Modeling Tropical Cyclones using the TRIP Framework

Glenn Banaguas
Environmental and Climate Change Research Institute
University Research Center
De La Salle Araneta University
email glenn.banaguas@delasalle.ph

Abstract: Tropical cyclone, a recurring meteorological cataclysm, has been the eye for the diminution of the immense impacts and colossal risks to the populace and to the agricultural panorama. Track-Risk-Impact-Policy (TRIP) Modeling, a newly disaggregated approach, is used to provide a dynamic impetus to address the threats of the environmental tumult. The tropical cyclones at their most intense from the period 1950 to 2009 were considered and assessed using the decadal and monthly analyses in order to identify the tracks and hotspots. Monte Carlo simulation was done to determine the optimum risk in terms of hazard (tropical cyclones), exposure (population), and vulnerability (poverty incidence) for the risk modeling. The use of Quantum Geographic Information Systems (QGIS) was also utilized to model the impacts (e.g. agricultural damages and losses) during the mutilated visits of the most destructive tropical cyclones. With the integration of the Hyogo Framework for Action (HFA), environmental policies that respond to the catastrophic patterns and processes were expansively analyzed and ensured for the attainment of the Millennium Development Goals.

Key Words: Tropical Cyclones; tracks; risks; impacts; policies; Hyogo Framework for Action; Millennium Development Goals

1. Introduction

Tropical cyclones are the most ruinous of natural peril both because of the loss of human life they cause and the significant economic losses they rouse. Vulnerability to tropical cyclones is becoming more prominent because the fastest population growth is in tropical regions like the Philippines. Understanding tropical cyclone genesis, development and associated characteristic attributes has been a challenging focal point over the last several decades. In recent years, attempts to associate tropical cyclone trends with climate change resulting from greenhouse warming has led to additional attention being paid to tropical cyclone prediction (e.g., Emanuel 1987; Evans 1992; Lighthill et al. 1994). Exploring possible changes in tropical cyclone activity due to global warming is not only of theoretical but also of practical importance.

A tropical cyclone (TC) is the generic term for a non-frontal synoptic scale low-pressure system originating over tropical or sub-tropical waters with organized convection and definite cyclonic surface wind circulation. Tropical cyclones with maximum sustained surface winds ranging from 45 to 61 kph are generally called "Tropical Depressions (TD)". Once a tropical cyclone achieves surface wind strengths of 62 to 117 kph, it is typically called a "Tropical Storm (TS)". If the surface wind reaches 118-239 kph, the storm is called a "Typhoon (TY)". And if the surface wind achieves more than 240 kph, then it is called “Super Typhoon (STY)”.

In the Philippines, despite the high annual losses, the broad macroeconomic impacts are relatively difficult to trace. This is because only the major disasters (e.g. Tropical Storm Ketsana or “Ondoy” in 2009, Super Typhoon Megi or “Juan” in 2010, Tropical Storm Washi or “Sendong” in 2011 etc.) are generally regarded as economically significant events. The macroeconomic ramification impacts of, cumulatively, considerable direct damage as a consequence of annual tropical cyclones is ignored except in years of exception losses.

In order to highlight the challenges posed to the Philippine economy both now and in the future, it is therefore necessary to take a more disaggregated approach, focusing on some of the country’s most vulnerable sectors - the agriculture. The TRIP (Track-Risk-Impact-Policy) Modeling solution, exploring the direct impacts and risks of the major hazard on specific areas and tracking the indirect and secondary effects through the economy may be far more illuminating in understanding vulnerability and the challenges posed to sustainable development and in identifying opportunities to strengthen resilience both of individual sectors and sub-sectors and the economy more broadly.

2. METHODOLOGY

2.1 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 (UNISDR), Ateneo De Manila University (ADMU), Manila Observatory (MO), National Disaster Risk Reduction and Management Council (NDRRMC) and the Bureau of Agricultural Statistics (BAS).

The period from 1950 to 2009 was utilized in the study.

2.2 *TRIP (Track-Risk-Impact-Policy) Modeling*

TRIP (Track-Risk-Impact-Policy) Modeling Framework as described in Figure 2.1 was formulated and used in the study in order to address the enigmatic conditions brought by the tropical cyclones.

Figure 2.1 TRIP Model

3. RESULTS AND DISCUSSION

3.1 Track Modeling

Tropical cyclones are formed at the Western North Pacific Ocean, which includes South China and the Philippine seas. At the most intense, these Tropical Cyclones make their landfall on the provinces of Bicol, Cagayan, and Central Luzon. Other areas such as CALABARZON, Cordillera, National Capital Region, Ilocos, and MIMAROPA have lesser number of cyclone visits while Visayas (Eastern, Western, and Central Visayas) and Mindanao (CARAGA, Northern Mindanao, Zamboanga Peninsula, ARMM, Davao, and SOCCSKSARGEN) have the least as shown in Table 1. The track of these Tropical Cyclones is from the eastern to the northern region.

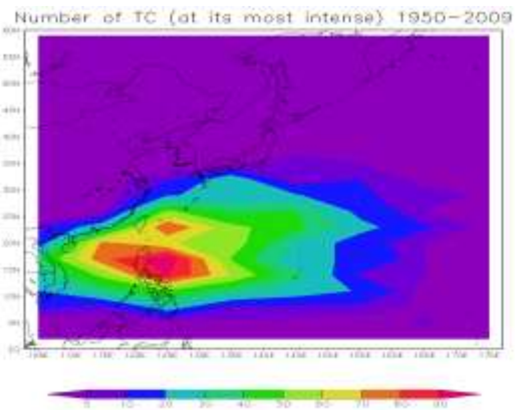

Figure 3.1 Track Model (1950-2009)

Figure 3.1 shows that from 1950 to 2009, there were 1785 tropical cyclones entered the Philippine Area of Responsibility. The highest number of cyclones occurred from 1960 to 1969, which constitutes 20% of the total cyclones. This is followed by the 1990-1999 decade that comprises 19% of the whole. It is also simulated that 17% of the cyclones occurred in the period 2000-2009 followed by the 1970-1979, which comprises 16%. The two decades, 1980-1989 and 1950-1959, share the 15% and 12% of the totality.

Most of these tropical cyclones occurred in the months of July, August, September and October. The highest number of tropical cyclones is observed during the period of 1960-1969 followed by 1990-1999 decade. The month of August is the month wherein most of these cyclones make landfall in the Philippine Area of Responsibility. It encompasses twenty percent (20%) of the total number of cyclones. This is followed by the month of September that comprises eighteen percent (18%) of the whole. October and July shares the fifteen percent (15%) and thirteen percent (13%), respectively. The month that has the least number of tropical cyclones is February.

Table 3.1. Regions with the most number of intense Tropical Cyclones (TCs) from 1950 to 2009

Regions	Number of TC	Rank
Bicol Region	156	1
Cagayan Valley	147	2
Central Luzon	147	2
CALABARZON	147	2
Cordillera	130	3
NCR	130	3
Ilocos Region	130	3
MIMAROPA	130	3
Eastern Visayas	113	4
Western Visayas	113	4
Central Visayas	95	5
CARAGA	78	6
Northern Mindanao	78	6
Zamboanga Peninsula	61	7
ARMM	61	7
Davao	43	8
SOCCSKSARGEN	26	9

3.2 Risk Modeling

The risk is quantified using the United Nations International Strategy for Disaster Reduction (UNISDR) equation, R=f(H,E,V); where R is the risk, H stands for hazard, E stands for exposure, and V stands for vulnerability.

For the hazard, the Global Climate Model demonstrates that there would be a tremendous increase in the number of tropical cyclones that would enter in the Philippine Area of Responsibility and apparently would put Luzon, Visayas, and Mindanao at a vulnerable scenario. It exhibits a total number 2088 tropical cyclones in the next sixty years with an average of 348 cyclones per decade. Based on the simulations, one tropical cyclone would stay in the main area for a maximum of five (5) days.

In terms of exposure, a simulated value of 96 Million individuals would be at risk. This signifies that this augmented average number of population would be in a probable fatal outcome.

For the vulnerability, the simulated Poverty Incidence value is 26.9 in the entire country. This value is 9% higher than the estimated data conducted by the National Statistics Coordination Board (NSCB) in 2009. This means that the "poorer would become poorer" once a probable environmental tumult happens.

It can also be seen in Figure 3.2 that the area at high risk is in Luzon due to the simulated number of tropical cyclones and its exposed large population. The poorest sector (e.g. agriculture) in this major island will become more poverty-stricken since it is the direct receptor of the hazard. With this kind of condition, there is a high probability that the region will suffer more than one (1) casualty a year. Visayas is considered to be less susceptible to a peril due to its fewer cyclone visits and lesser-settled population. Mindanao, which is the most impervious of the three major islands, has a more populated area than Visayas but there are diminutive numbers of meteorological hazards. This makes Mindanao less susceptible to risk.

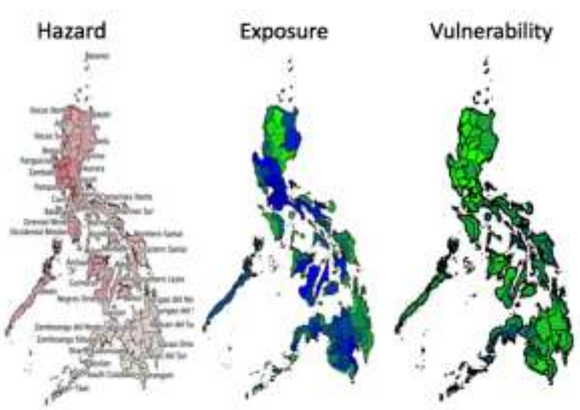

Figure 3.2. Simulated Risk as a function of Hazard, Exposure and Vulnerability

3.3 Impact Modeling

For the last three decades, there is a colossal upsurge of damages and losses that were brought by the most destructive tropical cyclones in the agricultural sector with an estimated cost of Php 138,488.893 Millions. This is an alarming condition since the increase happens in a decadal state of affairs. From 1980 to 1989, Php 16,284 Millions worth of agricultural goods were devastated. Sixty-nine (69%) escalation, which is around Php 51,775 Million, ensues after the mutilation. The damage also augments by twenty-eight (28%) from 1990-1999 to 2000-2009. This decadal rise of damage is a validation of the findings of the Intergovernmental Panel on Climate Change (IPCC) Assessment Report 2007 wherein the effects of intensity and frequency of tropical cyclones may exacerbate the socio-economic and environmental conditions of the country. Figure 3.3 describes the damages and losses in the agricultural sector brought by the meteorological tumult.

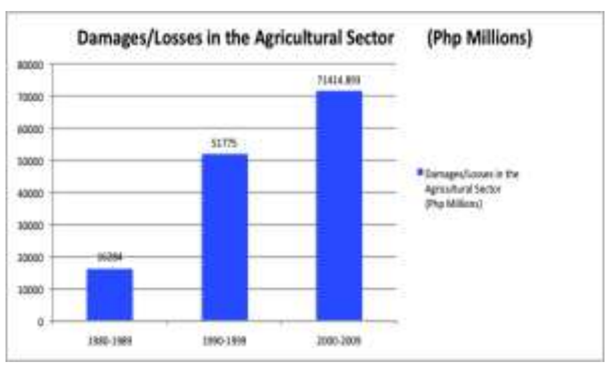

Figure 3.3. Damages and Losses in the Agricultural Sector (Php Millions)

3.4 Policy Modeling

There are three Republic Acts that were assessed in this study. They are as follows: (a) the Republic Act 7160, which is also known as the Local Government Code (b) Republic Act 10121, which is the Philippine Disaster Risk Reduction and Management Act of 2010; and (c) the Republic Act 9729, which is the Climate Change Act.

According to Section 324-d of the Local Government Code, five (5%) of the total revenue of the local government unit (LGU) should be allotted to the calamity fund. This is also stipulated on the other Republic Act, RA No. 10121 under Section 21 wherein a local calamity fund, which is the Local Disaster Risk Reduction and Management Fund, amounting to not less than five percent (5%) shall be set aside to support disaster risk management activities. Thirty-percent (30%) of this allocated amount shall be used for the Quick Response Fund. The same allotment is also mentioned in Section 18 of the Climate Change Act but there are no specific details how much a certain LGU or any government agency will provide.

For instance, the unforgettable mutilated visit of Tropical Storm Ketsana or "Ondoy" in one of the urban areas of the metropolis, the Marikina City, sixty million (Php 60 Million) was allotted for the calamity fund. It was found out that this was not adequate when sixty percent (60%) of the population was affected. It was estimated that the budget allocated was only Php 5.21 per individual.

This condition in Marikina was also validated in a rural coastal area in one of the Municipalities of Camarines Sur, Bicol. Cabusao, which is a fifth-class municipality, is also a hotspot of tropical cyclones. Using the revenue allotment of 2009, the Municipality of Cabusao registered a total collection of Php 10,053,996 (www.dbm.gov.ph). And using the five percent (5%) of the total revenue, the local government of Cabusao allotted Php 502,699.80 for calamity fund. It was calculated that this financial resource is inadequate to provide assistance to the affected individuals. A budget of Php 8.00 was given when sixty percent (60%) of the population was impinged on.

In the agricultural sector, Super Typhoon Megi, "Juan", a peril that entered in the Philippine Area of Responsibility (PAR), brought a pandemonium in the economic panorama of the country. More than Php 6,000,000,000.00 (Php 6 Billion) worth of agricultural lands, plantations, fishponds, and commodities were lost due to its meteorological strength. Provinces such as Abra, Apayao, Benguet, Ifugao, Kalinga, Mt. Province, Ilocos Norte, Ilocos Sur, La Union, Pangasinan, Cagayan, Isabela, Aurora, Bulacan, Nueva Ecija, Pampanga, Tarlac, and Zambales were affected. Their collective calamity funds for the affected individuals or households were not sufficient to address the said quandary.

This perennial dilemma of the three Republic Acts has been addressed not by the funds augmentation (e.g. calamity fund increase) but by the different disaster risk reduction and management schemes and adaptation capacities that were adopted from the international laws/policies such as the Hyogo Framework for Action (HFA). The CCA-DRR schemes are significant in order to reduce vulnerability and increase the resiliency level of the different sectors in the society, specifically the agriculture.

Food crop and fruit sector: (a) introduction and evaluation of crop varieties and lines to different agro climatic conditions; (b) breeding of new varieties; (c) Introduction of new crops; (d) evaluate varieties suitable for changing agro-climatic conditions such as drought, heat stress, high salinity, disease-resistance; (e) evaluation of crop production under protected culture; (f) optimizing water use efficiency; (g) drip irrigation in vegetable and fruits; (h) promote sustainable agricultural practices such as soil conservation, integrated plant nutrient management, integrated pest management and others

Livestock Sector: (a) modify the environment to minimize heat stress (cooling, shading); (b) provide adequate water; (c) lower stocking densities to minimize mortality; (d) provide better quality feed; (e) breeding for breeds resistant to heat stress

Capacity Building: (a) improve environmental education; (b) build staff capacity and infrastructure to implement flood warning system; (c) build capacity in weather forecasting; (d) hydro-climatic network monitoring; (e) strengthen commodity value chains and find new markets; (f) build knowledge and capacity

Policy: (a) design and implement zoning regulations and building codes; (b) inter-sectoral allocation; (c) facilitate access to credit; (d) water conservation and demand management; (e) compensation for flood damages;

4. CONCLUSIONS

In this study, the evidence implies that the frequency and intensity of tropical cyclones is a mounting and increasing phenomenon and becoming a vital issue not only in the national and international arena and policy-making entities but also to the communal parties. Track-Risk-Impact-Policy (TRIP) Modeling provides a dynamic impetus that created a panorama of genesis, resiliency, and progress. The colossal figure of the meteorological hazard would continue to intensify in the future and would give immense bearing and massive impacts to the populace and to the agricultural assets. The uncovering issue of worst-case scenario might be idyllic due to its plausible outcome but should be dealt with apposite solution and recommendations. The policies and frameworks that are only emerging right now due to sequential extreme events lack coherent conceptual accounts on specific areas (e.g. financial assistance, structural limitation, normative frameworks) that need particular attention. These must be altered and modified in order to provide an effective backcloth both for national and local action for the people and the environment.

section must summarize the key findings of the study and describe potential areas for further research.

5. REFERENCES

ADB. (2008). Country Environmental Analysis 2008

Banaguas, Glenn S. (2011) Hydrometeorological Risk Analysis of Climate Change in the City of Malabon, International Refereed Journal of Interdisciplinary Sciences

Jones, Roger (2001). An Environmental Risk Assessment/Management Framework for Climate Change Impact Assessments, Natural Hazards

Local Government Code of the Republic of the Philippines

Manila Observatory

O'Brien, K., Sygna, L.(2008). Disaster Risk Reduction, Climate Change Adaptation and Human Security, A Commissioned Report for the Norwegian Ministry of Foreign Affairs, Report 2008, ISSN:1504-5749

Omann, I., Stocker, A., and Jager, J. (2009). Climate change as a threat to biodiversity: an application of the DPSIR approach