with concerns about the negative consequences of hazards. Fear and anxiety were likely to be exhibited after they considered themselves as vulnerable to the uncertainties of being exposed to hazards, like contracting infectious diseases and losing their lives, properties, and livelihood. Hence, the participants were aware and not in denial of the risks. Despite their proximity to areas prone to natural hazards, the participants seemed to be accustomed to braving adverse consequences. As Bankoff (2003) explained, because of constant exposure to the threats of disasters, the Filipino culture has embraced the "normalization of threat" through indigenous coping mechanisms adopted at the community level.

Undoubtedly, such experiences and perceptions of risks and uncertainties could be linked to how participants view climate change. As advanced by Granderson (2014), communities frame climate change based on their lived experiences, which could largely depend on their localized exposure to risks. In the three coastal villages, the residents associated their encounters with flooding, extreme weather events, and extreme seasonal patterns to the increasing impacts of climate change. These direct experiences allowed them to make sense of climate change as a current and future threat. It should also be pointed out how their understanding of climate change leaned toward its conceptualization as a human-induced phenomenon. The participants specifically identified open waste burning, which they directly linked to poor waste disposal practices, as the principal anthropogenic activity that largely contributed to climate change. Similarly, Codjoe, Owusu, and Burkett (2013) found that burning of waste materials and firewood as well as deforestation were perceived by community members to be the dominant factors affecting climate change. Cogut (2016) and Reyna-Bensusan (2018) maintained that the uncontrolled yet common practice of open waste burning in rural communities contributes to air pollutant emissions.

Conclusion

This research set out to explore community-level perceptions and experiences of climate change impacts and adaptation. Using PGIS as a tool for facilitating the production of in-depth data from residents living in coastal villages, this study has generated dominant themes on climate change adaptation. It has shown that coastal residents are exposed to recurrent phenomena of natural hazards. Exposure to such hazards has revealed major sensitivities, which are driven mainly by the presence of vulnerable population groups and associated with the villages' geographic features.

Coastal residents have undertaken concrete measures to enhance adaptive capacities because of their awareness and understanding of their vulnerabilities. Such measures are mostly anchored on the disaster risk reduction management plans formulated at the local level. Through their active engagement in the mapping exercises, they have become more aware of the risks associated with the occurrence of natural hazards. The resulting hazard maps also reveal the uncertainties in the context of what they perceive as risks posed by natural hazards. Overall, the residents' perceptions and experiences are framed within their conceptualization of climate change as an on-going and future threat.

This study has demonstrated the value of integrating local knowledge into the mapping process, which offers relevant data on natural hazards, risks, and vulnerabilities at the community level. It has also reinforced the idea that utilizing local knowledge in climate change adaptation can empower community members to visualize their knowledge. It is in this context that PGIS has the potential to stimulate discussions, especially within a setting where participants fully understand the risks they face and the actions they need to undertake to adapt to the changing climate conditions.

The findings offer policymakers opportunities to consider how participatory mapping can complement local adaptation efforts. After all, the community members are in the best position to communicate climate-related information crucial for identifying the most appropriate actions toward adaptation. Thus, their active involvement in the decision-making process becomes an opportunity to build their capacity to adapt to the changing climate conditions. In adopting participatory methods for entirely utilizing a bottom-up planning process, the need to closely coordinate and work with the different village-based sectors should be underscored.

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