
Risk Assessment of Basic Social Services in the Province of Bukidnon

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Abstract

This study conducted a risk assessment and formulated a model to measure the disaster risk reduction of selected flood-prone and landslide-prone barangays in the Province of Bukidnon. It specifically focused on the basic social services on food, water, electricity, and health. Primary and secondary data were used to establish hazard and population density maps to determine the exposure of communities during disasters. Further, the adaptive capacity (CA) of a local government unit (LGU) to respond to disasters was computed. Key findings revealed that exposed communities could be classified into various levels of susceptibility. Using the model, results revealed that the reduction of risk depends on the adaptive capacities and risks of LGUs. Further, efficiency to address risk is a ratio between the adaptive capacity and risk. Thus, the higher the adaptive capacity of LGUs would mean better efficiency in disaster risk reduction.

Keywords and phrases: Disaster risk assessment, adaptive capacity, hazard, social services, reduction

Introduction

Some of the regions of the Philippines have recently experienced disasters that brought unexpected environmental devastation and loss of thousands of lives. It is a very alarming circumstance because these disasters, both natural and anthropogenic, seem to continue to occur in the future. As reported by the United Nations, countries in Asia and the Pacific are more prone to disasters than those in other parts of the world. Following the typhoons Ondoy (Ketsana) in 2009, Pablo (Bopha) in 2012, Sendong (Washi) in 2011, and Yolanda (Haiyan) in 2013 that hit some parts of the Philippines, causing negative effects on human physical, emotional, financial, and social well-being coupled with the destruction of properties,

assets, and environmental degradation, the country is taking its course to prepare for emergencies and mitigation measures.

A growing concern for disaster risk reduction is most apparent in national, regional, and even local regions. Raising disaster risk awareness of the community through disaster campaigns is one of the various programs that local government units have simply started. However, one very important step of risk reduction is to identify and analyze the potential risk that may happen in other areas or regions so that no similar disastrous event will occur or at least be lessened. This can be done through a comprehensive risk assessment that provides a

full understanding of the causes and impact of those losses.

Disaster risk reduction logically begins with risk assessment. Risk reduction entails knowledge of the hazards, physical, economic, and social risk exposure, and vulnerability of groups of people to these risks. As a process, disaster risk is defined by the UNDP as the probability of harmful consequences resulting from the interaction between natural or human-induced hazards and vulnerable conditions (UNDP, 2010). Risk assessment, on the other hand, often brings with it reviews of the technical features of hazards, such as their location, intensity, location, frequency, and probability. It further analyzes the physical, social, economic, and environmental factors of vulnerability and the elements at risk (exposure) in a given area. Such assessment will be used as a starting point to identify the social services provided by the local government units and other concerned agencies for the communities in the devastated areas. Water, food, shelter, electricity, and medicines are some of the necessities that are difficult to obtain due to disasters. In this particular study, the focus is on selected barangays in the Province of Bukidnon, a mountainous province, which is relatively free of the hazards attendant to storm surges and tsunamis but is exposed to other natural hazards such as flooding, landslides, and earthquakes. The traditionally considered vulnerable sectors of indigenous people and the poor live on mountain sides, leaving them exposed to landslides. When hazards of relatively large magnitude strike, the ability of government agencies responsible for basic social services to respond is yet to be established.

Disasters are increasingly felt and experienced by many countries globally, bringing various issues and concerns on risk reduction. Research on disaster risk reduction shows different conscious governance issues on policy, planning, legal and regulatory frameworks, administrative arrangements, resources and funding, and organization and structure.

The United Nations (UN, 2010) reported selected case studies on local governments and disaster risk reduction that address specific policy areas, including risk assessment, recovery, building structures, and water resource management. For example, the improvement of a flood early warning system is evident in Jakarta, Indonesia, while in Nepal Chitwan District, Nepal, has agricultural livelihood protection through flood mitigation and drought preparedness. In Saijo City, Japan, a risk-awareness program for schoolchildren and communities was developed, and an awareness-raising initiative against flood risk was also done in France. On the other hand, Taiwan developed an earthquake disaster assessment model to apply to risk management in the tourism industry. Other cases also emphasized institutional strengthening and local capacity building on different hazard types such as flood, water logging, and riverbank erosion. In the Philippines, a similar study on disaster risk reduction and management was conducted by Mohammed (2017) in Tarlac City. Based on the result, the thematic action plans of the City were aligned with the Sendai Framework for disaster risk reduction, which is evident in the list of programs and projects in their action plans. Domingo and Manejar (2018) also posited that policies have to be revisited, institutional arrangements have to be reviewed, and resource mobilization issues have to be addressed. These various initiatives resulted to further community development that has helped reduce disaster vulnerability. Risk reduction on physical, economic, and social risks in Risk assessment often begins with it reviews of shelter that focus on hazards

Conceptual Framework

The interaction among the elements of risk assessment, namely, hazard, exposure, and vulnerabilities, is vital to effective disaster prevention (Wisner et al., (1994). La Trobe and Davis (2003) reached similar conclusions, observing that the low priority afforded to risk reduction by development and disaster response specialists was due to a lack of knowledge

on, and understanding of, the cultural divide between the two realms, where risk reduction is not fully owned by either, and the perception that risk reduction competes with other development agenda and pressing needs.

The UNISDR Strategic Framework (2016-2021) in support of the Sendai Framework for Disaster Risk Reduction (2015-2030) substantiated that the reduction of disaster risk is essential to sustainable development. The framework further supported that the key to a successful management of disaster risk should be a risk-informed development.

The comprehensive risk assessment for local capacities as implemented by the United Nations Development Program (UNDP) (2010) in the Philippines consists of the following steps: (1) understanding of current situation to assess what already exists, avoid duplication of efforts and build on information and capacities; (2) hazard assessment identifies the nature, location, intensity and likelihood of major hazards prevailing in the community; (3) exposure assessment identifies population and assets at risk and delineates disaster prone areas; (4) vulnerability analysis aims to determine the capacity (or lack of it) of elements at risk to withstand the given hazard scenarios; (5) loss/ impact analysis estimates the potential losses of exposed population, property, services, livelihoods and environment and assess their potential impacts on society; (6) risk profiling and evaluation identifies cost-effective risk reduction options in terms of the socio-economic concerns of a society and its capacity for risk reduction; and (7) formulation and revision of DRR strategies and action plans that include setting priorities, allocating resources (financial or human) and initiating DRR programs.

Risk can be minimized by understanding its components, namely, hazard, exposure, and vulnerabilities. The UNISDR Strategic Framework (2016-2021) in support of the Sendai Framework for Disaster Risk Reduction (2015-

2030) substantiated that the reduction of disaster risk is essential to sustainable development. The framework also supported that the key to a successful management of disaster risk should be a risk-informed development. The Sendai Framework for Disaster Risk Reduction (2015-2030) recognized that the state has the primary role to reduce disaster risk. Further, the framework stressed that to reduce risk is a shared responsibility among stakeholders, which includes the local government.

The 2019 report of UNDRR conveyed the various approaches for building the resilience of communities. These ranges from highly technical and resource intensive to simple and inexpensive practices. These approaches may provide local governments ideas on how risks be reduced. The report also included the scorecard assessment progress of local governments in the achievement of the Sendai Framework. Likewise, the UN Global Assessment Report (2019) underscores the need of local governments to manage disasters and risks.

As illustrated in Figure 1, the elements of risk involve the related notions of exposure (E), hazard (H), and vulnerability (V) about the general framework for disaster risk. The concept of "risk" connotes losses and negative impacts of disasters and calamities. It involves the related notions of exposure (E), hazard (H), and vulnerability (V) about the general framework for disaster risk. Figure 1 also presents that Risk is a function of exposure hazard and vulnerability ($R = f(H, E, V)$). As DRR agreed in the 2011 United Nations GFDRR in South Korea, (UN-GFDRR, South Korea, July 2011). It is estimated that of the annual US\$10B allocated for calamity assistance, only 4% is earmarked for disaster preparedness and risk reduction by the United Nations (UNDP, 2012); whereas a significant portion of both human and economic losses could have been averted had greater attention been given to the latter by countries worldwide.



Figure 1. Schematic diagram showing the parameters of the study.

The first element of exposure includes the people, buildings and structures, infrastructure, economic activities, and public services exposed to hazards in a given area. Hazards are potentially damaging physical events, phenomena, or human activities, which may cause the loss of life, physical damage, environmental degradation, and social and economic disruption. Hazards may be defined as either natural (floods, landslides, cyclones, earthquakes, and volcanoes) or human-made (inappropriate policies, accidents, war, and conflict). Vulnerability refers to people's susceptibility to a given hazard, which is determined by the extent to which they can anticipate, cope with, respond to, and recover from its impact (Wisner et al., 2003). This is further defined as a set of conditions and processes resulting from physical, social, economic, and environmental factors.

The objective of this study is to strengthen governance capacity to increase resilience and minimize the vulnerability of communities on basic social services. To do this, disaster risk reduction (DRR) has to be determined. Disaster risk reduction refers to the prevention, preparedness, and mitigation of risks. Disaster risk reduction programs (DRR) begin with risk assessment. Risk assessment then requires information on the hazards (H) attendant to natural disasters, such as knowing "when and where" disasters are most likely to happen, how

often, and how intense.

In this study, risk assessment is done at the selected flood-prone and landslide-prone barangays of the province of Bukidnon. Hazard and population density maps are established to determine the susceptibility to disasters and formulate a model for disaster risk reduction of a locale. The basic social services are looked into where it is observed that these services are commonly needed by the communities in times of disasters.

Objectives

The research aimed to conduct a risk assessment of the selected flood-prone barangays in the Province of Bukidnon. Specifically, to:

1. establish hazard and population density maps at the barangay level;
2. establish population density maps at the barangay level;
3. overlay hazard and density maps to determine exposed elements; and
4. determine the capacity of LGUs to respond to disasters in terms of basic social services.

Methodology

The study utilized mixed methods research designs that include both quantitative and qualitative methods of research. In the establishment of the hazard and population density maps, shapefiles were used. Data for the maps were sourced from the Philippine GIS, NAMRIA, Philippine Statistics Authority, and Mines and Geosciences Bureau. Spatial analysis was employed to analyze the maps in terms of susceptibility to flood and landslide using QGIS.

In the computation of the DRR and other components, data used were from the GIS generated maps and actual data from the respective LGUs. The unit of analysis was then identified in the LGUs and concerned agencies.

Before the implementation, a proper protocol was observed in the selected locale. The researchers presented and requested permission from the local chief executives together with the DRRM coordinators and barangay captains of the two cities, three municipalities, and six barangays. Meetings were set for this purpose. Figure 2 shows the baseline map of the locale. These are as follows: (1) Barangay Guihean, Impasugong; (2) Barangay Aglayan, Malaybalay; (3) Barangay Batangan, Valencia City; (4) Barangay Magsaysay; (5) Sampaguita, Kibawe; and, (6) Barangay Palacapao, Quezon.

Establish hazard and density maps at the barangay level

The hazard maps of the six (6) barangays included in the study are presented in Appendix A. Significant data from the maps include the estimated area in hectares, elevation above sea level, population, population density, and several households. In the generated maps, levels of susceptibility are indicated. In the landslide-prone areas, there are three (3) ratings from the Mines and Geosciences Bureau (2012), namely: (1) low, (2) moderate, and (3) high susceptibility. For low susceptibility, these are areas with low gentle slopes and lacking tension cracks. While moderate susceptibility are those areas with inactive/ old landslides and tension cracks away from the communities, and the high susceptibility are areas with active/ recent landslides and tension cracks that would directly affect the community. Table 1 shows the various levels of susceptibility indicated in the landslide-prone areas and the land areas affected by hazard ratings.

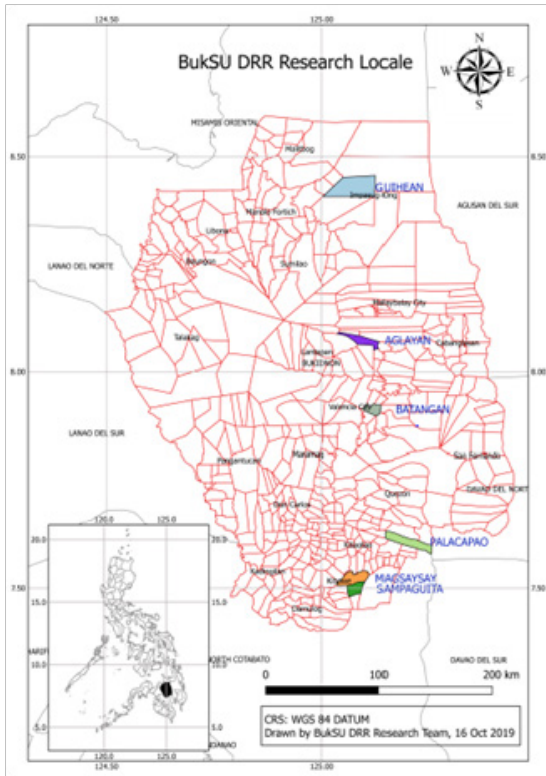


Figure 2. Baseline map of the locale

Results and Discussions

This section presents the results and discussions on the objectives of the study. The first part is on establishing the hazard and density maps specific to the barangay level. The second part is on the overlaying of these maps and analyzed, particularly on the exposed elements. The third part is on the application of the DRR model in the barangay setting.

Table 1. *Land Area of the Barangays Affected by Hazards (Flood or Landslide) and Susceptibility Ratings*

| Barangay | High Susceptibility | | Moderate Susceptibility | | Low Susceptibility | | Total Land Area |
|--------------|---------------------|----|-------------------------|----|--------------------|----|-----------------|
| | Area (in ha) | % | Area (in ha) | % | Area (in ha) | % | |
| Sampaguita * | 432.0 | 39 | 121.9 | 11 | 553.9 | 50 | 1107.74 |
| Magsaysay * | - | - | 1356.0 | 69 | 609.2 | 31 | 1965.20 |
| Palacapao * | 24.9 | 1 | 596.9 | 24 | 1865.4 | 75 | 2487.22 |
| Aglayan ** | 0.0 | | 478.7 | 32 | 1017.2 | 68 | 1495.92 |
| Guihean * | 708.1 | 13 | 1252.8 | 23 | 3486.1 | 64 | 5447.01 |
| Batangan ** | 798.1 | 84 | 152.0 | 16 | 0.0 | | 950.14 |

Note: Data are based on GIS generated maps.
 * landslide
 ** flood

Among the barangays identified as flood-prone areas, there are only two ratings: low to moderate susceptibility and high susceptibility. Table 2 summarizes possible affected families and individuals during hazards (landslide and flooding). Low to moderate ratings are for those areas with less than 1.0 meter-flood height, which are usually flooded during

prolonged and extensive heavy rainfall or extreme heavy condition. Simultaneously, a high flood susceptibility rating is for those areas with greater than 1.0 meter-flood height. These areas are usually flooded for several hours during heavy rains, including land forms of topographic lows such as river channels, abandoned river channels, and areas along river banks prone to flash floods as in the case of Barangay Batangan, Valencia City. The hazard maps identified Barangay Aglayan as susceptible from low to moderate landslide-prone areas. However, based on the recorded disasters for the last five years, the barangay experienced flooding because human activities contribute to flooding. It has been observed that the existence of banana plantations is prevalent in the vicinity. Thus, the occurrence of flooding is human-induced.

The population density maps of the six (6) barangays are presented in Appendix B. The hazard maps are obtained following a process using QGIS software. The process includes the input of the shape file of landslide susceptibility of each barangay. Consequently, these are categorized according to the susceptibility to hazards such as low, moderate, and high. Next, the barangay shapefile is overlaid to the hazard susceptibility. Finally, the rivers, roads, and contour shape files are overlaid to complete the hazards maps.

Table 2.
Number of People Affected at Various Hazard (Flood or Landslide) and Susceptibility Ratings

| Barangay | High Susceptibility | Moderate Susceptibility | Low Susceptibility | Total |
|--------------|---------------------|-------------------------|--------------------|-------|
| Sampaguita * | 529 | 172 | 730 | 1431 |
| Magsaysay * | - | 1194 | 537 | 1731 |
| Palacapao * | 29 | 551 | 2319 | 2899 |
| Aglayan ** | - | 1899 | 5696 | 7594 |
| Guihean * | 1660 | 170 | 298 | 2128 |
| Batangan ** | 10049 | 1502 | | 11550 |

Note: Data are based on GIS generated maps.
* landslide
** flood

Finally, the geographical features of the selected barangays are summarized as presented in Appendix D. The geographical features include the following: land area (hectares), elevation (masl), relative location (neighboring barangays), population (number of heads), population density, number of households, and susceptibility to hazards (landslide or flooding).

Barangays Sampaguita and Magsaysay are both located in the same municipality in Kibawe. Both barangays are prone to landslides and earthquakes as experienced by the residents. In Barangay Sampaguita, for instance, as seen from the map is prone to landslide. The land level of susceptibility ranges from low to high. A large portion of the barangay has high susceptibility. Barangay Magsaysay, on the other hand, has the susceptibility of landslide ranging from low to moderate. A large part of the barangay has moderate susceptibility, mostly in the central part, while the southern parts are low. Generally, there is a wide dispersion of the population in Barangay Sampaguita. However, it can be gleaned from the map that it is highly dense in the northeastern part. There is a large concentration of households in the northwestern part.

Palacapao is located in the southern part of the municipality of Quezon. It is accessible via Bukidnon-Davao area highway. This barangay shares borders with Linabo and Lipa to the north; Puntian in the east; and Digongan in the south. The barangay is generally low in susceptibility level in terms of the landslide. There is a high concentration of inhabitants on the western side of the river, while the other side is less dense.

Barangay Guihean is situated on the northeastern side of the municipality of Impasugong with exact coordinates of 8 24 59' 3.01" E. It borders with Barangay Kalabugao on the north; Sayawan on the south; Santiago, Manolo Fortich on the west; and San Vicente, Sumilao on the east. It has an upland area characterized by sloping and rolling hills, as

shown in Figure D-3. Demographics show a majority of the Higaonon tribe residing in the area. Since the barangay is located in a highly elevated area, most residents reside in the provincial road and are situated in a low area. There are residents in the eastern part near the boundary of Barangay Sayawan.

Aglayan is an urbanizing barangay in the city of Malaybalay. Its exact location is 8° 3' 15" N and 125° 8' 9" E, covering a total of 1,495.92 hectares. It is characterized generally by plain areas and with an elevation of 646 meters above sea level. Located strategically, it is a gateway to the municipalities of Lantapan, Cabanglasan, and the cities of Valencia and Malaybalay. It is bounded on the north by Barangay Laguitas; south by Bugcaun, Lantapan; on the east by Linabo; and on the west by Capitan Juan, Barangay Lantapan. The barangay has low to moderate susceptibility levels in a landslide, and generally low. The barangay has proximity to pineapple and banana plantations. Generally, the barangay has a lowland area where the population is widely distributed, as reflected in the map.

Batangan is one of the 31 barangays of the city of Valencia. It is contiguous to the city proper. It is located exactly at 7° 54' 11" N and 125° 5' 55" E. It has a total land area of 950.14 hectares and is generally a lowland area with an elevation of 298 meters above sea level. It is characterized by plains dotted with rice plantation and sugarcane fields. On its eastern side is the Pulangui River, and its flooding remains a challenge to its residents. It is bounded on the north by barangays Tongantongan; on the south by Pinatilan; on the west by Poblacion. Demographics reveal a total population of 11,550 and a population density of 1,215.61. The barangay is mostly surrounded by the Pulangi River. The largest concentration of residents can be found in the western-most part of the area, proximity to the Pulangui River.

Overlay hazard and density maps to determine exposed elements

Table 3 shows the summary of the barangays' disaster susceptibility ratings to flood or landslide as a result of the overlaid hazard and density maps.

Table 3.
Disaster Susceptibility Ratings of the Barangays on Highly Densed Areas

| Barangay | Landslide/Flood Susceptibility Ratings |
|--------------|--|
| Sampaguita * | High |
| Magsaysay * | Moderate |
| Palacapao * | Low to Moderate |
| Aglayan ** | Low |
| Guihean * | High |
| Batangan ** | High |

Note: Data are based on GIS generated maps.

* landslide

** flood

The overlay population density maps with hazard maps are shown in Appendix C. In Barangay Sampaguita, based on Figure C-6, the area with high population density is located in the north eastern part, with low susceptibility to a landslide. However, a large portion in the southern part of the barangay is found to have a high susceptibility to landslide with many populations/residents. Barangay Magsaysay, on the other hand, has a moderate susceptibility to landslide where the population distribution is concentrated. The southern part has a low susceptibility to landslide with a small population.

The majority of the land area in Barangay Aglayan is lowland, which is found to have low susceptibility to landslide from central to eastern parts. Most of the residents are located in areas with low susceptibility to a landslide. However, the western side of barangays, Capitan Juan, Mapayag and Magsaysay has moderate susceptibility to a landslide. Barangay Aglayan

and Cabangahan both experience intermittent flooding. It is reported that the flooding is caused by banana and pineapple plantations in the nearby barangays, which are situated in areas with higher elevation.

Barangay Palacapao landslide susceptibility ranged from low to high. However, most of the land area has low susceptibility. A small portion in the eastern part has high susceptibility. The population is widely dispersed in areas with low and moderate susceptibility.

Barangay Guihean is found to be highly susceptible to a landslide. The population is situated mostly on the eastern border of the barangay contiguous to Barangay Sayawan. The lower western portion near the provincial road has several residents.

Barangay Batangan is a flood-prone area with the Pulangi River traversing the barangay.

A small portion in the southeast has a low to moderate susceptibility. The highly dense area is situated in the western part near Poblacion, Valencia City, and is highly susceptible to flood.

Determine the capacity of LGUs to respond to disasters in terms of basic social services

To determine the capacity of LGUs to respond to disasters and disaster risk reduction, a mathematical model will be developed. The next section is on the development of these parameters.

Development of Disaster Risk Reduction Model on Basic Social Services

In developing the Model for Basic Services, these are the basic social services considered: food, electricity, water, and health. Based on the literature search, the parameters of the model are defined. The parameters are utilized and operationally defined as presented in Table 4.

Table 4
Parameters of the Disaster Risk Reduction Model on Basic Services

| Parameter | Notation | Operational Definition | Operational Formula |
|--|-------------|---|---|
| Disaster Risk Reduction on basic social services | DRR_{BSS} | Ability of the LGU to reduce the effects of disaster | $R_{BSS} - AC_{BSS}$ |
| Risk on basic social services | R_{BSS} | Intersection among the three elements, namely, hazard, exposure and vulnerability | $H \times E \times V$ |
| Adaptive Capacity on basic social services | AC_{BSS} | LGU's ability to respond to crisis situation | Percentage (%) of recipients who will receive the basic social service at the onset of the disaster |
| Hazard | H | Probability of occurrence of disaster over a given time in a specific area | (Frequency of occurrence of disaster in the community for last 5 years) / (Total number of occurrence of disaster in the province for the last 5 years) |

| | | | |
|---------------|-----|--|---|
| Exposure | E | The population exposed to hazard over a given time in a specific area (moderate and high susceptibility to disaster) No. of people exposed to hazard from moderate to high susceptibility/ Total no. of people in the locality in a given time | (Number of people exposed to disaster in the moderate to high susceptibility areas) / (Total population in the community) |
| Vulnerability | V | Percentage of morbidity or loss (illness, injury or death) due to hazard Total no. of morbidity or loss/ No. of people exposed to disaster from moderate to high susceptibility | (Number of morbidity or loss exposed to disaster) / (Total population in the community) |
| Efficiency | Eff | Ability of the LGU to fulfill its duty in terms of basic social services due to the effect of a disaster with the minimum time and effort | $\frac{DRR_{BSS}}{AC_{BSS}}$ |

To measure the DRR of a specific basic social service, the HEVAC model (Padua, 2014) on DRR is used. The HEVAC model on DRR is given as,

$$DRR_{BSS} = R_{BSS} - AC_{BSS}$$

To compute for the risk and adaptive capacity, these are as follows:

AC_{BSS} = % of recipients who will receive the basic social service at the onset of the disaster

$$= \frac{\text{Number of recipients who received the basic social service}}{\text{Total number of population in the community}}$$

$$R_{BSS} = H \times E \times V$$

where

$$H = \frac{\text{Frequency of occurrence of disaster in the community for the last 5 years}}{\text{Total number of occurrence of disaster in the province for the last 5 years}}$$

$$E = \frac{\text{Number of people exposed to disaster in the moderate to high susceptibility areas}}{\text{Total population in the community}}$$

$$V = \frac{\text{Number of morbidity or loss exposed to disaster}}{\text{Total population in the community}}$$

$$Eff = \frac{DRR_{BSS}}{AC_{BSS}}$$

where

- DRR_{BSS} = disaster risk reduction on basic social services
- R_{BSS} = risk on basic social services
- AC_{BSS} = adaptive capacity on basic social services
- H = probability of occurrence of disaster for the last 5 years in the locality)
- E = number of people exposed to disaster from moderate to high susceptibility/ total number of people in the locality
- V = total number of morbidity/number of people exposed to disaster from moderate to high susceptibility
- Eff = efficiency

Then DRR_{BSS} can then be computed.

In the analysis of the DRR model the the value of DRRBSS defines the decrease or increase of vulnerabilities to a disaster of the locale. This means that the higher the adaptive capacity of the LGU on basic social services, the DRR will decrease, thus, reduce the effect of disaster to the locality. The ideal condition is to have the adaptive capacity on basic social services equal to the risk.

The DRR formula was then applied to the basic services, specifically food, health, electricity, and water. It should be noted that the rest of the parameters have the same formula regardless of the basic service, except for the specific adaptive capacity. Here then are the formulas on the adaptive capacities:

AC_{FOOD} = % of recipients who received food at the onset of the disaster

$$= \frac{\text{Number of recipients who received food}}{\text{Total number of population in the community}}$$

AC_{HEALTH} = % of recipients who received medicine at the onset of the disaster

$$= \frac{\text{Number of recipients who received medicine during disaster}}{\text{Total number of population in the community}}$$

AC_{ELECTRICITY} = % of recipients of electricity at the onset of the disaster

$$= \frac{\text{Number of recipients who received medicine during disaster}}{\text{Total number of population in the community}}$$

AC_{WATER} = % of recipients who were supplied with water at the onset of the disaster

$$= \frac{\text{Number of recipients who were supplied with water during disaster}}{\text{Total number of population in the community}}$$

a. Basic Social Service on Food

To determine the capacity of the specific LGUs to respond to disasters on the basic social service (food), the following computations are shown based on the formulas derived and the available data. Tables 5 and 6 show the data on food.

Table 5.
Data on Food from the Selected LGUs

| Barangay | Number of Exposed to disaster (Source: PSA, 2015) | Number of persons served with food during the disaster (Source: Actual data from the LGU) | |
|-------------|--|--|-------|
| | | Landslide | Flood |
| Magsaysay | 1,731 | 1,180 | * |
| Sampaguaita | 1,431 | 1,396 | * |
| Aglayan | 7,594 | * | 764 |
| Batangan | 11,550 | * | 8,644 |
| Palacapao | 2,899 | * | 184 |
| Guihean | 2,128 | 812 | * |

*Not applicable

The adaptive capacity (CA) of the LGU can be interpreted as the percentage of the population that it can serve during a disaster, which is presented in Table 5. For instance, in Barangay Magsaysay, the LGU Kibawe can provide for the 68% of the population exposed to the disaster, while Barangay Batangan

can provide for the 78.4% of the exposed population. Among the barangays, Barangay Sampaguita has the highest AC with almost 98%. Results show that the concerned LGU can already prepare the approximate needed basic service at the onset of the disaster. To the barangays with small/low AC, this implies that they may augment their intervention to cater to all exposed populations in the barangays during a disaster (as in Barangays Aglayan, Palacapao, and Guihean). Given the capacity of the LGU, this implies that the exposed population can be immediately provided with basic services such as food. Hence, the scarcity of food during a disaster is not much of a problem.

Table 6.

Computed Adaptive Capacity of LGUs on Basic Service (Food)

| Barangay | R_{FOOD} | AC_{FOOD} | DRR_{FOOD} | Efficiency to Address Risk ($ DRR_{FOOD}/AC_{FOOD} $) |
|------------|------------|-------------|--------------|--|
| Magsaysay | 0.0014 | 0.6817 | -0.6803 | 0.9980 |
| Sampaguita | 0.0017 | 0.9755 | -0.9739 | 0.9983 |
| Aglayan | 0.0003 | 0.1006 | -0.1003 | 0.9969 |
| Batangan | 0.0004 | 0.7480 | -0.7480 | 0.9994 |
| Palacapao | 0.0017 | 0.0635 | -0.0618 | 0.9739 |
| Guihean | 0.0011 | 0.3816 | -0.3805 | 0.9970 |

Note: The negative DRR values mean $AC > R$

The computed DRR explains the ability of the LGU to reduce the effects of risk upon responding to the needs of the community. In terms of reducing the risk due to disaster, it is noted that if DRR_{FOOD} has a value closer to zero (0) or negative (-), the better it is for the community. Further, the least DRR are those with negative values farthest from zero. This means that the risk equals the adaptive capacity of the LGU, or the adaptive capacity is bigger than the risk. The LGU can assist its constituents or in terms of providing food. Based on available data and computations from the barangays, it can be seen that Barangay Magsaysay has the least DRR.

In contrast, Barangay Palacapao has the biggest DRR value, followed by Barangay Aglayan. It can be noted that these two barangays have the biggest risk among the locale. Thus, this implies more intervention to address the risk from flood or landslide is needed. More intervention should be done during a disaster. The intervention may be in the form of addressing the risk or augmenting its adaptive capacity. One possible intervention is to increase the food allocation to increase the number of recipients in the barangay especially during a disaster. These results are consistent with the DRR values, as shown.

Results further show the efficiencies of LGUs to address risk. Computed efficiencies shows that LGUs have high efficiency to address the needs, specifically the food of their constituents during a disaster. All the LGUs are almost 100% efficient. The efficiency values reflect the ability of the LGUs to fulfill their duty in terms of providing food due to the effect of a disaster at the minimum time and effort. Results further imply that the efficiency of LGUs to address risk is sensitive to the adaptive capacity of the LGU to address risk and the risk due to the disaster. Moreover, it is important that the LGU is also sensitive to the proportion of the population recipients of the basic service (food) during a disaster. The high-efficiency value is a good indication of good governance, particularly accountability.

a. Basic Social Service on Health

The second social service is on health. To determine the capacity of the LGUs to respond to disasters, the basic social service on health, the computations are shown based on the formulas derived, and the available data. Table 7 shows the data on health services.

Table 7.
Data on Basic Health Services from the LGUs

| Barangay | Number of Exposed to disaster (Source: PSA, 2015) | Number of persons provided with health, electricity and water services during the disaster (Source: Actual data from the LGU) | |
|------------|--|--|--------|
| | | Landslide | Flood |
| Magsaysay | 1,731 | 1,731 | * |
| Sampaguita | 1,431 | 1,431 | * |
| Aglayan | 7,594 | * | 7,594 |
| Batangan | 11,550 | * | 11,550 |
| Palacapao | 2,899 | * | 2,899 |
| Guihean | 2,128 | 2,128 | * |

*Not applicable

The adaptive capacity of the LGU on health services is presented in Table 8. It can be seen that of the six (6) barangays, 67% have a low risk of health. The assumption holds that all barangays can provide the basic health services to all their constituents.

Table 8.
Computed Adaptive Capacity of LGUs on Basic Service (Health)

| Barangay | R_{HEALTH} | AC_{HEALTH} | DRR_{HEALTH} | Efficiency to Address Risk ($ DRR_{HEALTH} / AC_{HEALTH} $) |
|------------|--------------|---------------|----------------|--|
| Magsaysay | 0.0014 | 0.2772 | -0.2758 | 0.9949 |
| Sampaguita | 0.0017 | 0.6491 | -0.6474 | 0.9974 |
| Aglayan | 0.0003 | 0.1006 | -0.1003 | 0.9970 |
| Batangan | 0.0004 | 0.2150 | -0.2110 | 0.9814 |
| Palacapao | 0.0017 | 0.0793 | -0.0776 | 0.9786 |
| Guihean | 0.0011 | 0.1109 | -0.1098 | 0.9901 |

In terms of reducing the risk due to disaster, all barangays have negative values, which means that their adaptive capacities are greater than the risks they are facing. From Table 8, results further show the efficiency of LGUs to address risk. Again, all the barangays have high efficiencies, which implies that the LGUs, with a minimum time and effort, can fulfill their duties in providing health services.

b. Basic Social Service on Electricity

Table 7 shows the data of the barangays supplied with electricity, which were used to compute the adaptive capacity. The adaptive capacity of the LGU on electricity can be interpreted as the percentage of the population that it can supply during a disaster. This is presented in Table 9. It is again observed that all of the barangays have negative DRR values, which implies they can provide electricity to all or 100% of the population exposed to disaster. Results also explain that the LGUs are effective in providing the basic services on electricity to their respective barangays.

Table 9.
Computed Adaptive Capacity of LGUs on Basic Service (Electricity)

| Barangay | $R_{ELECTRICITY}$ | $AC_{ELECTRICITY}$ | $DRR_{ELECTRICITY}$ | Efficiency to Address Risk |
|------------|-------------------|--------------------|---------------------|----------------------------|
| Magsaysay | 0.0014 | 1.000 | -0.9986 | 0.9986 |
| Sampaguita | 0.0017 | 1.000 | -0.9983 | 0.9983 |
| Aglayan | 0.0003 | 1.000 | -0.9997 | 0.9997 |
| Batangan | 0.0004 | 1.000 | -0.9996 | 0.9996 |
| Palacapao | 0.0017 | 1.000 | -0.9983 | 0.9983 |
| Guihean | 0.0011 | 1.000 | -0.9989 | 0.9989 |

The computed DRR and AC on electricity again explain the efficiency of the LGUs to respond during a disaster. It can be noted that Barangays Batangan and Aglayan have a bigger reduced risk of electricity. Since both barangays have the largest population, more supply of electricity is needed. This implies further that more intervention to lessen the risk from flood or landslide. Based on the interviews conducted, it is important to augment the workforce and equipment to restore electricity in the fastest possible time. This will also help facilitate the economic activities of the affected areas of Barangays Batangan and Aglayan. These economic activities include banking, post-harvest production facilities, medical facilities, and small-medium enterprises (SMEs). It should be noted that Barangays Batangan and Aglayan are also considered as trade routes for economic activities, most especially agriculture.

From Table 9, results further show the efficiency of LGUs to address risk. It indicates that all LGUs have high efficiencies.

c. Basic Social Service on Water

The fourth social service is water. From Table 7, the data will be used again to compute for the adaptive capacity of LGU on water. The adaptive capacity of the LGU on the water can be interpreted as the percentage of the population that it can supply during a disaster. This is presented in Table 10. For instance, in Barangay Aglayan, the LGU Malaybalay can supply water to all or 100% of the population exposed to a disaster. It is worth noting that all of the LGUs from the 6 barangays can supply water to all their constituents. This implies that the LGUs are effective in providing the basic services on the water to their respective barangays.

Table 10.
Computed Adaptive Capacity of LGUs on Basic Service (Water)

| Barangay | R_{WATER} | AC_{WATER} | DRR_{WATER} | Efficiency to Address Risk ($AC_{\text{WATER}}/R_{\text{WATER}}$) |
|------------|--------------------|---------------------|----------------------|--|
| Magsaysay | 0.0014 | 1.000 | -0.9986 | 0.9986 |
| Sampaguita | 0.0017 | 1.000 | -0.9983 | 0.9983 |
| Aglayan | 0.0003 | 1.000 | -0.9997 | 0.9997 |
| Batangan | 0.0004 | 1.000 | -0.9996 | 0.9996 |
| Palacapao | 0.0017 | 1.000 | -0.9983 | 0.9983 |
| Guihean | 0.0011 | 1.000 | -0.9989 | 0.9989 |

Based on the data available and computations from the barangays, it can be seen that Barangay Sampaguita has the least DRR, while Barangay Batangan has the biggest DRR_{WATER} . It can be noted that Barangays Batangan and Aglayan have a greater reduced risk on the water. Although these barangays have the largest population and more supply of water is needed, but then their risks are less compared to the other barangays. This implies that there should be more intervention to address the risk of floods or landslides. One of the possible interventions is to strengthen mechanisms of water distribution of the different water concessionaires to the affected areas.

Based on the model developed and the assessment of the risk reduction of the barangays located in the flood-prone and landslide-prone area, Table 11 presents the summary of results on how the DRR and Eff behave and how sensitive they are with the changes of the two parameters, R and ACs, respectively. The following observations include: (a) If the risk and adaptive capacity move to the same direction, the risk reduction as well as the efficiency move to the same direction as well (i.e., as R and AC increase, the DRR and Eff also increase); (b) If the risk and adaptive capacity move to the opposite direction, then the risk reduction and Eff will move to the direction with the adaptive capacity; (c) risk reduction and efficiency have the same direction regardless of the behavior of the risk and adaptive capacity, and (d) risk reduction and efficiency are sensitive with the behavior of adaptive capacity.

Table 11.
Summary of Results on the Behavior of the Parameters on Risk, Adaptive Capacity, Disaster Risk Reduction and Efficiency

| PARAMETER | | | |
|-----------|----------|----------|----------|
| R | AC | DRR | Eff |
| Increase | Increase | Increase | Increase |
| Increase | Decrease | Decrease | Decrease |
| Decrease | Decrease | Decrease | Decrease |
| Decrease | Increase | Increase | Increase |

R = Risk
AC = Adaptive Capacity
DRR = Disaster Risk Reduction
Eff = Efficiency

Conclusions

The developed Disaster Risk Reduction Model for Basic Social Services can assess the risk reduction of a locale. The model further explains the sensitivity of the risk reduction and efficiency to adaptive capacity regardless of the weight of risk.

Recommendations

The local government units in the barangay, municipal, and city levels may look into their adaptive capacities in the delivery of basic social services in food, health, water, and electricity during disasters. LGUs may consider that an increase or high adaptive capacity is a necessary precondition in responding efficiently to disaster risk.

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