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Analysis of Climate Risks on the Food Security of Saguday, Quirino Province

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Problem Statement

The municipality of Saguday in Quirino Province was formerly a barrio of the municipality of Santiago in Isabela; however, upon the final settlement of the boundary dispute between Isabela and Nueva Vizcaya, Saguday became a regular barrio of Diffun in Nueva Vizcaya by virtue of Executive Order No. 386, issued by President Elpidio Quirino. In June 21, 1959, Saguday was elevated into a regular municipality of the province of Nueva Vizcaya by virtue of House Bill No. 2541, which was authored by Hon. Leonardo B. Perez, then congressman of the lone district of Nueva Vizcaya. Saguday was born as a sixth-class municipality composing of seven barrios; however, two additional barangays were created in the early 80s. Barangay Cardenas was created in 1980 pursuant to Sangguniang Bayan Resolution No. 02, series of 1980, while Barangay Gamis was founded in 1981, pursuant to Resolution No. 05, Series of 1981. At present, Saguday is still a fifth-class municipality with limited income and scarce resources.

Saguday is comprised of nine barangays. These are La Paz, Cardenas, Salvacion, Santo Tomas, Rizal, Tres Reyes, Dibul, Cardenas, and Gamis. All nine barangays of Saguday are vulnerable to climate change and extreme events due to their geographical location and climatological condition. Being located in Quirino Province, it is part of the biggest watershed area in the region. The Cagayan Valley Plains actually start at the foothills of Quirino. Given its allocation of vast highlands, Quirino Province including Saguday could pose a region-wide environmental threat if its water resources are not adequately managed and protected (PENRO Quirino, 2013). The major industry in the province of Quirino is farming. Aside from cultivating staple crops like rice and corn, they also raise crops with high commercial value including banana, mango, and vegetables. Another industry related to farming is the furniture and gifts and decor making. There is also some tourism activity ongoing in the province. The present study identified the climatological problems and difficulties particularly in food security that confront the municipality due to climate change.

A policy framework has been proposed to help mitigate the effects of the projected impacts faced by Saguday citizens and other stakeholders. These impacts brought about by climate change include those that are affecting food production. This study will be valuable and beneficial not only to policy-making bodies/institutions but also to other communities that are vulnerable to the impacts of climate change.

Review of Related Literature

Risks created by disasters and the impacts of climate change are major threats to humans and the environment, and both can adversely reinforce the other's effects. Exposure to disaster risk is an inherent feature of human settlements. Often, disasters arise from the combination of natural and anthropological factors. The adverse impacts of climate change on society and the individual may aggravate disaster risk effects by eroding environmental and social resilience. This in turn further increases our vulnerability to climate change. More data on the link between extreme weather events and climate change are needed, and these data can facilitate the formulation of strategies to reduce vulnerability. Interestingly, both preparatory actions and responses to climate variability and long-term climate change are often similar to one another (O'Brien & Sygna, 2008).

Recent findings also emphasize the nexus between rapid urbanization and occurrences of disasters. Unfortunately, urbanization has become the dominant feature of human settlement patterns over the past centuries. More than half of the world's current population lives in cities. By the year 2015, there are 60 megacities expected to be in the world, each with a population of 10 million or more people. Over the next several decades, the largest urban population changes are expected to occur in coastal areas, particularly in

Asia and Africa (O'Brien & Sygna, 2008). In the Philippines, the population is expected to be 94 million by 2010 and 14.6 million by 2040 (ADB, 2008).

This linkage between rapid urbanization and increased occurrence of disasters is sometimes described as reflexive. As an example, cities create their own risks by causing degradation of the local, regional, and global environments. Putting a large concentration of resources and people within cities also means that the economic, social, and environmental costs of extreme events are high in urban areas. These costs are more likely to increase as a result of growing populations in coastal settlements, many of which are already highly vulnerable to sea-level rise, tsunamis, typhoons, and other hazards (O'Brien & Sygna, 2008).

Consequently, there are emergent calls for a common framework in approaching the reduction and diminution of hazards and vulnerability to disasters, climate variability, and long-term climate change. Coming up with such framework is the main objective of this study. This was undertaken by conducting an in-depth risk analysis, which is composed of two phases: Phase 1, the risk assessment, and Phase 2, the risk management (Banaguas, 2010, and Smith, 1994). A definition of terms is also necessary to facilitate the discussion.

One of the important concepts that need to be well understood is risk. *Risk* is defined by the US Presidential/Congressional Commission on Risk Assessment and Risk Management as the probability that a substance or situation will produce harm under specified conditions (Jones, 2001). Risk is a combination of two factors: the probability that an adverse event will occur and the consequences of the adverse event. In many cases, a huge amount of money is involved. The (+) principal concern is its low-probability (-) high-consequence events, events that lead to damage, loss, injury, death, or environmental impairment, for example. Often, the work of predicting risk is done as an aid to decision making. In consequence, risk analysis pervades modern technical life.

There are three elements involved in risk analysis. These are (a) hazard, (b) exposure, and (c) vulnerability (Crichton, 1999) (see Fig. 1). *Hazard* as defined by RA No. 10121 (also known as the "Philippine Disaster Risk Reduction and Management Act of 2010") as a dangerous phenomenon, substance, human activity, or condition that may cause loss of life, injury or other health impacts, property damage, loss of livelihood and services, social and economic disruption, or environmental damage. Climate and weather-related hazards refer to the direct and indirect effects of observed changes and/or projected deviations from present-day conditions of natural climate events and impacts of changes in the frequencies and occurrences of extreme weather/climate events (such as increases and decreases in precipitation and temperature) and impacts of changes in the frequencies and occurrences of extreme weather/climate events (i.e., tropical cyclones, droughts, and El Niño and La Niña events). Tropical cyclones that enter the Philippine Area of Responsibility (PAR) are one of the hazards considered in this research. These tropical cyclones can be classified into four different types: (a) tropical depression (TD, ≈45–61 kph), (b) tropical storm (TS, ≈62–117 kph), (c) typhoon (TY, ≈118–239 kph), and (d) super typhoon (STY, ≈>240 kph; NWSI, 2013). The occurrence of floods and droughts and their frequencies are also included in this study.

RA No. 10121 of 2010 defines *exposure* as the degree to which the elements at risk are likely to experience hazard events of different magnitudes. It is an access of what bridges the gap between a hazard and a risk. Release mechanisms, transport and transformation characteristics, and the nature, location, and activity patterns of the exposed population (receptors) are important aspects of the exposure condition. Population is the parameter in this study.

Vulnerability is defined as a condition determined by physical, social, economic, and environmental factors or processes, which increases the susceptibility of a community to the impact of hazards (UNISDR, 2009). The Human Development Index (HDI) is the vulnerability indicator that is measured in terms of (a) life expectancy, (b) weighted average of functional literacy and combined elementary and secondary net enrolment rate, and (c) real per capita income. Human development, as described in the Human Development Report 1990 of the United Nations Development Programme (UNDP), is a process of enlarging people's choices, most critical of which are to lead a long and healthy life, to be educated, and to enjoy a decent standard of living. Poverty incidence, another vulnerability parameter, is the proportion of individuals whose income cannot provide for the basic food and nonfood requirements (Virola & Martinez, 2007).

Figure 1. Modified risk triangle model (adapted from Crichton, 1999).

The influence of climate change on the achievement of food security is evident in many forms including direct nutritional effects (e.g., changes in consumption levels and nutritional value) and effects on earning capacity and thus capacity to buy food (e.g., changes in employment opportunities and cost of acquiring adequate nutrition) (see Ericksen et al., 2011; FAO, 2007; FAO, 2008; and HLPE, 2012). Climate change can also have biophysical effects on crop, livestock, and farming system (through sudden and drastic weather and geophysical changes in the environment). Furthermore, changes in environmental temperature and amount of precipitation affect food production, which translates to lesser earnings for farmers and higher prices for consumers (Cline, 2007; Dinar et al., 2008; FAO, 2011; European Commission, 2006; Gornall et al., 2010; Hassan, 2010; Hatfield et al., 2011; and HLPE, 2012).

Conceptual Framework

The warming up of the atmosphere lowers its capacity to hold water, resulting in increases in extreme precipitation events. Both observational data and modelling projections show that with atmospheric warming, wet regions will generally (but not universally) become wetter, and dry regions will become drier (Sanderson et al., 2011; John et al., 2009). In the Sahel area of Africa, the timing of critical rains will shift, shortening the growing season (Biasutti & Sobel, 2009), and more extensive periods of drought may result as temperatures rise (Lu, 2009). In the Haihe River basin of northern China, projections call for less total rainfall but more extreme weather events (Chu et al., 2009). Indian monsoon rainfall has already become less frequent but more intense, part of a pattern of climate change that is reducing wet-season rice yields (Auffhammer et al., 2011).

Knutson et al. (2010) noted however that although there have been a lot of studies made about the effects of climate change on tropical cyclone activities, the actual magnitude of the projected impacts still remain uncertain. Rainfall rates are projected to increase due to climate change on the order of +20% within 100 km of the tropical cyclone center. There will also be some likely increase in mean tropical cyclone maximum wind speed (+2% to +11% globally) due to the projected 21st-century warming. However, these increases may not occur in all tropical regions. Nevertheless, the global frequency of tropical cyclones will either decrease or remain essentially unchanged due to greenhouse warming. This information is important because the main drivers of agricultural responses to climate change are biophysical effects and socioeconomic factors (Matthews, 1997; Parry et al., 2004).

Crop production is also affected biophysically by meteorological variables, including rising temperatures, changing precipitation regimes, and increased atmospheric carbon dioxide levels. On the other hand, socioeconomic factors influence responses to changes in crop productivity, with price changes and shifts in comparative advantage. A global assessment of the potential impact of climate change on world food supply suggests that doubling of the atmospheric carbon dioxide concentration will lead to only a small decrease in global crop production (Rosenzweig & Paiz, 1994). But developing countries are likely to bear the brunt of the problem, and results from the simulation of the effectiveness of adaptive measures by the former imply that these will do little to reduce the economic disparity between developed and developing countries.

A new advocacy is needed urgently to bring together governments, international agencies, nongovernmental organizations (NGOs), communities, and academics from all disciplines to adapt to the effects of climate change (Costello et al., 2009). Any adaptation should sit alongside the need for primary mitigation: reduction in greenhouse gas emissions and the need to increase carbon biosequestration through reforestation and improved agricultural practices. The recognition by governments and electorates that climate change has enormous health implications should assist the advocacy and political change needed to tackle both mitigation and adaptation. Management of climate change will require inputs from all sectors of government and civil society, collaboration between many academic disciplines, and new ways of international cooperation that have hitherto eluded us. Involvement of local communities in monitoring, discussing, advocating, and assisting with the process of adaptation will be crucial.

As an example of a strategy, an integrated and multidisciplinary approach to reduce the adverse effects on food production by climate change requires at least three levels of action. First, policies must be adopted to reduce carbon emissions and to increase carbon biosequestration and thereby slow down global warming and eventually stabilize temperatures. Second, action should be taken on the events linking climate change to impacts. Third, appropriate response systems should be put into place to deal with adverse outcomes.

Research Questions

Climate risk assessment is used to help decision makers optimize resources for responding to climate-related disasters and reducing risks and impacts associated with current and future-projected climate variability and change. Climate risk assessments typically include statistical analyses of historical climate indicator records and assessment of information on climate-sensitive impacts, together with understanding of the climate mechanisms and the cascade of processes leading to these impacts. Indicators of climate-related risks (impacts, hazards, and vulnerabilities) are often used to focus a risk assessment on the specific areas of interest for the decision maker. Indicators are values that can be monitored (and/or modelled) to assess changes in the state of a system and are important tools for simplifying complex processes, with potentially multiple drivers and feedbacks, into useful and accessible information (Linkov & Bridges, 2011). It is along this paradigm that the following research questions guided the course of this study:

1. To what climate risks is the municipality of Saguday exposed and vulnerable? To which of these hazards are the residents of Saguday exposed? To which hazards are the residents of Saguday vulnerable?
2. What are the projected costs of these hazards in terms of casualties and money?
3. What areas of Saguday are most sensitive to the hazards?
4. What approach is most appropriate for Saguday in order to mitigate the impacts of climate change?

Methodology

Sources of Data/Information

The data and other types of information that were used in this study were provided by the United Nations International Strategy for Disaster Reduction, Institute of Social Order, Ateneo De Manila University, Manila Observatory, and Municipality of Saguday in Quirino. Interviews of Saguday public officials and focus group discussions with barangay officials were also conducted.

Research Question 1: To what climate risks is the municipality of Saguday exposed and vulnerable? To which of these hazards are the residents of Saguday exposed? To which hazards are the residents of Saguday vulnerable?

Probabilistic modelling is any form of modelling that utilizes presumed probability distribution for chosen output metrics. This statistical analysis tool estimates, on the basis of past (historical) data, the probability of an event occurring again. This differs from a standard deterministic model (e.g., Excel spreadsheet) where you can change the values of input assumptions at random and see the impact of those changes on the outputs. These key analytical tools (e.g., Monte Carlo simulation, real options, game theory) had been used for several decades already for dealing with uncertainty. Probabilistic and similar modelling methods can be tremendously useful as a structuring device to organize and combine all available insights about the relevant uncertainties and their impact. To address the first research question, the risk simulation model, mathematical algorithm, and the Monte Carlo simulation were used.

The probabilistic and deterministic simulation model was used in determining the risk parameters such as hazard, vulnerability, and exposure. The indicators (tropical cyclone, drought, and flood for hazard; the Human Development Index for vulnerability; and population for exposure) were the inputs both in the probabilistic and controllable model. Figure 2 as shown provides the risk simulation model employed by the study. On the other hand, the simulation experiment involves the use of the following algorithms:

a. Generate a random number of *indicators* using Poisson distribution.
b. Generate a discrete random number for each produced random number using the *indicator* distribution probability.
c. Generate the discrete random number of months (α).
d. Generate the discrete random number of days (β).
e. Multiply the number of months and days column (αβ) to produce the total number of months and days each *indicator* will enter for a particular *hotspot*.
f. If the sum of all the generated products of number of months and days column is less than or equal to "σ" days, then go to step 1 (next iteration), else stop.
g. Compute for the total number of "indicator," which is equal to the total number of iterations (*n*).

The sequence of logical and mathematical operations required to conduct a risk simulation is depicted with a flowchart (see Fig. 3 below). Several Monte Carlo simulations (1,000 replications per indicator) using MATLAB software were made in order to come up with the optimal results.

Research Question 2: What are the projected costs of these hazards in terms of casualties and money?

Risk in terms of *casualties per year* was determined using the formula ***R****isk* = ***H****azard* × ***E****xposure* × ***V****ulnerability,* while risk in terms of *cost per casualty per year* was determined using the formula *(Millions in USD) = Risk (casualties per year) × USD 50,000.00 / casualty.*

In theory, one's life is worth \$50,000.00 (which is around PhP 2,100,000.00 at 1 USD = PhP 42) according to the international standard most private and government-run health insurance plans worldwide use (Kingsbury, 2008). *If and only if* fatal outcome really enters into the arena, for instance, can the risks be gauged to its financial correspondence.

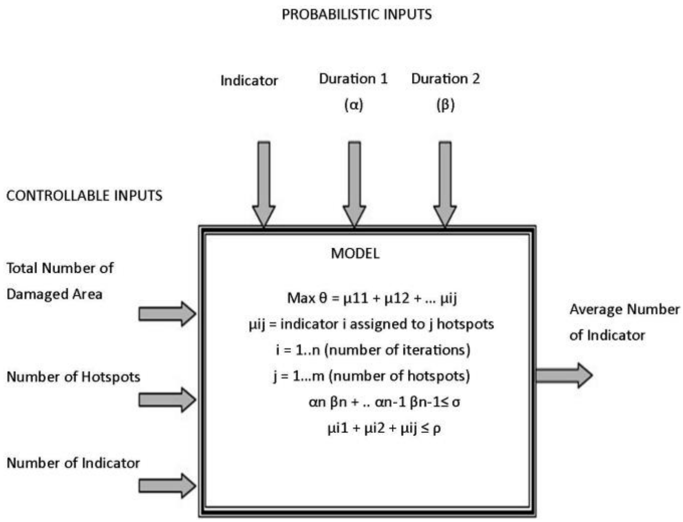

Figure 2. Diagram of the risk simulation model (Carandang & Banaguas, 2014).

Research Question 3: What areas of Saguday are most sensitive to the hazards?

To determine the levels of risk each barangay is facing, the geographic information system modelling and the risk rank system were used. Using the geographic information system (GIS) modelling, the three parameters of risk (hazard, exposure, and vulnerability) were mapped. This was used to identify the most vulnerable areas during climate change and other related events. On the other hand, the barangay with the highest risk was determined using the risk rank system. This particular method provides the order of the most susceptible areas during extreme perils. This is a significant stratagem in order to identify what area needs a particular assistance and attention from the threats of a pandemonium.

Research Question 4: What approach is most appropriate for Saguday in order to mitigate the impacts of climate change?

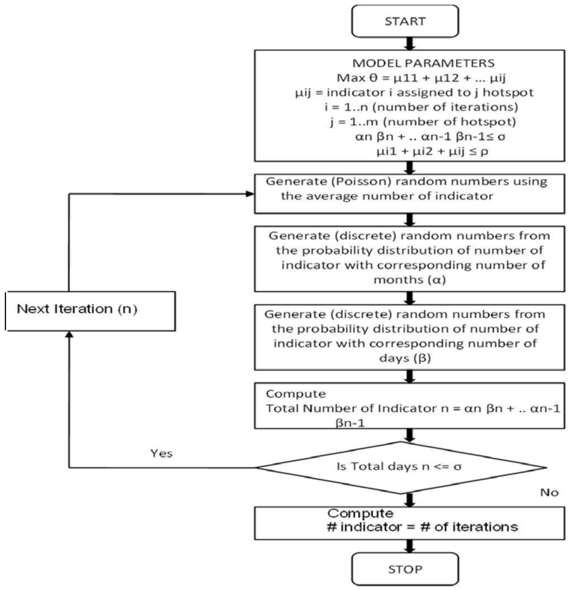

Figure 3. Flowchart of Risk Simulation Modelling (Carandang & Banaguas, 2014)

The outputs from the risk assessment were further evaluated for policy formulation and evaluation through consultations in the form of key informant interviews of local heads and focus group discussions with the officials of each barangay. The existing disaster management strategy was checked for conformity with the local and international laws essential to a community. Figure 4 provides the steps in risk management and was used as a guide in evaluating the current disaster risk management policy of Saguday. Based on the results of consultations with the community leaders, a modified DPSIR model was developed for the formulation of an upgraded disaster risk management policy more appropriate to their current and future needs.

The DPSIR Framework. The DPSIR model provides a useful cause and effect framework (which is used internationally to explore the relationships between the environment and socioeconomic systems) to introduce the linkages between a natural disaster/climate change–related hazard and PPPs (planning, policy, and program). ***Drivers*** such as hazard, vulnerability, and exposure create ***p****ressures* including tropical cyclones, the Human

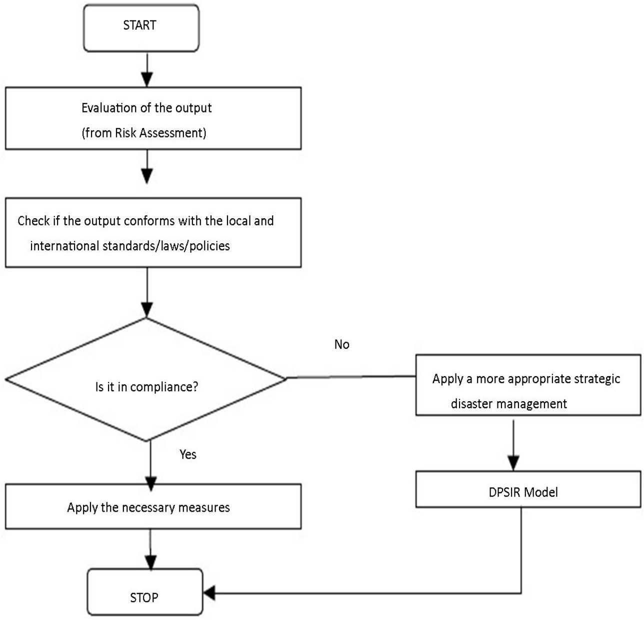

Figure 4. Steps in the risk management (Carandang & Banaguas, 2014).

Development Index (HDI), and population to a ***state*** of the environment/area where there is a greater risk. This leads to social, environmental, and economic ***impacts*** and consequently a need to develop ***responses*** to mitigate the frequency, duration, and intensity of these impacts and risks. Aside from strategies to reduce the risks of hazard, responses can also be targeted towards influencing the drivers, relieving the pressures, and altering the state of the environment that contributes to the problem of risks. Figure 5 describes the DPSIR model adapted from Omann et al. (2009).

Results and Discussion

Risk Studies

Monte Carlo Simulation Output

Climate change has resulted in less and more erratic rainfall, especially in regions where food security is very poor (IPCC, 2007; Funk et al., 2008; Lobell et al., 2008). The risks being faced by the citizens of Saguday

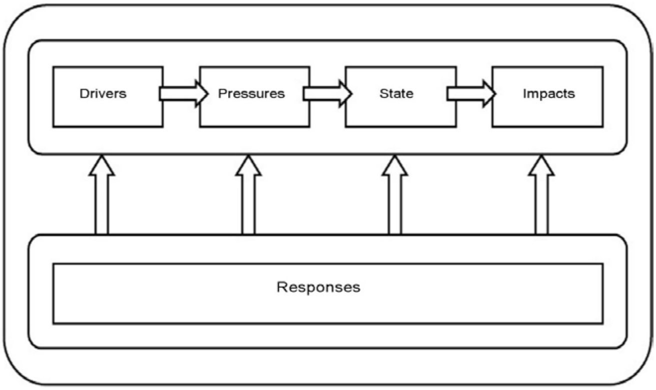

Figure 5. The basic DPSIR model (adapted from Omann et al., 2009)

as brought about by climate change are similar to what our neighbors in Southeast Asia are exposed to. In South Asia, where millions of smallholders depend on irrigated agriculture, climate change will drastically affect river flow and groundwater, the backbone of irrigation and rural economy (Nellemann et al., 2009). Furthermore, high-magnitude flooding often leads to losses of cropland, uprooting of fruit trees, death of animals caught in high floodwater surges, and destruction of infrastructure, such as irrigation facilities and rural roads. The damages done by floods tend to be exacerbated by an ongoing desertification process and land degradation (Wiebelt et al., 2011).

For the hazard studies, 1,000 simulation experiments were performed. The results (see Table 1) suggest that there will be an increase in the number of tropical cyclones (an average of 33) that would enter and would stay for 5 days in the Philippine Area of Responsibility (PAR). These tropical cyclones would place the nine barangays of the municipality of Saguday in a vulnerable situation. There will also be 6 tropical depressions (TD), 10 tropical storms, 14 typhoons, and 6 super typhoons. Furthermore, there would be 20 floodings, and each would last for 3 days. For the projected drought occurrence, five events are projected and each would last for 3 days.

Table 1. Types and Frequency of Occurrence of Hazards During Simulations

Type of Hazard	Frequency of Occurence
Tropical cyclones (TC)	33
Floods	20
Typhoons (TY)	14

Table 1 continued...

Tropical storms (TS)	10
Droughts	5
Super typhoons (STY)	5
Tropical depression	4

Note. Results were obtained from 1,000 simulation experiments using the Monte Carlo method.

To simulate the probable exposure of the population to the hazard, another 1,000 simulations were performed to calculate the optimum number of people that may be exposed to the hazards in Saguday. The population of Saguday was 15,392 as of 2009. Results of the simulation exercise indicated an exposure value for 17,023 individuals or that the whole population of Saguday is potentially exposed to these hazards.

For estimates of vulnerability of Saguday to hazards, the simulated Human Development Index value was 0.77, which suggests that the municipality of Saguday is at the medium level (0.500–0.799) in terms of growth and progress (Virola & Martinez, 2007). This result suggests the capability of Saguday residents to adapt to an extreme event. Take note that the actual Human Development Index of Saguday is 0.78, which is very close to the simulation value.

Calculation of Risks

Risk Calculations in Terms of Casualties per Year

Based on the results of the simulation exercises, there are 33 tropical cyclones (TC) that may enter in the Philippine Area of Responsibility (PAR). The risk in terms of probable casualties per year is expressed as follows:

Table 2. Calculation of Risk in Terms of Casualties per Year.

Risk = Hazard × Exposure × Vulnerability	Probable Casualty per Year (× 1,000)
Tropical cyclone = 33 × 17.023+ × 0.77*	432
Flooding = 20 × 17,203 × 0.77	262
Drought = 5 × 17,023 × 0.77	65

Note. +Calculated exposure value of the Saguday population; *simulated Human Development Index value.

Risk Calculations in Terms of Cost per Casualty per Year

In practice, one's life has been valued to be equivalent to USD 50,000.00 (which is around PhP 2,500,000.00 at USD 1 = PhP 42). This value is the international standard most private and government-run health insurance plans use worldwide (Kingsbury, 2008). However, *if and only if* a fatal outcome really enters into the question can the risk be gauged to its financial correspondence. To estimate the cost per casualty per year, the following calculations were made:

Table 3. Calculation of Cost of Risk in Terms of Casualties per Year.

Cost of Risk = Risk × USD 50,000* per Casualty	Cost per Year in Billions of Pesos (1 USD = PhP 42)
Tropical cyclone = 432,554/year × USD 50,000/casualty	908
Flooding = 262,154/year × USD 50,000/casualty	550
Drought = 65,538/year × USD 50,000/casualty	137

Note. *Estimated value of one's life (Kingsbury, 2008).

Budget Allocation by the Local Government Unit (Municipality of Saguday)

According to Sec. 324-d of the Local Government Code of the Philippines (Republic Act 8185), 5% of the estimated revenue from regular sources shall be set aside as an annual lump sum appropriation for unforeseen expenditures arising from the occurrence of calamities: provided, however, that such appropriation shall be used only in the area, or portion thereof, of the local government unit (LGU) or other areas declared by the president in a state of calamity.

Table 4. Budget Allocation for One Hazard (Municipality of Saguday, 2009)

% of Affected Population (Population Size = 15,392)	Budget Allocation	
	PhP for 5 Days	PhP for 1 Day
100	20	102
80	25	128
60	34	170
40	51	256
20	102	512

Based on the revenue allotment of 2009, the Municipality of Saguday registered a total collection of PhP 31,575,441.91. This was culled from the report of the Comprehensive Land Use Plan (CLUP) in the province of Quirino. Based on 5% of the total revenue, the local government of Saguday can only allot PhP 1,577,782 for the calamity fund. Table 4 provides the summary of the probable affected population and the budget distribution based on the above figure. Apparently, a budget of around PhP 20.00 is allotted per individual for a worst-case scenario. This sum is not even enough to buy a decent meal for each victim.

Identification of Hazard Areas and Intensity of Hazard for Each Barangay

Geographic Information System Modelling Output

Hazard modelling. Extant data collected indicated that Saguday has been experiencing disasters (e.g., tropical cyclones, floods, droughts) for the last 10 years. The figure resulting from the hazard modelling (see Fig. 6) confirms this fact. This finding coincided with the records of the National Disaster Risk Reduction and Management Council (NDRRMC) indicating that Saguday is one of the most susceptible areas in the region during disasters and other extreme events.

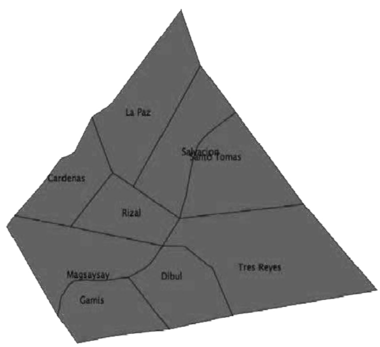

Figure 6. Hazard modelling.

Exposure modelling. Results of the exposure modelling exercises (see Fig. 7) show how differently each barangay of Saguday is exposed to hazards. The redder the color coding of the barangay, the more densely populated it is. Conversely, the more people in the barangay, the more people are exposed to the hazard since the simulation exercises showed that 100% of Saguday's population is potentially exposed to the identified hazards. La Paz, Rizal, and Magsaysay are the three barangays projected to be the most exposed to hazards while Cardenas, Gamis, and Tres Reyes are the least exposed. The intensity of exposure to hazard by the different barangays follows this sequence: La Paz = Rizal = Magsaysay > Salvacion = Santo Tomas = Dibul > Cardenas = Gamis = Tres Reyes.

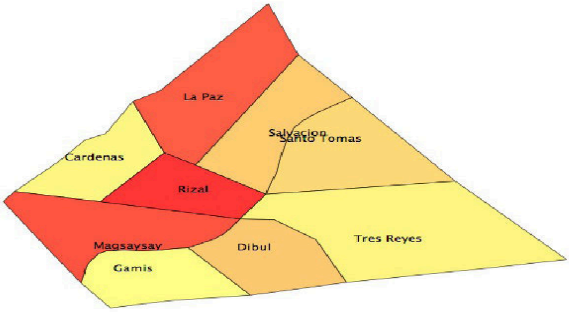

Figure 7. Exposure Modelling.

Vulnerability modelling. Based on these results of the vulnerability simulation exercises, Tres Reyes is the most vulnerable to hazards because it has the lowest capacity amongst the nine barangays to respond to the projected hazards (see Fig. 8). Rizal, Gamis, Dibul, and Cardenas are the most capable of the nine to respond to hazards and thus the least vulnerable. The red color-coded barangays in the figure signifies the highest HDI, and the green should imply a lower HDI although there is no green color-coded barangay in the model. This means that barangays with the redder color have a lower capacity to respond to a hazard. The sequence of vulnerability of the nine barangays is as follows: Tres Reyes > La Paz > Magsaysay = Santo Tomas > Salvacion > Rizal = Gamis = Dibul = Cardenas.

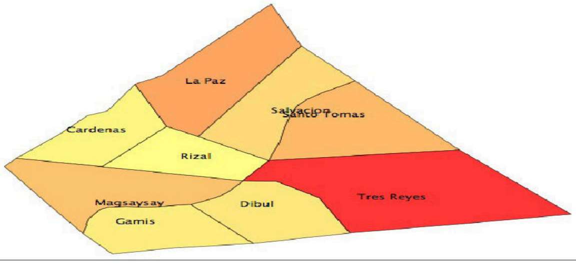

Figure 8. Vulnerability modelling.

Risk modelling. The risk model shown in Figure 9 is the outcome of the integration of hazard, exposure and vulnerability models. Based on the modelling results, the barangays most at risk or the "hotspots" during disaster and climate change modulations are the barangays of La Paz, Magsaysay, and Rizal. The projected risks involve life, property, and livelihood and even food security of the residents of Saguday. The model show that barangays with the redder color are at a higher risk to a hazard event. The barangays by order of decreasing risk factor are listed as La Paz = Magsaysay = Rizal > Dibul = Salvacion = Santo Tomas > Cardenas = Gamis = Tres Reyes.

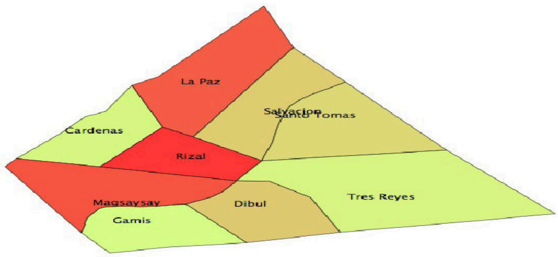

Figure 9. Risk modelling.

Risk rank system. Table 6 in turn provides the order of the most vulnerable areas in terms of their individual ranks per simulated indicator. Based on the results of the study, Rizal, Magsaysay, and La Paz have the largest populations but the lowest capacity to respond to climate hazards. These combined put them at a higher risk that the other barangays although all of the barangays of Saguday are vulnerable to the climate hazards identified.

Table 6. Risk Ranking by Barangay

Barangay	Rank
Rizal	1
Magsaysay	2
La Paz	3
Dibul	4
Salvacion	5
Santo Tomas	6
Tres Reyes	7
Gamis	8
Cardenas	9

Proposed Disaster Risk Management Policy Recommendations

The findings of this project were relayed to local government officials up to the barangay level. A series of meetings in the form of key informant interviews with elected officials and focus group discussions with local residents was conducted during site visits. It was apparent that the citizens of Saguday are familiar with the climate-related hazards and how these affect their lives and compromise the food security of their locality. It was also apparent to them that there is a need for a disaster risk management program that should be formulated and be implemented the soonest time possible. However, the planning and implementation of actions in reducing the risks, mitigating potential losses, and preserving imminent prospects are critical challenges the local government of the municipality of Saguday must face.

A number of risk management approaches to the adverse effects of climate change are found in literature (UNFCCC, 2014). The first is the provision of pertinent insurance schemes to the poorest and most vulnerable localities. Insurance has become a key component of adaptation to climate change and disaster risk reduction because it can provide economic security and enable vulnerable populations to pool economic losses, thereby mitigating the impacts of adverse weather events and avoiding knock-on effects. The type of insurance scheme to be set up should be tailor-made to the actual need of the stakeholders. Another approach is the use of innovative technologies to counter the adverse effects of climate change. Drought-resistant or flood-resistant crops or cash crops that grow well in extreme conditions can be introduced in vulnerable agricultural communities. Fabrication and improvement of postharvest facilities can also minimize spoilage and maximize agriculture outputs. Innovative technologies have been used also as an adaptation option in different economic sectors. The third approach is economic diversification. Economic diversification may be defined as the process in which a growing range of economic outputs is produced. Sectors such as tourism, agriculture, fisheries, forestry, and energy production are all sensitive to the adverse effects of climate change. Mixing more stable sources of income with the traditional economic activities can enable the community to be resilient during adverse conditions. To help the local government to face these challenges, policy recommendations are given below.

Current disaster risk management of Municipality of Saguday. Due to the climate change and extreme events that have been happening in the municipality for the last 50 years, a municipal disaster preparedness plan was developed. This plan focuses on the strategies on how different stakeholders would play their roles during disasters. There was also a contingency plan for typhoons that was prepared by the municipal disaster coordinating council and that helps the entire community to strengthen their disaster control capability. Nevertheless, climate change has been predicted to increase not only the frequency but also the intensity of climate hazards. It is timely that the municipality of Saguday update their disaster risk management program to compensate for the effects of climate change.

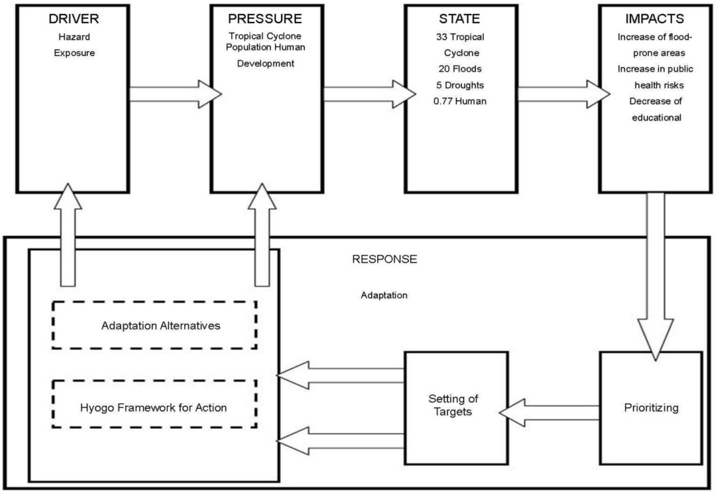

Figure 10. Proposed DPSIR framework for Saguday (Carandang & Banaguas, 2014).

Proposed management system framework. A new disaster risk management framework was developed for the municipality based on the DPSIR model. This model is being proposed to be applied as a strategic management tool. The DPSIR model provides a useful cause-and-effect framework (which is used internationally to explore the relationships between the environment and socioeconomic systems) to introduce the linkages between a natural disaster/climate change-related hazard and PPPs (planning, policy, and program). Drivers such as hazard, vulnerability, and exposure create pressures including tropical cyclones, Human Development Index (HDI), and population to a state of the environment/area where there is a greater risk. This leads to social, environmental, and economic impacts and consequently a need to develop responses to mitigate the frequency, duration and intensity of these impacts and risks through the Hyogo Framework for Action (HFA) and adaptation alternatives. Figure 10 illustrates the proposed DPSIR model.

Adaptation as the main response. The Hyogo Framework for Action (HFA) provides a strategic and comprehensive global approach in reducing vulnerabilities to natural hazards and represents a significant reorientation of attention toward the root causes of disaster risks, as an essential part of sustainable development, rather than on disaster response alone. It stresses the need for greater political commitment and public awareness and defines an expected outcome, three strategic goals, and five priority areas of action (UNFCCC, 2008). This framework is beneficial as a response to the adaptation and disaster risk management. Table 4 identifies the adaptation alternatives that can be applied to the municipality of Saguday. The recommendations given in Table 5 were culled from the results of the key informant interviews of local government officials and the focus group discussions with local residents and the review of the current disaster preparedness plan of Saguday.

Table 5. Proposed Disaster Risk Management Program Policy Recommendations for the Municipality of Saguday

Policy Issues	Recommendations
Lack of infrastructure	Improve flood control system, improve irrigation system, construct food storage facilities, install weather monitoring facilities
Capacity building	Improve environmental education, build staff capacity and infrastructure to implement flood warning system, build capacity in weather forecasting, install hydroclimatic network monitoring, strengthen commodity value chains and find new markets, build knowledge and capacity in adaptation to climate change impacts
Policy development and implementation	Design and implement zoning regulations and building codes, intersectoral allocation, facilitate access to credit, water conservation and demand management (including metering and price structure), compensation for flood damages, develop coastal resource management plans at the barangay levels
Adaptation of best practices	Incorporate risk assessment and mitigation information system into micro-watershed management plans, implement rainwater harvesting

Hyogo Framework for Action (HFA). The *Hyogo Framework for Action 2005–2015: Building the Resilience of Nations and Communities to Disasters* was adopted at the World Conference on Disaster Reduction held in Kobe, Hyogo, Japan, on January 18–22, 2005. It provides a strategic and comprehensive global approach to reducing vulnerabilities to natural hazards and represents a significant reorientation of attention toward the root causes of disaster risks, as an essential part of sustainable development, rather than on disaster response alone. It stresses the need for greater political commitment and public awareness and defines an expected outcome, three strategic goals, and five priority areas of action.

The framework's implementation is identified as primarily the responsibility of the state, but with the active participation of others such as local authorities, nongovernment organizations, the scientific community, and the private sector. Regional and international communities, including the international financial institutions, the UN system, and the International Strategy for Disaster Reduction (ISDR), are called on to provide an enabling environment and to support capacity development. The ISDR system undertakes international efforts to reduce disaster risk and includes governments, intergovernmental and nongovernmental organizations, international financial institutions, scientific and technical bodies, and civil society (UNFCCC, 2008). The Hyogo Framework calls for the following priority actions that can be adopted by the Municipality of Saguday. These are given in Table 6 below.

Table 6. Recommended Priority Actions to Mitigate the Impacts of Climate Change for the Municipality of Saguday

Recommendations	Priority Actions
1. Ensure that disaster risk reduction is a national and a local priority with a strong institutional basis for implementation.	Methodical local risk assessment with the help of the different institutions such as Manila Observatory may coalesce downscaled climate models that focus on projected changes with local-level vulnerability assessments and on current threats in order to increase understanding of climate change/natural disaster impacts on human life, food security, access to natural resources, agriculture, fisheries, marshland other industries. This will require a) reviewing climate risk information available at the local level; b) determining capacities for data collection and use; c) undertaking wide risk profiling with a focus on vulnerable areas, sectors and groups; and d) reviewing the Saguday zoning and land use plan taking into account the danger areas. Furthermore, planning, sufficient budgeting and implementation of risk reduction policies have to be done in order to avoid settlement in hazardous areas and the protection of crops from floodings and drought. For instance, it is a must that there are enough hospitals and schools that are hazard resistant to minimize the perils. Other examples like construction of "day care centers" in certain barangays have to be one of the priorities that will serve as the permanent evacuation centers in times of catastrophes. The construction of dikes and embankments to minimize flood levels and to put up postharvest logistical facilities for temporary storage of harvest during heavy rains and flooding.

Table 6 continued...

2. Identify, assess, and monitor disaster risks and enhance early warning.	Knowing the risks and taking action involves identifying, assessing, and monitoring disaster risk and enhancing early warning are some of the most important things that need to be undertaken and applied in the Saguday area. Enhanced people-centered early warning systems and mechanisms are necessary to allow for early alerts to trigger early action taking into consideration issues of trust and differences in access to information because of gender, social status, or age and people mobility potential. In Saguday, it is not enough to have a warning gadget/ device that will monitor the risks. The siren/warning device should provide sophisticated services such as full automation that will air 8 to 14 km (from southeastern to southwestern point) in order for the people to prepare in advance.
3. Use knowledge, innovation, and education to build a culture of safety and resilience at all levels.	Improved use of climate change/natural disaster information that requires more investment in networks of climate stations, capacity building for interpreting information, user-friendly forecasting tools and products, linkages between service providers (researchers and hydro-meteorological services) and service users (humanitarian actors and climate sensitive sectors), and production of impact outlooks for specific audiences. Also, raising awareness and educating all sectors in the society, through school curricula and segmental trainings to reduce vulnerability, have to be done. These trainings should also be given not only to the educated and professionals but also to the marginalized sectors in the society. Seminars, conferences, and forums should be organized by the overseers to be given to all the barangays. Apparently, these trainings will be conducted and taught by the barangay officials to their different cohorts and subsidiaries. Farmer awareness about drought- and flood-resistant crops should also be enhanced.
4. Reduce the underlying risk factors.	Reducing communities' vulnerability and risk in sectors through land-use zoning and building codes, by protecting ecosystems and natural defenses, and developing insurance and microfinance initiatives can be done by integrating the risk mitigation measures and climate change adaptation. Some of the specifics are the following: a. Adapting agriculture, fisheries, and other industry practices through, for example, adjustment of crop and fishing calendars, and introduction of climate-resilient crop and tree varieties; b. Climate proofing of post-production management practices such as storage, drying and processing; c. Improving sustainable natural and coastal resource management to increase resilience of food production systems;

Table 6 continued...

	f. Investing in infrastructure and hazard proofing critical facilities; and g. Diversifying livelihoods through decreasing dependence on the usual activities, and increasing small-scale enterprise development.
5. Strengthen disaster preparedness for effective response at all levels.	Being prepared and ready to act, which can be maximized by developing and testing contingency plans, establishing emergency funds and coordination systems that are vital and essential at all times. In strengthening this preparedness, the following have to be taken into consideration: a. Expanded contingency planning, especially in areas prone to flood, windstorms or drought, that considers new and evolving risk scenarios and integrates the three "build back better" (3Bs) principles to induce prevention and adaptation in rehabilitation; b. More flexible funding mechanisms at the international level that allow development and humanitarian resources to be invested in preparedness; c. Preparedness for diversified livelihoods response options combined with social protection measures both to individuals and households; and d. Proper communication through responsible avenues with the use of TV and radio stations.

Conclusion and Recommendations

The results of the study indicate the vulnerability of Saguday, Quirino, to climate hazards, that is typhoons, floodings, and drought. It was projected that Saguday will experience 33 typhoons with 20 floodings that would stay 3 days per flooding. Five drought occurrences with a duration of 2 days each were also projected. When these disasters occur, food production and availability in the municipality will certainly be affected. The forecast derived from the present study is comparable with those made by the National Disaster Risk Reduction and Management Council (NDRRMC). Amongst the nine barangays of Saguday, Tres Reyes is the most vulnerable to the three hazards although it is third only to Gamis and Cardenas in terms of risk exposure. To lower the vulnerability of Saguday to these hazards, it is recommended that infrastructure support to coastal resource management be improved; technical capacity building be conducted to improve weather surveillance, disaster preparedness, and environmental infrastructure buildup; environmental policy implementation be improved; and best practices to alleviate the impacts of climate change particularly on food production and security into the governance and management of Saguday be incorporated. The DPSIR model and the Hyogo Framework for Action (HFA) were used as a guide for this pursuit.

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