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Effects of Natural and Socio-Economic Changes on Coastal and Upland Ecosystems in San Miguel Island, Albay, Philippines

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Abstract
Survey results demonstrate the interconnected effect of natural and socio-economic conditions on the coastal and upland ecosystem changes. When nature works negatively, it can severely affect the ecosystem and the socio-economic well-being of the people who depend on it. For instance, typhoons can wipe out gains from years of trying to reduce poverty, causing loss of life and damage to property and the environment. The effect of nature on the island's ecosystem is noticeable in the landscape and farming system. The occurrence of climate-related disasters threaten the capacity of the environment to provide food and livelihoods. In coastal areas, siltation and sedimentation severely affect critical habitats to varying degrees with major implications for agricultural productivity, fish catches and human settlement.
On the other hand, the effects of socio-economic changes on the ecosystem can be traced back to the 1800s when the agro-ecological changes started from a position of abundance in agriculture and continued until production diminished and new areas were explored. Farming started with the "kaingin system" of plantation-based farming. Today, farming is characterized by permanent, diversified and specialized cropping patterns dominated by agro-forestry, root crops, corn and rice.
In summary, nature, together with socio-economic pressures, has shaped and transformed the island's ecosystem into what it is today. Reducing poverty and increasing people resilience are urgent requirements. It is therefore recommended that Local Government Unit (LGU)'s invest in manpower, resources and facilities for climate change adaptation, natural resource management and disaster risk reduction and management in their policy and development agendas.

Key words: climate-related natural disasters, coastal and upland ecosystems, San Miguel Island

1. Introduction

In the Philippines, San Miguel Island of Tabaco City is one of the most vulnerable areas being exposed to seasonal weather changes and extreme events originating in the Pacific Ocean(Fig. 1). This has impacted the island's ecosystem including the socio-economic conditions of the people in a dynamic manner. These changes have molded local lifestyles and adaptive capacities over time, I though there is very limited published work on the subject.

This paper descriptively presents the effects of nature and socio-economic changes on the coastal and upland ecosystems of the island. The primary objective is basically to understand the causes and effects of nature and socio-economic pressures on the island's ecosystems and to recommend relevant adaptive measures or strategies to sustain the island's resource base and life support system and to enhance the coping mechanisms and the resilience of the local people.

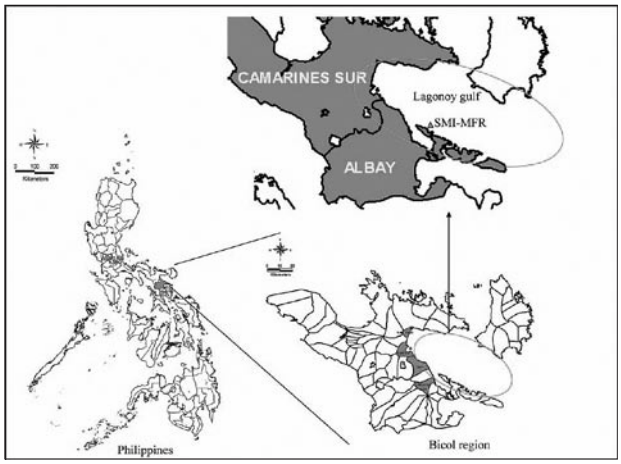

Fig. 1. Location of San Miguel Island of Tabaco, Philippines.

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2. Materials and Methods

A descriptive assessment of the effects of nature and socio-economic changes on the coastal and upland ecosystems was obtained from a random sample of forty-two percent (1,035 respondents) of households which cut across sectors that include local village officials, fishers, farmers, local entrepreneurs, youth, teachers, women and other interested parties.

A combination of participatory rural appraisal (PRA) and participatory coastal resource assessment (PCRA) were used to collect relevant numerical data and other information. A number of exercises were carried out with groups of randomly selected respondents from selected villages on the island. Transect maps were prepared by the respondents and validated by a walk-through around the island. Focus group discussion using a historical trend line exercise and resource map matrix scoring were also conducted to generate information on observed changes in human settlement and population growth, vegetative succession, technological development in coastal and upland areas, infrastructure development, changes in both terrestrial and marine environments and related issues.

A standard semi-structured questionnaire was also used to generate relevant data from the household's heads and key informants. Relevant reports, published and unpublished literature and records on file were used as secondary data sources. Conceptually, the study recognizes the influence of factors such as population, technological development and daily life activities as well as the factors of climatic changes and global warming. Their dynamic interactions over time result in changes and subsequent impacts on the environment, ecosystem and the people, and therefore on changes in the environment and ecology over time. Finally, this change is manifested in the socio-economic conditions of the residents and also in the status of the environment and ecology in the area.

3. Profiles of the Survey Site and Typhoon Reming

1) San Miguel Island

San Miguel Island (SMI) is situated in Tabasco Bay within the Lagoon Gulf area The island partly encloses Tabaco Bay at the southern portion of the Gulf and is located between the island province of Catanduanes and Rapu-rapu Islands, hence strategically providing protection to mainland Tabaco City from direct exposure to storms or any weather disturbances originating in the Pacific Ocean.

It has a total land area of 44 km^2, ranging from hilly, mountainous, or slightly rolling areas to plains elevated 35 m above sea level. The upland barangays include: Angas, Visita, and Hacienda with Rawis and Sagurong, being the coastal barangays. It can be reached by motorized boat in 20 to 30 minutes from the Maritime Port of Tabaco City travelling to Barangay Rawis and Barangay Sagurong, respectively. Given its geographical setting, the island is a special area of interest being exposed to frequent climate-related disasters. As a matter of fact, houses along its coastal area built along the hazard-prone shoreline, are at risk from storm surges and strong waves. Lastly, the economy is typically resource-dependent. Therefore, natural and socio-economic changes greatly affect the island's coastal and upland ecosystems.

2) Current socio-economic conditions

SMI consists of 2,391 households with a total population of 12,668. The population consists of 46% aged below 16 and 3.6% aged 65 and above, indicative of high dependency rate. Farming (42.5%) and fishing (25.9%) are the major occupations. Males are the dominant household breadwinners, tend to be badly educated and have an average of 22 and 30 years' fishing and farming experience, respectively. The mean household size is 5.0 which is not far from the national and regional averages of 5 and 5.2 (Pelea *et al,* 2004), respectively.

The mean household income is P 55,700 which is 52.1% lower than the national average and 36.7% less than the regional average (NSCB 2005). The mean per capita income of P 10, 427 is notably lower than the regional poverty threshold of P 12, 700 in conformity with the findings of Pelea *et al,* (2004) in Lagonoy Gulf where 86% of the population lives below the poverty threshold. In terms of income sources, farming (28.9%), service-related jobs (29.8%) and fishing (18.3%) account for a significant proportion of the occupational groupings. Farming and fishing are the only means to augment income in combination with other economic activities. For instance, mat-making among housewives also provides additional income to 11.4% of households. Other sources of income include work in professions or in government services (3.29%), and in business (3.3%).

Household characteristics and assets are shown in Table 1. Findings reveal that radios, TVs and cell phones are considered very important assets on the island as sources of information especially during typhoon season or during any extreme events.

A lack of employment opportunities is the reason for outmigration towards urban centers. A similar obser-

Table 1. Household characteristics and assets.

Economic Indicators	Characteristics
Household ownership	81.8% owned
House Roofing	41.4% have galvanized iron roofing, 37.9% Nipa shingle roofing, 16.8% bricks and 3.86% use concrete slabs.
Walls	54.3% have concrete walls which are either finished or rough finished, 28.3% are made of Nipa shingles and 17.4% wood.
Flooring	57.9% are made of concrete, 29.6% compacted soil and the rest are bamboo (7.8%), wood (4.1%) or concrete tiles 0.6%).
Household Assets	58.7% own a radio, 19.1% have TV sets and 15.8% have cell phones.
Other assets	CD-Component (6.1%), Electric fan (5.9%), Generator (1.1%), Refrigerator (0.5%), motorcycle (0.4%) and computer (0.2%).

vation was made by Gavino (2003) where the young educated sector moves out to urban areas for better jobs and the opportunity to earn a living. Women usually engaged in mat weaving and fish vending to augment meager household incomes.

In terms of service and support facilities, each barangay has a concrete barangay hall that serves as the local government office, a chapel, primary and secondary schools, health centers and concrete pavements that serve as a road network, as well as having a solar dryer. Transport within the island is made possible through motorbikes locally known as "*habal-habal*'. A small water impoundment for irrigation purposes is also present. A potable water system is also operational in several barangays and the latest addition is the 24 hours electric service. Travel outside the island is via motorized boat with regular trips to and from the island.

3) Climate-related natural disasters

Typhoons or "bagyo" in the local dialect are the most destructive climate-related disasters on the island. These can wipe out gains from years of trying to reduce poverty, and cause loss of life and damage to property. Climate-related disasters occur in the form of storm surges, floods, strong winds and prolonged rain or drought. According to the Philippine Atmospheric Geophysical and Astronomical Services Administration (PAGASA 2004), an average of 6 to 7 tropical cyclones hit the Philippines per year (Joint Typhoon Warning Center. 2008). Typhoons are categorized by PAGASA into four types according to their wind speeds as shown in Table 2.

Table 2. Tropical cyclone categorization in the Philippines.

Storm Signal	Maximum Sustained Wind (kn)
Tropical depressions	Between 55 km/hour (30 kn) and 64 km/ hour (35 kn) near its center.
Tropical storms	Maximum sustained winds of 65 km/ hour (35 kn) and 119 km/hour (64 kn).
Tropical storms Typhoons	Maximum sustained winds of 120 km/ hour (65 kn) to 185 km/hour (100 kn)
Super typhoons	Maximum winds exceeding 185 km/ hour (100 kn).

SMI's location on the eastern Pacific seaboard makes it vulnerable to tropical storms and cyclones originating in the Pacific bringing destructive winds, heavy rainfall and storm surges several times a year. The latest typhoon that severely hit the island was Typhoon Reming (also called Durian) in 2006. This triggered landslides and widespread flooding, while the associated strong winds caused destruction to houses, government facilities, agricultural crops farms and fishing craft.

4. Results and Discussion

1) Effects of nature on coastal and upland ecosystems

The exposure of SMI to the eastern Pacific seaboard greatly influences on the island's ecosystem. The prevailing weather, climate-related disasters and the daily anthropogenic activities on the island have shaped and transformed it into what it is today. The aftermath of the devastation caused by Typhoon Reming highlighted the vulnerability of the islanders to nature's worst effects which visibly affect the islands resources and ecology.

In coastal areas, the associated critical habitats are the hardest hit. Focus group discussions and on-site observations revealed changes in the shoreline morphology. Tremendous changes in the original coastline configuration are noticeable. Varying degrees of ecosystem change are evident in sea grass beds, coral reefs areas, mangrove areas and tidal flats because of shoreline erosion and sedimentation. These changes could also be attributed to unsustainable human intervention. For instance, dynamite fishing has caused a massive reduction of most coral reefs in the area resulting in habitat and stock degradation.

Survey results also affirm that changes in weather patterns have major implications for agricultural productivity, fish catch and human settlement. For example, longer droughts or frequent flooding destroy agricultural crops and reduce fish catches. According to the World Fish Centre's Annual Report (2006), fishs migrate to deeper water with increasing temperature or rising water temperature may reduce the upwelling of food supplies for the fish in the upper layers. As a matter of fact, it has been reported that El Niño has affected the distribution and abundance of tuna in the Tropical Pacific (World

Fish Centre Policy Brief 2008).

Typhoons are the islands' most common natural disaster and they affect coastal habitats including the fisheries. They destroy almost everything from coastal settlements and infrastructure to livelihood and livelihood assets (i.e. fishing boats, farm crops and implements, etc.) including shoreline morphology, coastal bathymetry and the near shore marine environment. They also affect the productivity and distribution of fisheries and the quality of habitats that support them. In addition, the accompanying heavy rains create further damage to the livelihoods of the fishers and farmers as flooding brings high sediment loads and silt to coastal habitats around the island. It is interesting to note that the sea grass bed population is still stable indicating the resiliency of this habitat to typhoon impact relative to the rest of the marine habitats around the island. The health of coral reefs is also affected because of siltation and presumably because of rising seawater temperatures in addition to the already existing illegal fishing practices. Findings obtained also showed that capture fisheries have been declining over the years due to overfishing and mismanagement, as well as habitat and coastal zone modifications. Sustaining fisheries in the face of these challenges will be more difficult as the climate changes.

Human settlements along the coast are highly vulnerable to storm surges. Similarly, houses located on mountainsides with steep and unstable slopes are prone to landslides. It is interesting to note that despite the sad experiences and damage caused by typhoons, locals still have the courage to rebuild their houses in the same risky places. When asked why they do this the usual answer is because they have nowhere to go, and they lack the resources and productive assets and that they value proximity to their livelihoods.

In the upland, the occurrence of climate-related disasters is the major factors of change that affects the ecosystem. Their effects were noticeable in the island's landscape; a loss of forest cover and the appearance of annual tree crops such as coconuts and fruit bearing trees as well as the evolution of root crop farming. Whether the progress and development of the resource use pattern is contributing to or impacted by climate change, current changes in the agro-ecological landscape are characterized by the dominance of short production cycle crops such as root crops (i.e. sweet potato and cassava) with far reaching implications for soil stability and the fertility of the already degraded soil. These make the agro-ecology of the island more susceptible to the negative effects of climate change resulting in low agricultural productivity.

As climate change stresses progress and are compounded, they continue to threaten the capacity of the environment to provide food and livelihoods. In fact, the immediate effects of global warming and climatic change are now being felt. For instance, summer months are getting hotter, while typhoons during the rainy season are getting stronger and more destructive. The occurrence of *La Niña* or *El Niño* is also getting worse, affecting the island's water resources and the overall vegetative cover including agricultural crop yields with harvests much smaller than usual due to unpredictable weather conditions.

2) Effects of socio-economic changes on coastal and upland ecosystems

The effect of socio-economic changes on the coastal and upland ecosystems on the island can be traced back from the island's historical timeline. The Ecosystem's transformation from forest-based to agriculture-based started when people from other places started to settle on the island. As the population increased, extractive economic activities also increased over time; the resultant effect is the existing island landscape and ecosystem changes.

With fishing a way of life for 84.3% of locals working as full time fishers and a population with 86% living below the poverty threshold (Pelea *et al.,* 2004), huge economic pressure is placed on the island's life support system. This in turn creates a resource use pattern that often does not consider the limits of what nature can provide, resulting in ecosystem degradation and eventual collapse. In terms of its fisheries, heavy fishing produces extraction rates ranging from 9.3 mt/km^2 /yr on SMI (Soliman *et al.,* 1997) to as high as 39.4 mt/km^2 /yr along the Tiwi coast. Fishing effort was reported to have increased by 40% in terms of gear units in operation causing significant pressure on the bio-ecological limits of the resources, particularly the major species. The observed appearance of less-preferred species and the disappearance of large economically important species indicate ecosystem overfishing. This clearly shows the high dependence on fisheries as a dominant extractive economic activity for local livelihoods. Other resource-dependent economic activities are dominated by processing of raw materials existing on the island. These include mat-weaving from Karagomoi (*Pandanus textiles*), nipa and anahaw shingle making, siganid fry fermentation, and sea cucumber drying.

Another example that demonstrates the pressure of socio-economic conditions on the ecosystem is the encroachment of the Sagurong Marine Fish Sanctuary after typhoon "Reming." Despite there being a known

conservation area with a no fishing zone, fishers deliberately fished in the area. It could be gleaned from this experience that individual economic needs easily take priority over conservation of the resource base.

The effects of nature and socio-economic conditions can be practically observed in built-up areas. Concrete houses are reflective of one's socio-economic condition. First because with concrete and strong houses residents are safe and secure whenever inclement weather occurs. Second, only the affluent families can afford to construct such houses since construction materials are procured in the city center which is about 20 to 30 minutes from the Maritime Port of Tabaco by motorized craft. On the other hand, houses made of light materials are easily blown away.

In the upland area, historical accounts reveal that the agro-ecological changes in SMI started in the 1800s when three Borehon brothers from nearby Sorsogon Province escaping from Moro bandits, settled in barangay Visita. In the 1930s, the settlement started to expand towards the mid-upland village of Angas and then to other parts of the island.

Today, farming on the island is characterized by small land holdings and traditional farming methods. With the recent global warming and climate change phenomenon, the number of poor farmers may likely increase and in turn this may increase pressure on the upland resources and ecology. It should be noted that about half of Asia's poor live in rural areas and these include special vulnerable groups with few economic opportunities (Asian Development Bank, 2007).

FGD revealed that the agro-ecosystem on the island undergoes a cycle of transformation brought about primarily by socio-economic development. The cycle started from a condition of abundance; in its pristine condition changing with a shift in agriculture until production diminishes and new areas are explored. This can be traced back to early settlers that introduced new species and consequently altered the natural vegetative cover of the island. For instance, in the 1900s the island was forested, however, from the 1930s to the 1940s, a significant portion of the forest was converted for agricultural purposes. Conversion process started with the "*kaingin system,*" which is generally unproductive and ecologically destructive. The idea is the need to get as much as they can from the resource in order to sustain their growing economic needs. It should be noted that soil in the "*kaingin system*" is not adequately protected since the removal of the forest canopy exposes the soil when planted with root crops.

Begining with the "*kaingin system*," plantation-based farms were introduced with coconut, abaca and sugar cane as the common base crop. The introduction of corn farming and the expansion of cattle ranching in the 1960s, further reduced the remaining forest cover. With plantation-based farming, the loss of soil due to erosion can be hardly noticed compared to the *kaingin* system (Mallion, *et al.,* 1998). This shift in the land use pattern could be attributed to the influx of population in the peripheral communities in the upland areas.

With the implementation of the Comprehensive Agrarian Reform Program (CARP), significant portions of former hacienda were distributed to tenants who opted to plant corn and root crops. Such conditions in the late 1980s and early 1990s paved the way for increased land fragmentation, increased cropping intensity and hastened the demise of the remaining forest cover.

The changes in the physical environment vis-à-vis the ecosystem are manifested in the plant–succession pattern of natural forest growth to annual crops and fruit trees; followed by patches of grasslands, weeds and shrubs; and to the present system characterized by permanent, diversified and specialized cropping patterns dominated by agro-forestry, root crops, corn and rice.

The occurrence of strong typhoons in the 1970s severely damaged the coconut and abaca plantations and other crops. This then created changes in the bio-physical conditions of the upland ecosystem. Recently, the emergence of rain-fed rice farms in some areas, small-scale backyard vegetable farms and the proliferation of pockets of Karagomoi plantations providing raw materials for mat-making was noted. But, the biggest challenges are the unpredictable weather and rainfall patterns, the recurrence of droughts that directly affect agriculture yields and the livelihoods of improvised island communities.

5. Conclusion and Recommendation

The effects of nature and socio-economic conditions on the coastal and upland ecosystems of SMI cannot be ignored and should be taken seriously. With its exposure to the eastern Pacific seaboard it is expected that the island's ecosystem will experience perturbation caused primarily by naturally induced climate-related disasters and by the anthropogenic economic activities of the people trying to survive on the island. These factors have shaped and transformed it into what it is today.

Typhoons are the most common and worst natural phenomenon that affect the island's ecosystem. In coastal areas critical habitats (i.e. sea grass, coral reef, and tidal flats) are the hardest hit resulting in varying degrees of ecosystem change. Typhoons destroy almost

everything ranging from coastal settlements, to infrastructure, to livelihood and livelihood assets including shoreline morphology, coastal bathymetry and the near shore marine environment. In upland areas, changes in weather patterns have major implications for agricultural productivity. Their effects are noticeable in the island's landscape and the evolution of root crop farming.

On the other hand, socio-economic changes were brought about by the increasing extractive economic needs and the influx of people which dates back to the early 1800s. The transformation from conditions past of abundance to what we see today is the resultant effect of socio-economic development. The cycle started from abundance in its pristine condition to a shift in agriculture until production diminished and new areas were explored.

The alarming threat of global climate change is a reality that deserves due attention. The dismal state of the socio-economic conditions of the people on the island is a sad reality. They struggle to make a living under constraints of resource scarcity, limited employment opportunities and threats caused by recent global warming and climate change which naturally increase the number of poor farmers and fishers and correspondingly increase pressure on the islands' resources and ecology.

Efforts should therefore be directed towards reducing poverty and increasing resilience as well as the provision of long-term solutions that would enable people to earn a living, meet their minimum basic needs and have a safe place to live. It is therefore recommended that livelihood adaptation to climate change in agriculture and fisheries programs should be promoted to increase the resilience of island residents. LGU's should likewise invest in manpower, resources and facilities for climate change adaptation including natural resource management and the development of disaster risk reduction and management strategies in their policy and development agendas. Finally, ecologically sustainable development should always be given a place in any development efforts. Thus, in preparing action plans for conservation and management, any implementation must consider not only the biophysical but also the socio-political dimensions of resource utilization and management.

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