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Potential in-Situ Adaptation Strategies for Climate-Related Sea-Level Rise: Insights from a Small Island in The Philippines Experiencing Earthquake-Induced Land Subsidence

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Abstract

In October 2013, a 7.2-magnitude earthquake struck the province of Bohol, Philippines and induced land subsidence to some of its small island communities, causing them to now experience over-flooding during normal spring tides. The present research discusses the recovery experience and adaptation strategies of one of these island communities, Isla Batasan, which suffers from knee-level, complete inundation during +2.0m high tides. The results indicate that, although the local government is encouraging Isla Batasan residents to relocate to the mainland via a government-funded permanent relocation program, residents have preferred to remain on the island due to concerns regarding livelihood opportunities. Instead, residents have initiated a self-help approach to flood risk management via raising the floors of their homes, school, church and road in the island. However, if not properly supported, such efforts may inadvertently lead to other problems, such as environmental degradation due to the use of coral stones as materials for raising floors. As the practical flooding effects of earthquake-induced land subsidence and climate-related sea-level rise are the same, these findings from Isla Batasan suggest that residents of low-lying island states will probably also initially learn how to live with floods rather than immediately relocate, especially if the relocation scheme does not suit their needs.

Keywords: *sea-level rise; climate change adaptation; flood risk management; living with floods; island communities*

1. Introduction

According to the 5th Assessment Report of the Intergovernmental Panel on Climate Change [1], the average projected climate-related sea-level rise globally at the end of the 21st century would be between 0.28 and 0.98m. Due to this, recent literature has explored the possibility of entire Atoll Island States becoming completely permanently inundated, and their populations being displaced [2].

Migration is not an entirely new concept [3], especially for Atoll Island States. However, given the slow onset of climate change, it is difficult to fully appreciate the extent to which the decision to migrate is influenced by climate-related changes or by other socio-economic factors [4] and, consequently, to determine whether the populations affected could be protected by international law [5]. Also, it is important to note that historical migration patterns have not yet reached the level which is being predicted by some in literature [6], and thus all discussions on mass migration are mainly happening at the conceptual level.

Another common criticism of the mass migration theory is that the proposed direct causal relationship between mass migration and climate-related sea-level rise has not been explicitly demonstrated, and instead has only been based on "common sense" [7]. In particular, the theory tends to emphasize environmental factors as the primary factors that affect the decision to migrate, thus reasoning that if sea-level rise will result in complete and permanent inundation, salt water intrusion and greater storm surge penetration, among others, it will ultimately lead to mass migration. However, other studies have highlighted the importance of social factors as well [8].

The only existing case study that outlines actual human adaptation strategies to relative sea-level rise has demonstrated a more complex process and cause-effect relationship. Gibbons and Nicholls (2005) conducted a historical analysis of the experiences of a community in Holland Island, Chesapeake Bay, USA [9]. Sea-level rise in Chesapeake Bay began after the Little Ice Age ended in the 1850s, and was further accelerated by groundwater extraction and sediment loading [10]. In particular, Holland Island experienced a net sea level increase of 0.2m between 1850 and 1920, which resulted in a 89% loss of land by 1989 . When the upland ridges where most of the population resided gradually became flooded, the community began to relocate to higher grounds within the island.

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However, they eventually ran out of land available for relocation, prompting some families to begin leaving the island. After their church, school and stores closed in the 1920s, what was left of the community finally decided to abandon the island – even before it became physically uninhabitable (37% upland loss by 1901, 89% by 1989).

This case study indicated that, rather than immediately migrating as a result of sea-level rise, the community first tried to adapt in-situ. The study also suggested that social factors could indeed play an important part in the decision when to finally relocate. Similarly, Warner, et al (2009) documented the migration of about 3,000 Tuvaluans to Auckland, New Zealand as a result of uncertainties about the future, rather than actual environmental concerns [11].

However, some studies warn against the inevitability of climate-related mass displacement, considering the number of other adaptation solutions already available, such as voluntary labor mobility [12,13] and the fact that the disappearance of islands depends more on the continuity of supply of coral debris from the coral reefs than on sea-level rise [4,14]. Male, the capital of Maldives, has lined its coast with engineering structures and artificial harbors [14]. There is similar anecdotal evidence that residents of the Marshall Islands have built makeshift seawalls for protection against higher sea-levels caused by changing global trade winds, though the connection between this and climate change remains debatable [15]. In addition, at the international level, the COP has established a limited number of mechanisms for financing adaptation measures, although these are not entirely new and additional to already existing development aid [4]. The World Bank has also launched the first multi-country catastrophe insurance pool to help Atoll Island States deal with natural disaster events exacerbated by climate change [11]. Other possible adaptation strategies are also currently being explored, such as coral preservation and transplantation [4].

Still, empirical studies which extensively investigate how small island communities actually pursue adaptation strategies for climate-related sea-level rise remain insufficient. To address this gap, the present research aims to present a case study of an island community that has suffered from earthquake-induced land subsidence and complete inundation during normal spring tides. The case study can serve as an analogy for the effect that climate-change related sea-level rise could have on low-lying islands. As the practical flooding effects of sea- level rise and earthquake-induced subsidence are the same, this study focuses on exploring the human responses to these effects in order to identify possible adaptation strategies. However, the analogy has some limitations due to differences in the rate of change in relative water levels, with earthquake-induced subsidence being an abrupt phenomenon. Essentially, there will also be some differences in the social perspective of the changes (comprehension of the slow or abrupt changes might be different), leading to different outcomes. Nonetheless, it could be argued that tidal flooding following earthquake-induced land subsidence represents a more extreme case than the gradual climate-related sea-level rise most islands are likely to experience.

Being only the second case study on the subject (to the authors' knowledge there is no other documented case regarding small low-lying islands, though the effect of land-subsidence due to earthquakes on large bodies of land has been documented elsewhere [16,17]), this research seeks to address the limitations of the first case study conducted by Gibbons and Nicholls (2005), which was mostly based on census records from the late 19th century and interviews with a small number of former residents [9] that did not allow for a more in-depth investigation of the motivations for developing and implementing specific adaptation strategies. In fact, the study was only able to identify one in-situ adaptation strategy: relocation to higher ground. By investigating the in-situ adaptation strategies of an island community that is currently dealing with flooding during high tides following earthquake-induced land subsidence the present research will challenge many common ideas regarding the inevitability of mass migration.

2. Isla Batasan and the 2013 Earthquake

Isla Batasan is an island community in the Bohol Province in central Philippines (see Figure 1). It inhabits a narrow sandbar that is located a few kilometers offshore from the Municipality of Tubigon, accessible only through an hour-long ride on small motorised boats. The island is approximately 900m long and 50m wide, being surrounded by a 52-hectare mangrove forest, and resting on a large reef flat of about 260 ha [18]. It is currently home to 1,029 individuals, or 256 households [19].

The island is one out of 6 island communities in Tubigon that lie on or near the Danajon Bank, the only double barrier reef in the country and one out of only three in the Indo- Pacific [18]. Given its high marine biodiversity, the bank serves as a major fishing ground in the central Philippines [18]. Due to this, residents of Isla Batasan mainly rely on fishing for their livelihood. They engage in fishing activities throughout the year, including harvesting from fish corrals, conducting grouper culture, gillnetting blue crab, fishing using fish or crab pots, and gleaning [20]. Despite the abundance of marine resources, Isla Batasan remains an impoverished community, ranking eighth amongst Tubigon's 34 communities in terms of the level of deprivation [21]. As of 2010, almost 40% of its households are living below the poverty threshold. In the first half of 2014, this threshold was defined as an average monthly income of PhP8,788 or US$198.6 for a family of 5, covering both basic food and non-food needs [22].

On October 15 2013, at 8:12AM, a 7.2-magnitude earthquake with a focal depth of 12 km struck the Province of Bohol, Philippines. The earthquake caused massive destruction to the province, especially around the Municipality of Tubigon, which is located only about 20 km from the epicenter. Due to reverse faulting, the earthquake

induced land subsidence in Tubigon, including its offshore island communities. In Isla Batasan, the earthquake-induced land subsidence ranged between 0.2 m and 0.7 m (0.4 m on average) [23]. Due to this, the entire island now becomes inundated during spring tides, especially when these reach +2.0m (the highest local high tide level).

3. Methodology

This paper draws its results from data collected by the authors during field visits to Isla Batasan in August 2014 and March 2015, within one and a half year of the earthquake. The authors employed a mixed methodology during these site visits. A household questionnaire survey (n=41, or 16% of all households on the island) was conducted to capture the experiences that residents of Isla Batasan had gone through after the disaster. In particular, the questionnaire asked about the following topics: damage suffered as a consequence from the earthquake, the type of external assistance received, the main challenges to recovery, effects of earthquake on livelihood and willingness to relocate, and demographics. The survey data was analyzed via descriptive statistics, summarizing the results as a percentage of respondents that stated a certain point and refining by cross-tabulation.

To triangulate the results of the questionnaire survey, interviews with local residents and key informants and focus group discussions were also carried out. Individual interviews with island residents were conducted to better understand how to interpret the results of the questionnaire survey, while key informant interviews with local government officials and community leaders aimed to gather information about the government's relocation program and whether this was being welcomed by the island's residents. Two focus group discussions, attended by 5-8 randomly selected residents, were also organized to understand the communities' opinion of the relocation program, and whether they were willing to participate in it and why. Participants were also asked about other adaptation strategies they were implementing. The data obtained from these series of interviews and focus group discussions was qualitatively analyzed, grouping recurrent responses into different themes and comparing conflicting responses from various respondents to elucidate the differences in their perspectives.

Finally, direct site observation, coupled with brief interviews with house owners, was conducted to investigate the different adaptation strategies being implemented on the island.

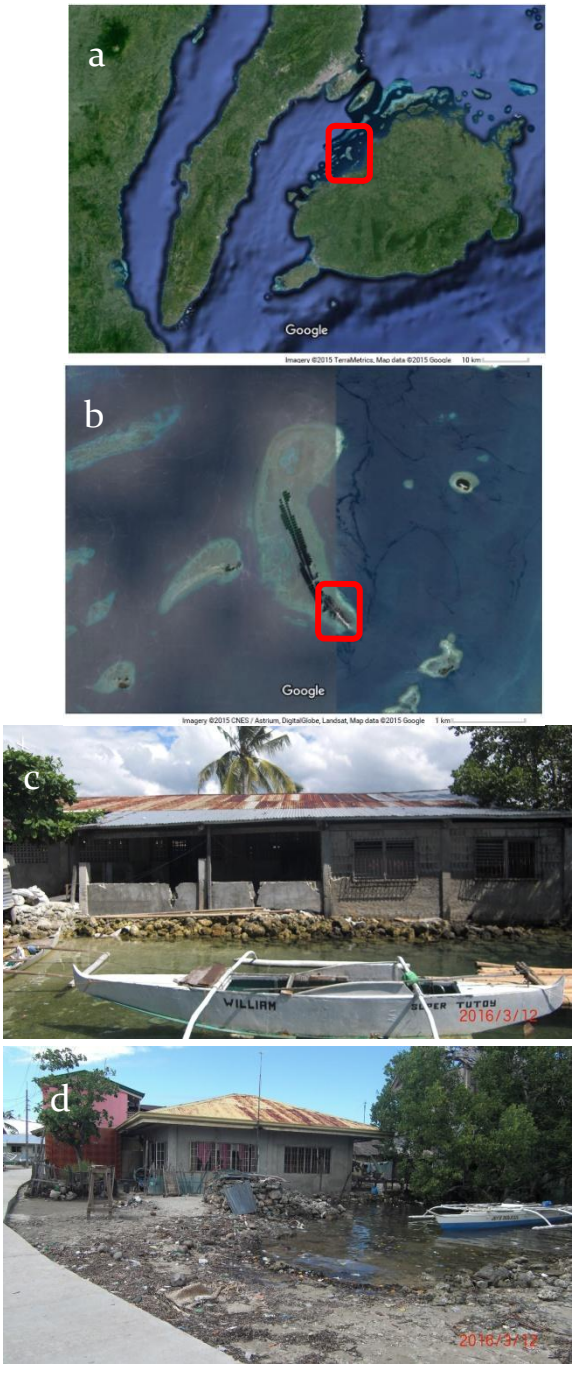


Figure 1 a) Satellite image of Bohol (highlight: Isla Batasan, Tubigon). b) Satellite image of Isla Batasan (highlight: community residence). c) Side view of a local chapel where large cracks formed due to the earthquake. The pile of coral stones on which it was built also became loose and uneven. d) Seawater almost reaching Isla Batasan's main road during a +1.5m high tide.

4. Damages from the earthquake

4.1. Housing Damage

Following the earthquake, the majority of Isla Batasan residents suffered from their houses being partially damaged (73% of respondents), with most of them reporting having experienced flooding (93%) due to land subsidence (59%), as shown on Figure 2a. However, apart from housing damage, residents also suffered losses with respect to their livelihoods (85%) and belongings (41%). In response to these damages, government and non-government agencies provided the residents mostly with housing repair assistance (51%), livelihood training (46%) and house items (39%), see Figure 2b. A housing repair assistance of Php10,000 (USD 215) was provided to house owners who suffered partial damage by the Department of Social Welfare and Development or National Housing Authority through the Municipal Government of Tubigon. The assistance came either in the form of cash or materials, including plywood, nails and GI sheets.

4.2. Livelihood Damage

As mentioned earlier, the livelihoods of the residents of Isla Batasan also suffered due to the earthquake, as shown in Figure 3a. Respondents engaged in fishing (51%), and buying and selling of fish and marine products (21%) suffered a decrease in livelihood performance. Specifically, fishermen reported a general decline in fish catch after the earthquake, as they could not find fish in the areas where they used to. Focus group discussions revealed that this could be mainly attributed to the fact that the earthquake also damaged the island's surrounding coral reefs, with residents observing large cracks and collapsed corals. In line with this, a preliminary site survey conducted by the Marine Science Institute of the University of the Philippines in the neighboring island of Pangapasan observed collapsed and newly exposed reef margins, as well as cracks along the edge of the reef flat [23]. In addition, as the tidal flat also deepened due to land subsidence, gleaners now have a smaller area from which to collect shells and other marine products.

Despite these livelihood damages, survey results indicate that 59% of residents, including both house owners and tenants, do not plan to permanently relocate away from Isla Batasan, with only 24% remaining undecided, as shown by Figure 3b. A key informant residing on the island explained that:

"We do not know any livelihood activity other than fishing. Even if we relocated to the mainland and tried to farm, we would not really know what to do. With farming, we would have to wait months or years to harvest our crops – and even that cannot be guaranteed. But with fishing, we only have to go out to the sea at any time we like. There are always fish to catch."

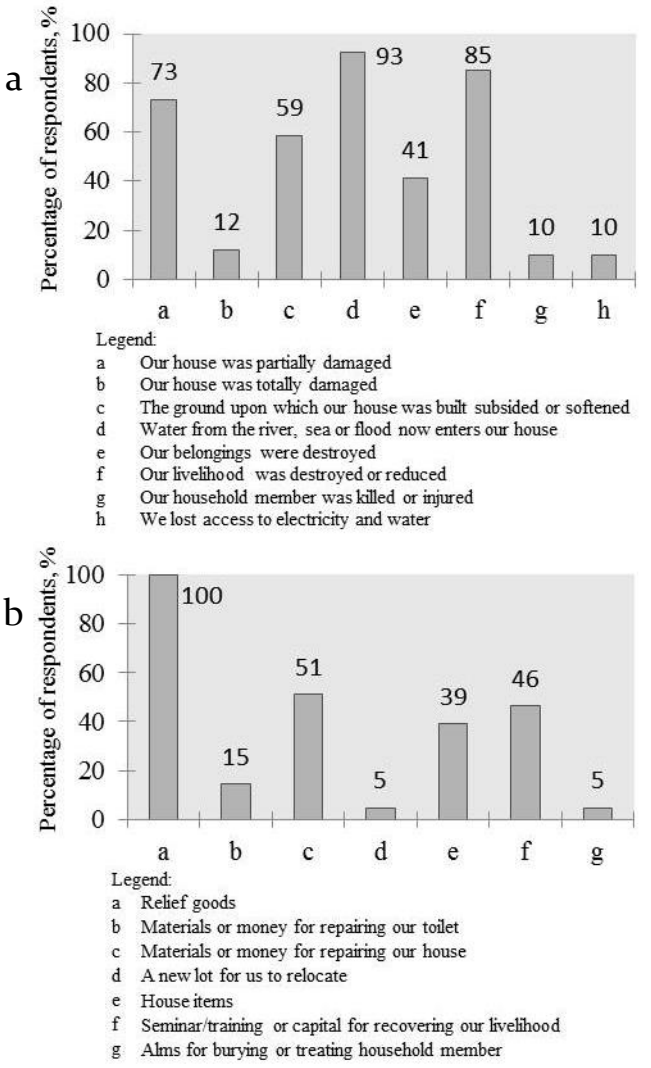
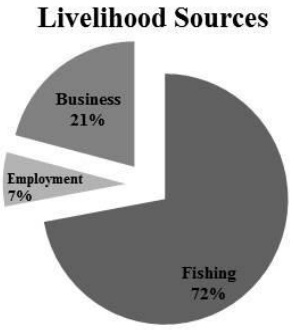


Figure 2 a) Damages suffered and b) assistances received by Isla Batasan residents (n=41). In the questionnaire "softened" was used instead of "liquefaction", given that the respondents were not familiar with the latter term.

On the other hand, to address the decline in fish catch, during a focus group discussion fishermen expressed their determination to find new places where the fish may have migrated, using the small motorized boats that they own. Furthermore, gleaners have begun to teach themselves how to dive in order to gain access to more produce. There is no significant farming in the islands, aside from very small-scale subsistence level vegetable gardening by some residents in their very small backyards. Thus, it is clear that the residents of Isla Batasan plan to remain on the island to continue their fishing-related activities, and are adapting to the changing environmental situation.

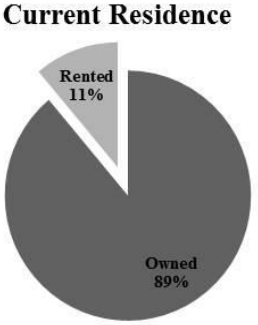
a



Earthquake impact on Livelihood

	Decreased (count)	Lost (count)	Increased (count)	No change (count)
Fishing	21	1	0	1
Business	9	0	0	0
Employment	1	0	0	0

b



Relocation Plans

	Do not relocate (count)	Relocate (count)	Not yet decided (count)
Owned	22	1	8
Rented	2	0	2

Figure 3 Earthquake impact on a) livelihood sources and b) residential arrangements (n=41). The table under figure 3a indicates the answers provided by respondents on the effect of the earthquake on the performance of their livelihoods. The table under Figure 3b shows the residents' willingness to relocate for both house owners and tenants.

4.3. Flooding problems

Prior to the earthquake, seawater only flooded the Lawis (lower end of the island) during +2.0m high tides, and never reached the main road. However, due to earthquake-induced land subsidence, the entire Isla Batasan currently starts to over-flood at around +1.6m high tides, with water levels reaching up to knee-level during +2.0m high tides, according to key informant interviews and focus group discussions. Although flood frequency varies widely with respect to variations in the annual tidal range and local weather, it typically happens at high tides during the new and full moon monthly period, for several days at a time. One flooding episode can last between 30 minutes and 2 hours, depending on the ebb and flow of tides, monsoons, and local effect of typhoons. Flooding takes place during daytime in the Amihan period (north-east monsoon) around May to July, and in the nighttime during Habagat (south-west monsoon) around November to January.

During flooding episodes, sea water enters residents' homes, soaking the floors and belongings, and carrying garbage items and seaweed into the houses. Although the flood level during daytime and nighttime are similar, adaptation becomes significantly more difficult at night due to lack of electricity in the island, which prevents residents from monitoring the water level and properly assessing the potential dangers. For example, snakes that come from the large mangrove forest planted around the island are hard to detect without proper lighting and thus pose a real threat during nighttime flooding. This is potentially the only negative effect of the planting of these mangroves, as they have otherwise greatly contributed to preventing coastal erosion (as opposed to other adjacent islands that did not plant them and have experienced erosion, as witnessed during the authors' field surveys to surrounding islands). The mangroves themselves seem to have adapted and compensated for the subsidence, though they appear ineffective in preventing the tidal flooding in the island, especially given the many openings in their belt to allow ship access. Nonetheless, these openings also proved to be helpful as shelter for the residents' small boats during typhoons and high winds as mangroves serve as natural barriers against high waves.

5. Discussion on Adaptation Options

5.1. Relocation

In view of the new flooding problems in the island, the municipal government has initiated a relocation program that would grant permanent housing to Isla Batasan residents in the mainland. However, focus group discussions indicate that, as the program does not guarantee livelihoods, a large part of the community does not readily welcome the prospect of relocation. Nonetheless, in order to encourage Isla Batasan residents to participate in its program, the municipal government is exploring an alternative approach to permanent relocation.

As of March 2015, the government is considering the possibility of residents still retaining temporary houses on Isla Batasan for their fishing needs while, at the same time, also having permanent houses in the mainland. This way residents can still engage in fishing, but can readily evacuate to their permanent houses during typhoons. Prior to the earthquake, Isla Batasan residents often did not comply with evacuation orders issued by the municipal government for various reasons, including fear of looting, inconvenience in evacuation centers and a sense of fatalism, among others. Based on this experience, the municipal government is negotiating with Isla Batasan residents to strictly comply

with evacuation orders as a critical requirement of this adaptation strategy.

At present, as Isla Batasan does not have schools beyond elementary level or work opportunities beyond fishing, many children and employees commute to the mainland on Mondays, stay in rented or relatives' houses, and come back on Fridays. Therefore, members of the household who do not participate in fishing could cut commuting and renting costs by staying in the permanent houses, while fishermen could continue to benefit from having temporary houses for storing fishing equipment. It should be noted that this commuting is not a regular service, but rather the renting of a privately owned boat, which has a fixed schedule and a fixed fare.

Still, several difficulties remain regarding the final implementation of the proposed relocation approach. With respect to the Ladder of Community Participation[24, 25], the relocation program of Isla Batasan ranks only at the middle level, with the community having no real decision-making powers. Although the Municipal government is at least hoping to conduct an in-depth consultation with the residents and to organize them into a homeowner's association, it has, so far, only informed them about the program. However, there is a broad consensus, especially in the context of sustainable development [26], that community participation is a key aspect of program performance. Community participation can also help dampen the large risks associated with relocation by negotiating the main source of the risk and, at the same time, initiating their own coping activities [27].

However, should this modified relocation program be pushed through, the possible dissolution of Isla Batasan as a basic administrative unit poses a political challenge, as former residents of the island may feel poorly represented, and former local leaders may feel disempowered. Furthermore, as of March 2015, the local government has so far only procured one lot that is good for 50 houses, with actual construction yet to start. Due to such delays in program implementation, Isla Batasan residents have already found ways to rebuild and adapt to flooding in situ by themselves, as will be explained in the next section.

5.2. Living with floods

Given that the entire island now becomes flooded during +2.0 m high tides, most residents have repaired/rebuilt their houses by elevating their floors. In some cases, they did this by rebuilding their houses' foundations and placing them on stilts, as shown in Figure 4a. However, in most cases, residents raised their floors by piling coral stones they collected from the shallow reef (see Figure 4b). Although this has been banned by the Department of Environment and Natural Resources, residents have continued to use coral stones due to the lack of alternatives. Basically there are no other construction materials readily available on the island (there are very few trees on the island other than the mangroves planted around it), and transporting them from the mainland would entail additional costs that most residents cannot afford. Unfortunately, the housing repair assistance provided by the government was very limited, and did not allow residents to build stilts or buy filling materials.

It is worth mentioning that, in the 1930s [18], residents of Isla Batasan had also piled up coral stones as a means of expanding the island, particularly "to create more land for constructing new households" [28]. However, following the earthquake, piling more coral stones for raising floors could further deepen the reef flat, allowing for higher waves to be able to reach the island. Computer simulations suggest that an increase in water depth of the order of 0.5–1 m on 1–2 m deep reef flats could result in larger wave heights and setup, which would in turn result in much higher waves in the area between the fringing reef and the beach [29]. This could reopen an "energy window" that would allow geomorphic processes to gather pace [14], and this is particularly worrying as this region of the Philippines is frequently affected by typhoons.

However, the key consideration, as always regarding talks on coral islands on top of reefs, refers to the amount of sediments produced by the corals. These islands essentially are made up of the dead skeleton of the coral reefs, and they have stayed above water during past increases in sea levels by the accumulation of sediments from the reefs [14]. Much is still unknown about these islands and their past capacity to keep up with sea-level rise. The fact that islands on reefs have been able to withstand past changes is not surprising given that corals would have been far healthier than what they could be during the course of the twenty-first century [30]. It is worth noting that already the overall health of the reefs in Danajon Bank is considered to be rather degraded [31], and conditions could further deteriorate in the future.

In addition to elevating their floors, most residents have also decided to elevate important home items in anticipation of floods by building what is locally known as "lantay", a tall make-shift bamboo furniture for sitting or sleeping (see Figure 5a). Whenever the water starts to rise, they place themselves and important personal belongings on such furniture. However, when the water is too high they evacuate to their fishing boats instead. When the flooding happens at night, household members take turns in watching over their family and belongings, using fishermen's kerosene lamps. After each flooding episode, the residents then clean their houses and dry their belongings. Despite this dire situation, most residents of Isla Batasan consider flooding more as an inconvenience than an emergency. A key informant explained that, "Anyway, we only have to do this about 2 to 3 times a month. The rest of the time, we can continue living our normal lives and still go fishing."

Figure 4 a) Model stilt house in Isla Batasan donated by a religious group a few months after the earthquake, and b) Kitchen area raised by piling coral stones.

Figure 5 a) "Lantay" or raised chairs/beds indoors, and b) Road elevation under construction.

In terms of collective effort, the community has also decided to elevate a section of the only road on the island to ensure that those living in the lower end can still be mobile during high-tide flooding. As sufficient funds were made available through donations, the community was able to purchase and use standard stones for construction, rather than coral stones. As of March 2015, the road construction was still ongoing (see Figure 5b). However, tidal flooding could eventually cause some damage to this elevated road through localized scouring.

Parishioners on the island have also tried to restore normality to their lives by raising the floor of a chapel where they hear mass every Sunday, again using coral stones (see Figure 6).

The elementary school in Isla Batasan was quickly repaired after the earthquake and now continues to serve its students, although classes are generally suspended whenever there are strong winds alongside flooding. Furthermore, small stores usually attached to the residents' own houses have also been repaired and elevated, together with the houses. In this sense, the present research confirms the findings of Gibbons and Nicholls (2005), which suggest the importance of maintaining community services when adapting to sea-level rise [9].

Figure 6 a) Chapel under repair as of August 2014, b) Chapel fully restored as of March 2015.

5.3. Recovering livelihoods

Displacement literature has emphasized livelihood assistance as a central requirement for proper relocation, given that typically the main risk of relocation is the impoverishment of those displaced [27]. This is especially true for climate-induced displacement, given that climate change threatens to reduce the very capital that they need to relocate, let alone restart their livelihoods [32]. Similarly, this study highlights livelihood as one of the most important factors influencing the decision of Isla Batasan residents to remain on the island. Although the livelihoods of residents were also affected by the earthquake, they are determined to find alternative fishing sites so that they may continue their fishing-related activities on the island, or to find alternative livelihood sources altogether. Under the guidance of the Zoological Society of London – Philippines (ZSL), an international non-government organization, the community established the Batasan Fisher's Association (BAFA) in November 2014. The association aims to organize and help residents engage in alternative livelihood activities, which may include craft-making using seashells, buying and selling of rice, rag-making and pig farming. However, as of March 2015, priority activities have yet to be decided. The association has a total of 98 members, who each have to make monthly contributions of Php 10 (USD 0.2). As further support, ZSL has also committed to providing the association a seed capital grant of Php 100,000 (USD 2,160), and to finding appropriate markets for the association's products.

Unfortunately, these efforts to find alternative livelihoods are largely self-initiated and lack proper government support as the municipal government is instead focusing its efforts on developing a relocation program that does not prioritize the provision of livelihood assistance. However, given the poor response of island residents to the proposed relocation program, it is clear that the Municipal Government of Tubigon should not only be concerned about safety against natural disasters when planning the permanent relocation of Isla Batasan residents, but should also consider the need for livelihood assistance.

Finally, migration theory hypothesizes that migrants prefer relocation sites that are in close proximity to their original communities in terms of geography, language and trade volumes [7]. In line with this, as of March 2015, the municipal government has already decided on one relocation site in Barangay Macaas, a coastal community that is located 3 to 4 km from the Tubigon Port Area, the point of embarkation on the way to Isla Batasan. Macaas has a population of 2,226 individuals [19], many of whom are also engaged in fishing [21].

Still, although Macaas would appear to be a logical choice for a relocation site, Isla Batasan residents remain hesitant about moving there. This suggests the need for the government to actively involve the community in the whole process of planning relocation, including the selection of relocation sites. As mentioned earlier, although the municipal government has already laid out some concrete plans about the relocation program, in-depth consultation with the community has yet to be conducted.

6. Conclusion

Through various household and community initiated efforts, it is evident that the residents of Isla Batasan are learning to adapt to higher water levels. In order to continue living on the island, they have elevated the floors of their houses, mainly by piling coral stones. They have also ensured that the road, school, church and stores were able to continue providing basic community services. Finally, they are also trying to recover their livelihoods by attempting to find new fishing grounds and alternative income sources. Altogether, these efforts indicate the community's continued faith in the viability of their settlement and the future of their island. As Gibbons and Nicholls (2005) have pointed out, such faith – or the lack of it – ultimately determines a community's willingness to remain on an island, despite the potential future impacts of sea-level rise [9].

However, while Isla Batasan's community is focusing on rebuilding their houses and recovering their livelihoods as their main adaptation strategy against flooding, the municipal government is instead focusing on developing a permanent relocation program. Furthermore, the program does not include a livelihood component, which is the main driver of the community's decision to remain on the island. Unfortunately, this gap between the community's needs and the government's assistance has resulted in a range of potential problems regarding the self-managed adaptation strategy of the island residents, including the negative impact of the use of coral stones on the island's surrounding environment. Still, this gap is further aggravated by the lack of community involvement in the development of the relocation program, which only further contributes to deterring Isla Batasan residents from relocating.

The case study described in the present research can provide important insights to small island communities regarding possible adaptation strategies to future climate-induced sea- level rise. Although it remains to be seen whether relocation is inevitable, this study has demonstrated that the initial response to sea-level rise involves in situ flood risk management, rather than immediate mass migration, as suggested by other theoretical studies. Following this, and considering that sea-level rise is a slow process that can take decades to reach the levels of relative movement seen in Isla Batasan, governments should strive to understand the distinction between short-term and long-term adaptation strategies, rather than focusing solely on the development and implementation of relocation policies from the start. As this study has shown, in the short-term communities will first try to adapt to sea-level rise in-site and will need various types of assistance. In terms of housing, island communities will need repair assistance that would enable them to adapt to sea-level rise in an environmentally sensitive manner. In

terms of livelihood, communities will need assistance for recovering their livelihoods following a disaster, or for finding alternative sources of income that they can pursue if relocation does actually take place. Taking a long-term view, governments should engage communities in the entire displacement process, including the selection of destination and the planning of key program components such as alternative livelihoods.

As a final note, and especially in the context of the Philippines, it is important to ensure that communities remaining on their home islands despite sea-level rise or land subsidence are nevertheless able to evacuate whenever typhoons or other natural hazards threatens to cause a disaster. Evacuation strategies must also be responsive to the needs of the most vulnerable groups, in terms of gender, social status and age, among others. While the island residents in Chesapeake Bay, USA, decided to relocate only after community services have closed [9], natural disasters pose an altogether different challenge, especially for Isla Batasan (which experiences typhoons every year, typically between September and December [20]). Although this has not been addressed in this paper, the authors' future studies will focus on how natural disasters can affect the decision of residents to relocate.

Table 1 Summary of adaptation strategies for tidal flooding implemented or considered by residents of Isla Batasan within 1 year of the earthquake

Focus Area	Details	Implementing Office/Persons	Issues
Migration	- Build permanent house in coastal community in mainland; keep temporary house on island	Municipal government	- Delayed (only procured land for 50 houses during the first year) - Minimal opportunities for community participation - No livelihood assistance
Housing	- Raise floor of house - Raise furniture and belongings - Build Stilted house	Island residents	- Lack of available construction materials - Coral mining can allow high waves to reach the island
Livelihood	- Alternative, non-water-based livelihood in islan	Fishermen's association NGO	- No goverment support - Priority activities not yet decided - NGO funding not yet available
Infrastructure	- Raise road at lower end of island	Local community government	- Only a small section raised - Raised road may still fail due to scouring
Community services	- Raise floor of church	Parishioners	- Lack of vilable construction materials - Coral mining can allow high waves t reach the island

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