# Mainstreaming Disaster Risk Management to Sustain Local Roads Infrastructure

**Risk Assessment**

Ana Laura Costa
Thomas Bles
Kristina Abrenica
James Dexter Grageda

Deltares

**Title**
Mainstreaming Disaster Risk Management to Sustain Local Roads Infrastructure

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# Contents

# 1 Introduction

## 1.1 Introduction to the project

The 2017-2022 Philippine Development Plan recognizes that road infrastructure is a key point of convergence with productive sectors, but the quality remains inadequate. As of 2015, 97 percent (of 31,242 km) of national roads, 62 percent (of 15,377 km) of city roads, and 29 percent (of 31,075 km) of provincial roads were paved. The World Economic Forum-Global Competitiveness Report (WEF-GCR) 2015-2016 ranked the Philippines 97th out of 140 countries in terms of quality of road infrastructure, below neighbouring countries such as Indonesia, Vietnam, Cambodia and Laos.

The KALSADA-Conditional Matching Grant to Provinces (CMGP) program was developed by the national government to help Local Government Units (LGUs) improve the quality of provincial roads, which is significantly below that of national and city roads. This program positions the national government to support, but not supplant, the provincial governments in their responsibility to provide an efficient network of provincial roads which are currently inadequate to meet the need of the population for easier mobility within the provinces.

For sustainability, climate resilience considerations need to be better factored into local roads (provincial, city, municipal and barangay roads) planning and design, especially in the Philippine setting. Drainage on many local roads is frequently absent resulting in recurrent damages caused by runoffs and flooding. Even new roads are sometimes implemented without recourse to properly addressing drainage requirements, and thus the estimated funding requirements for local roads are likely underestimated. This is further exacerbated by the lack of comprehensive drainage plans in LGUs. For local roads, LGUs typically apply the adopted standards of the national roads agency, however how it is applied is largely up to the LGUs, as there is no supervision from national roads agency. Thus, there is a need to assess how road design standards relevant to climate resilience are actually interpreted and applied by LGUs in practice. Moreover, there are possible interventions by national agency for flood management in a specific area that could have significant implications on project identification and selection at the LGU level, but which otherwise will not be considered without proper linkage and coordination between the national agency and LGUs. How these various interventions are planned and the timing of their implementation to ensure sustainability and resilience of local roads is critical.

This project aims to specifially increase the capacity of LGUs in dealing with climate and other risks affecting local roads, and enhance coordination with the national roads agency towards improving the resilience of local roads.

## 1.2 Project objectives and scope of this report

Within the context described, the major objectives of the project can be described as

- increase the capacity and knowledge of a selected LGU in dealing with climate/disaster risks faced by local transport infrastructure;
- and pilot an institutionalized coordination process with the national agencies to better inform local roads planning, using a learning-by-doing approach.

Moreover, the results of the TA must comply with good river basin planning practices based on an IWRM approach and should explicitly address the high levels of uncertainty.

Though formal capacity building activities are outside the scope of this TA, this pilot project is executed within the Nueva Ecija province, allowing for a case to apply the ‘learning by doing’

aspect of the objectives together with the LGU and local stakeholders. In this respect, two workshops have been organized in which approach and results have been presented, followed by hands on exercises by LGUs, national agencies and DILG.

The results of the project are discussed in three reports:
- Risk assessment report
- Adaptation strategy report

This report discusses the risk assessment and the prioritization of interventions for the provincial road network of Nueva Ecija. Recommendations for future implementations by the LGU are presented.

## 1.3 Scope and structure of the risk assessment

The project is focussed on the local road network in the province of Nueva Ecija. More specifically, the project is focussed on the provincial roads and in this report the results of the risk assessment of the provincial roads is presented. The national roads are only taken into account in the traffic analyses. Municipal and Barangay roads are not considered.

After a first inventory of natural hazards in the province of Nueva Ecija, it was decided to focus on the following three natural hazards:
- Flooding
- Landslides
- Earthquakes

Given the objective to mainstream Disaster Risk Management to sustain local infrastructure, it was the challenge to use the available existing information in such a way that an LGU should be able to perform the analyses themselves. In that sense no new hazard assessments have been undertaken. Also, the risk assessment is only undertaken for the current climate.

Furthermore, the risk assessment has been undertaken using the following elements
1 Collection of data to perform the assessment related to the hazards, the road itself and traffic
2 Calculating exposure of the road network for the different hazards
3 Calculating the consequences, expressed in
3.1 Damages to the road
3.2 Losses for the users of the road
4 Evaluation of the risk

These elements have been derived from the UNISDR framework of risk that is schematically shown in Figure 1.1. Since we are investigating the risk for roads, we need to consider vulnerability in greater detail which can be explained with Figure 1.2. In this context, we apply the term vulnerability for gaining an understanding of the degree of physical damage to the road and which scope is under the jurisdiction of the LGU. The damages are expressed in monetary terms. Furthermore, we apply the term ‘losses for road users’ together with the term criticality, when the road is not functioning as it is constructed for. These are outside direct influence of the LGU, but within the primary objective of having road infrastructure which is to serve society. Also the losses are expressed in monetary terms.

Damages and losses are calculated for the various return periods for which the hazard intensity is known. Risks are then calculated by combining the return period (likelihood) and the calculated damages and losses.


*Figure 1.1 Components of risk (source: UNISDR[1])*

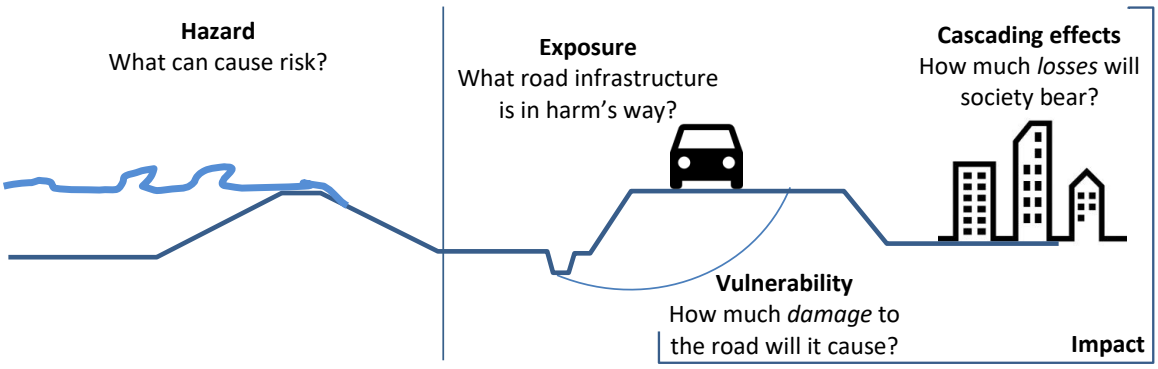



*Figure 1.2 Schematic overview of the concept of risk in this paper (source: bles et al[2])*

## 1.4 Structure of the report

Following this introductory section, the report introduces the Province of Nueva Ecija in section 2. Subsequently, section 3 discusses the collection of data for the available hazard information, the road infrastructure network and the traffic information. Section 4 describes the Road Exposure, Section 5 discusses the assessment of damages to the road network by natural hazards and section 6 reports the road criticality and the losses for road users due to natural hazards disruption. Section 7 builds on all previous discussions to present a risk-based prioritization of the roads for future interventions.

Each of sections 3 through 7 provide recommendations on the specific topic. Section 8 finalizes the report with summary conclusions.

[1] *UNISDR. 2016. "Report of the Open-Ended Intergovernmental Expert Working Group on Indicators and Terminology Relating to Disaster Risk Reduction." Vol. A/71/644*

[2] *Bles, T., Costa, A.L., Hüsken, L., Woning, M., Espinet, X., Muiswinkel, K. van, Page, S., Progressing road infrastructure resilience from different institutional development perspectives, PIARC WRC, Abu Dhabi, 2019 (in press)*

# 2 Introduction to the province of Nueva Ecija, Central Luzon, Philippines

Nueva Ecija is a landlocked province in the Philippines located in the Central Luzon region, the largest island in the country (Figure 2.1). Covering a total area of 5,751.33 square kilometres, it is the largest province in Central Luzon. It is bounded by (north going clockwise) Aurora, Bulacan, Pampanga, Tarlac, Pangasinan, Nueva Vizcaya.
It is composed of 27 municipalities (Aliaga, Bongabon, Cabiao, Carranglan, Cuyapo, Gabaldon, General Natividad, General Tinio, Guimba, Jaen, Laur, Licab, Llanera, Lupao, Nampicuan, Pantabangan, Penaranda, Quezon, Rizal, San Antonio, San Isidro, San Leonardo, Santa Rosa, Santo Domingo, Talavera, Talugtug, Zaragoza) and 5 cities (Cabanatuan, Gapan, Munoz,


*Figure 2.1. Location of Nueva Ecija*

Palayan, San Jose) with a population of 2,151,461 people and a density of 370 inhabitants per square kilometre, as of the 2015 census. Currently, the province has 28 provincial government department/division heads namely Legal Officer, Budget Officer, Accountant, Treasurer, General Services Officer, Human Resource Management Officer, Planning and Development Coordinator, Social Welfare and Development Officer, Engineer, Assessor, Agriculturist, Veterinarian, Trade and Industry Officer, Environment and Natural Resources Officer, Provincial Information Officer, Acting Chief of Hospital, Personal Staff Head, Chief Administrative Officer, Station Manager, Warden, Sports and Manpower Development Services Chief Officer, Supervising Tourism Operations Officer, Manpower Training Center Officer, Civil Security Unit Chief, Disaster Risk Reduction and Management Officer, ELJMC Chief, and Cooperative Officer.
Nueva Ecija is also known for being Rice Granary of the Philippines since one its major industries is agriculture for rice, corn, and onions. Other industries include poultry and dairy

farms, mining, and health services. It is one of the provinces that is traversed by Pampanga River. The river provides the province for irrigation, fishponds, and others. However, it also floods the province given extreme weather conditions.
The province is linked to the main highway system of Luzon, the Maharlika Highway, through a system of roads that interconnect the various municipalities. The road system makes Nueva Ecija easily accessible from all surrounding provinces and from Manila as well.

# 3 Collection of data

## 3.1 Hazards identification and mapping

### 3.1.1 Introduction

Natural hazard maps characterize, for natural phenomena such as floods or earthquakes, the intensity, the probability of occurrence and the areas affected by such an event. The probability of occurrence of a hazard is commonly characterized through the respective return period, and the intensity of the hazard can be qualitatively or quantitatively defined by classes. These classes can then be mapped for a certain area. The goal of hazard data collection is to identify any type of natural hazard affecting the province of Nueva Ecija and gather hazard maps showing hazard intensities and return periods in GIS format. Digitally available data is crucial to perform accurate estimates.

### 3.1.2 Data repositories

Data sources include the following agencies and programs:

**Mines and Geosciences Bureau**

Mines and Geosciences Bureau (MGB), a government agency in the Philippines under the Department of Environment and Natural Resources (DENR), is committed to the promotion of sustainable mineral resources development, aware of its contribution to national economic growth and countryside community development. (source: www.mgb.gov.ph)

**Philippine Institute of Volcanology and Seismology**

Philippine Institute of Volcanology and Seismology (PHIVOLCS) is a service institute of the Department of Science and Technology (DOST) that is principally mandated to mitigate disasters that may arise from volcanic eruptions, earthquakes, tsunami, and other related geotectonic phenomena. (source: www.phivolcs.dost.gov.ph)

**Philippine Atmospheric, Geophysical and Astronomical Services Administration**

Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAG-ASA) is one of the agencies under Department of Science and Technology that is mandated to “provide protection against natural calamities and utilize scientific knowledge as an effective instrument to ensure the safety, and well-being and economic security of all the people, and for the promotion of national progress.” (source: bagong.pagasa.dost.gov.ph)

**Disaster Risk and Exposure Assessment for Mitigation Program**

Disaster Risk and Exposure Assessment for Mitigation (DREAM) Program is a Department of Science and Technology (DOST) Grants-In-Aid (GIA) Program-funded effort that is implemented by the University of the Philippines Training Center for Applied Geodesy and Photogrammetry (UP TCAGP). It is one of the nine (9) components of the Nationwide Operational Assessment of Hazards Project (Project NOAH). (source: www.dream.upd.edu.ph).

### 3.1.3 Data collection process

This section documents the data collection process. Such evidence is important to identify what information is available and where it can be solicited. With this, gathering of such data in the future will be easier and can be more efficiently replicated by other institutions, namely local government units in the Philippines.

#### *3.1.3.1 Flood hazard*

Flood hazard maps are available on the internet from MGB’s official website. They can be readily available for download in an image format (.jpeg); this format, however, lacks the coordinate references that are required for it to be directly applicable for the project. After a visit

to the MGB's Central Office in Quezon City, it was learned that GIS files are not normally made available, and a letter of data request should be drafted and sent to their office for approval. With an authorized letter and aid from DILG, SCHEMA was granted an appointment with the focal person in MGB Pampanga to collect the flood and rainfall-induced landslide susceptibility maps in GIS format for the province of Nueva Ecija.

For an effective assessment of flood hazards though, it is important to have the maps with varying return periods. This was not the case with the data obtained from MGB. Hence, it was necessary to find another data source. The LiPAD (LiDAR Portal for Archiving and Distribution) website was found after further research. LiPAD serves as the primary data access and distribution center of the Phil-LiDAR 1 and Phil-LiDAR 2 Programs which are included in the DREAM Program. Updated and top-quality flood maps are generated through the use of LiDAR and showcased in LiPAD website. These are also the same maps that are exhibited in the NOAH website.

Due to the fact that DREAM/Phil-LiDAR Program is a government-funded project, it does not provide private entities such as SCHEMA with data unless there is a formal letter approved by their Program Leader. Fortunately, flood maps do not belong under the restricted data, so these were easily acquired through a link sent by LiPAD's support team in an e-mail. Shapefiles, a format of GIS data, for flood hazard maps of Nueva Ecija with 5-, 25-, and 100-year return periods were gathered from the provided link, and are the ones used for the assessment. However, other data other than flood maps can be acquired only with assistance from public entities.

#### *3.1.3.2 Landslides*

As mentioned under the flood hazard section, shapefiles for landslides were obtained upon meeting up with a focal person in MGB Pampanga. The rainfall-induced landslide maps collected, however, do not characterize the landslides probability, i.e., no return period is associated with such maps. In such instances, the landslide maps collected can be classified as susceptibility maps. To address this gap, it is be advantageous for the project to have a landslide inventory of the area, in order to relate how prone to landslides an area is with the actual frequency of occurring landslides and their characteristics. A landslide inventory shapefile was obtained upon contacting NOAH, but was found to be not substantial for it did not provide monitoring period and magnitude of landslides. Moreover, according to the focal person in MGB Pampanga, the process of elaborating a landslide inventory is ongoing for Region 3.

#### *3.1.3.3 Earthquakes*

##### 3.1.3.3.1 *Earthquake triggered landslides*

Earthquake-triggered landslide susceptibility maps are also available for download in PDF format in the PHIVOLCS website but lack a document explaining how the susceptibility classes were obtained. Since this pdf file format cannot be directly used for the assessment, a visit to the PHIVOLCS Central Office in Quezon City had to be done. An authorized letter from DILG was prepared for assistance. The fact that the endorsement letter did neither explicitly mention the name of the private entity requesting the data nor defined the specific data to be collected, created some initial issues that were resolved after talking to the focal person in PHIVOLCS.

To conform to PHIVOLCS process of data requests, a form was filled up and Data User Agreement (DUA) was signed, after which the GIS data was obtained approximately one month later. Unfortunately, the GIS data does not include the earthquake-triggered landslide susceptibility maps and this is not included in the risk assessment.

3.1.3.3.2 *Peak ground acceleration*

Since a Peak Ground Acceleration (PGA) map is important to assess direct earthquake related damages, a second visit at the PHIVOLCS Central Office was necessary. Same with the first visit, a form had to be filled up and a Memorandum of Understanding (MoU) was signed. PGA and location of Volcanoes in GIS format were requested and received after a week.

3.1.3.3.3 *Other earthquake related hazards*

Among the data collected for Nueva Ecija are earthquake-related hazards such as ground rupture/active faults and liquefaction. Both were obtained in GIS format from PHIVOLCS. Although a liquefaction susceptibility map was acquired, classifying the ground into liquefaction-prone and non-prone areas, this map was not used for the assessment. This is due to the reason that it is found to be based on very coarse input and not being able to capture site conditions at a scale that can be used to distinguish the liquefaction hazard actually affecting the road. Since background information was also not provided, there is no way to know if proper tests such as Standard Penetration Test (SPT) were really performed to generate the map.

*3.1.3.4 Wind*

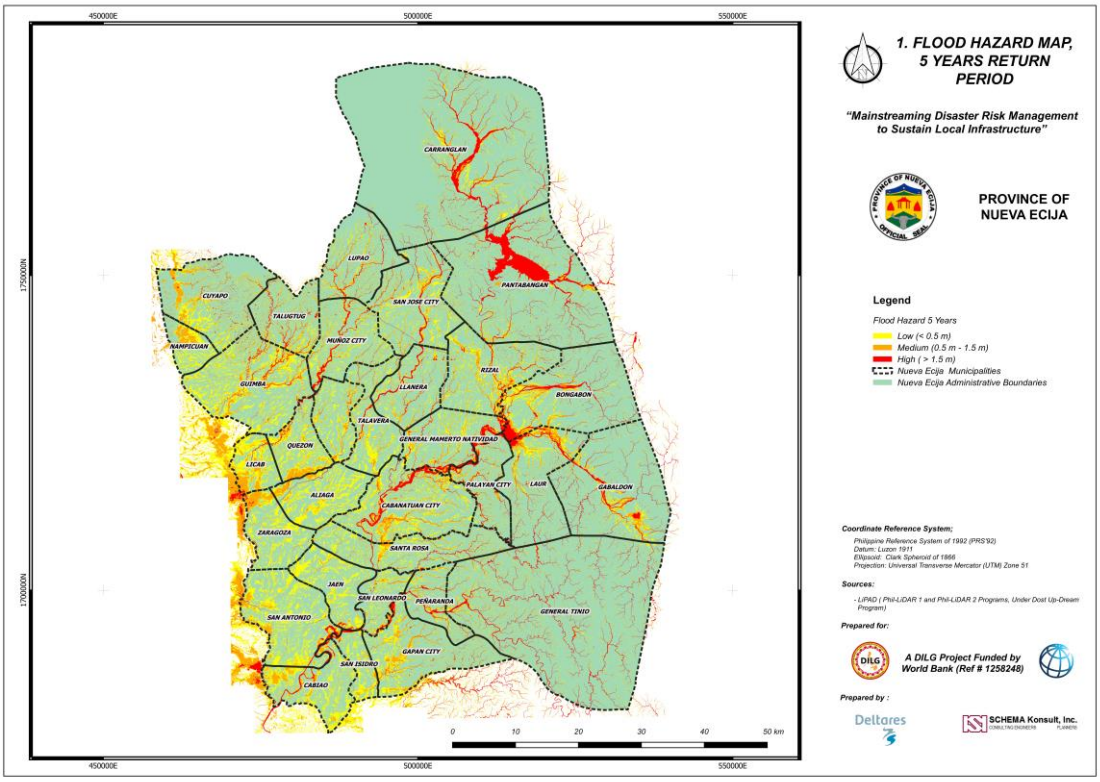
Wind data were requested from PAG-ASA. A total of 2 files were obtained from their Cabanatuan Station namely Cabanatuan Monthly Average Wind Speed and Direction and Cabanatuan Maximum Gust Wind and Direction for years 1980 to 2017.

*3.1.3.5 Volcanoes*

Location of volcanoes in Nueva Ecija in shapefile format is gathered from PHIVOLCS on the second visit as stated under Earthquakes section. Volcanoes don't pose a threat to the provincial road network in Nueva Ecija and are therefore not further taken into account.

### 3.1.4 Hazard maps for risk assessment

With the gathered data from different agencies and programs, specific hazard maps for the province of Nueva Ecija were generated (Figure 3.1 to Figure 3.4) and are used for the risk assessment of Nueva Ecija. The original content of the shapefiles collected and the process of generating the maps for each of the hazards are presented in detail in the following sub-sections. All maps are presented in Annex I.


1. FLOOD HAZARD MAP, 5 YEARS RETURN PERIOD
"Mainstreaming Disaster Risk Management to Sustain Local Infrastructure"
PROVINCE OF NUEVA ECIJA
Legend
Flood Hazard 5 Years
Low (< 0.5 m)
Medium (0.5 m - 1.5 m)
High ( > 1.5 m)
Nueva Ecija Municipalities
Nueva Ecija Administrative Boundaries
Coordinate Reference System;
Philippine Reference System of 1992 (PRS'92)
Datum: Luzon 1911
Ellipsoid: Clark Spheroid of 1866
Projection: Universal Transverse Mercator (UTM) Zone 51
Sources:
- LiPAD ( Phil-LiDAR 1 and Phil-LiDAR 2 Programs, Under Dost Up-Dream Program)
Prepared for:
A DILG Project Funded by World Bank (Ref # 1258248)
Prepared by :
Deltares
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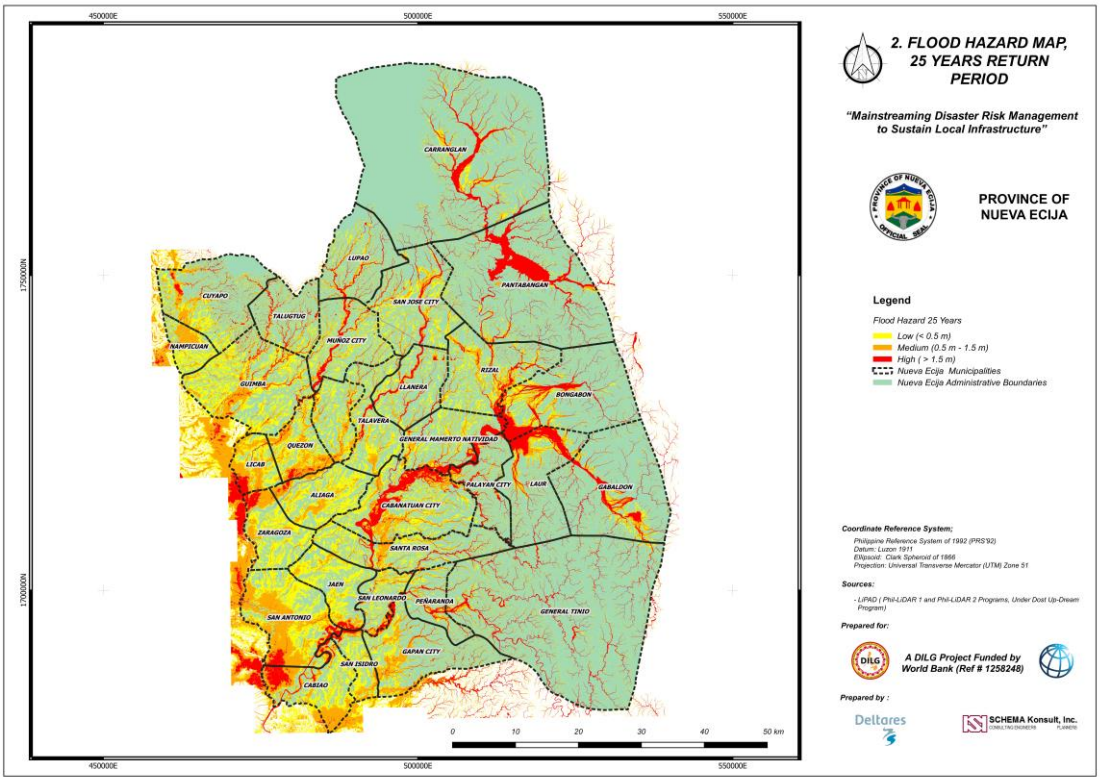
2. FLOOD HAZARD MAP, 25 YEARS RETURN PERIOD
"Mainstreaming Disaster Risk Management to Sustain Local Infrastructure"
PROVINCE OF NUEVA ECIJA
Legend
Flood Hazard 25 Years
Low (< 0.5 m)
Medium (0.5 m - 1.5 m)
High ( > 1.5 m)
Nueva Ecija Municipalities
Nueva Ecija Administrative Boundaries
Coordinate Reference System;
Philippine Reference System of 1992 (PRS'92)
Datum: Luzon 1911
Ellipsoid: Clark Spheroid of 1866
Projection: Universal Transverse Mercator (UTM) Zone 51
Sources:
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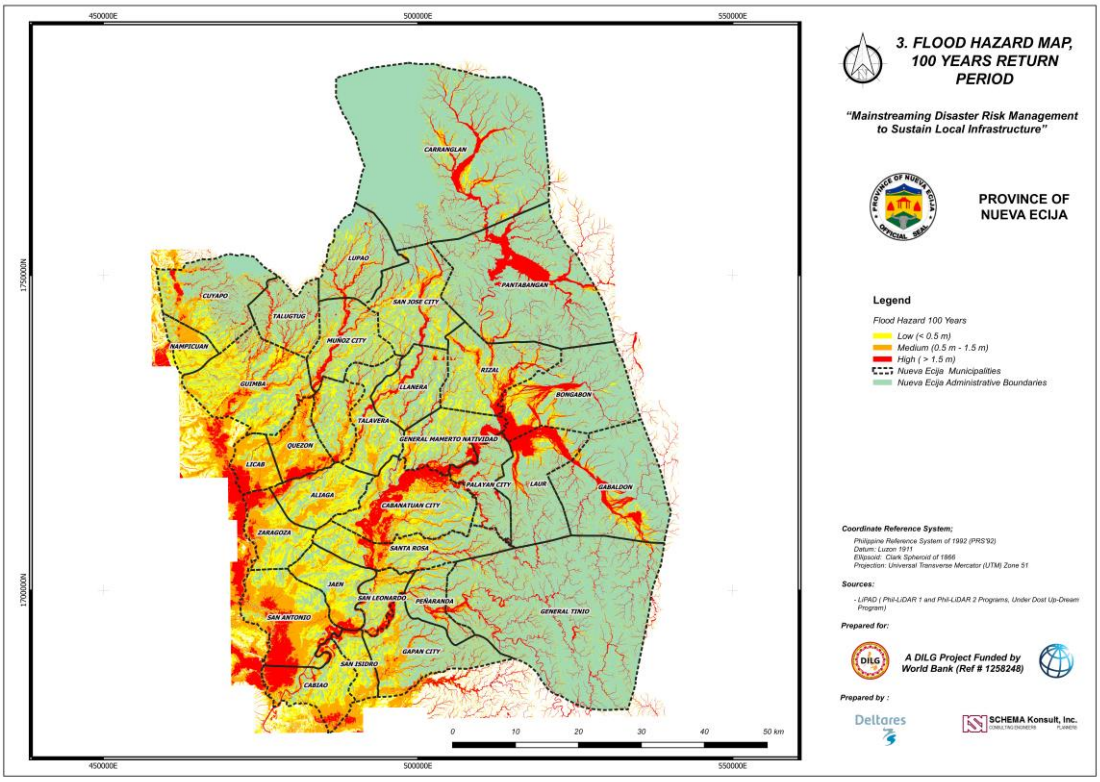



c)

*Figure 3.1. Nueva Ecija Flood Hazard Maps with a) 5-year return period b) 25-year return period c) 100-year return period*

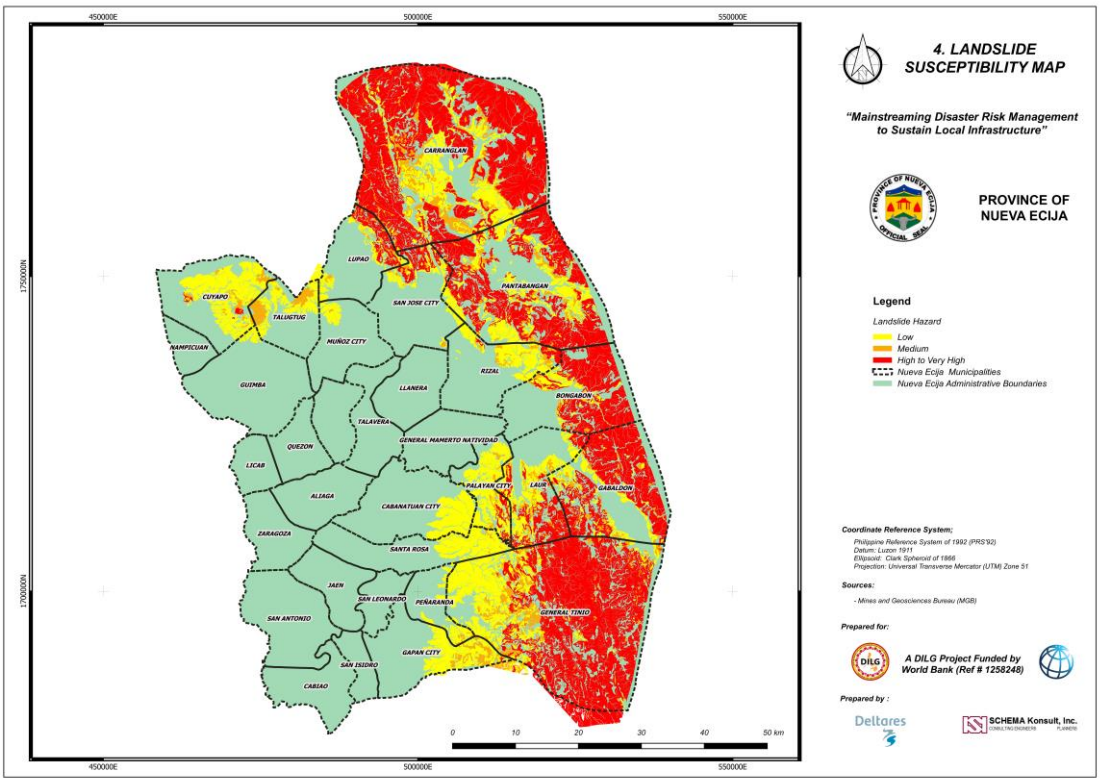



*Figure 3.2. Nueva Ecija Landslide Susceptibility Map*

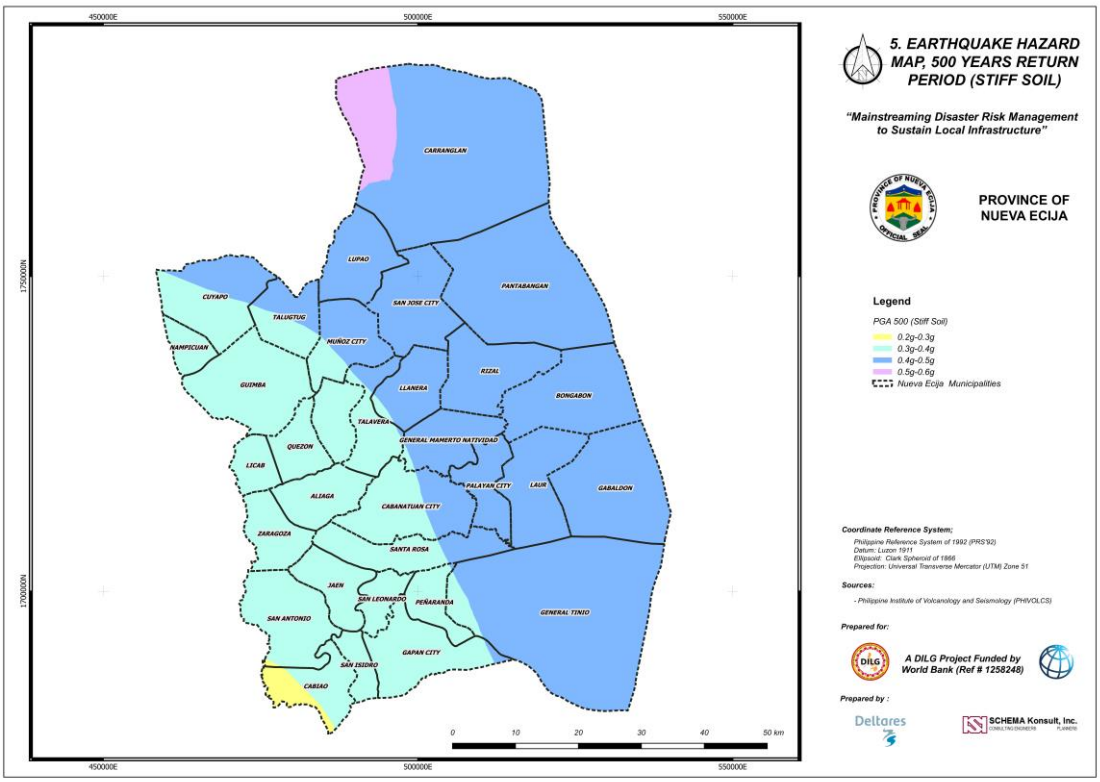
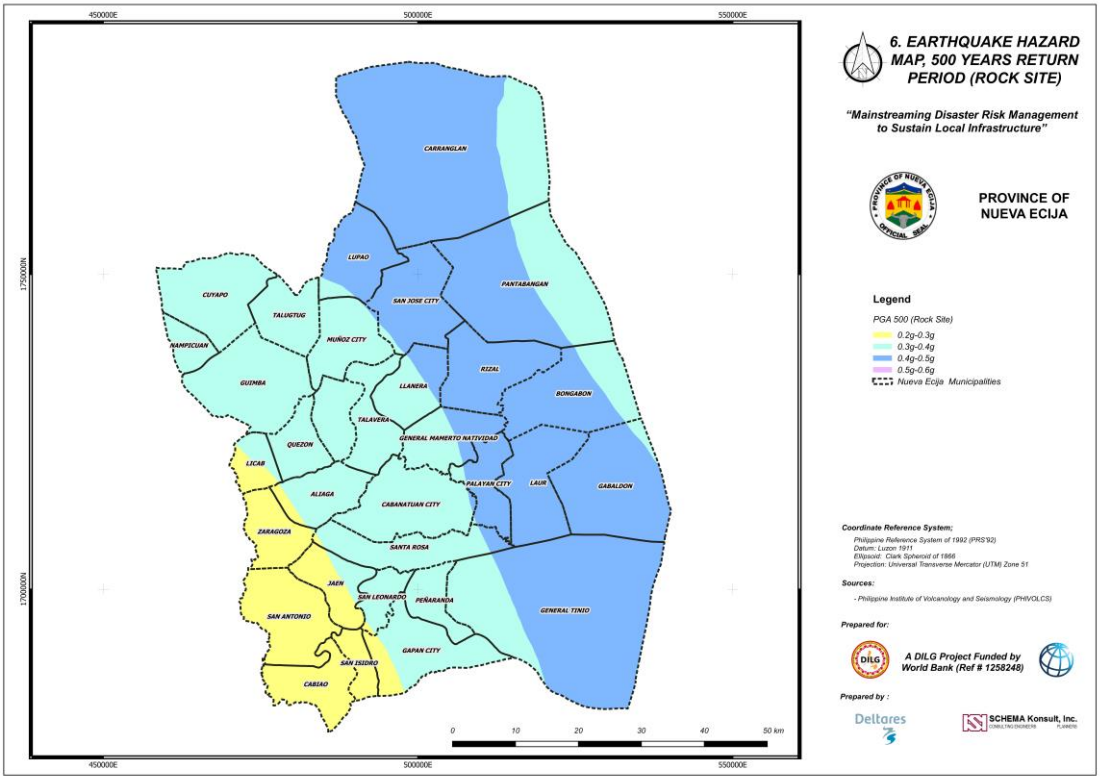
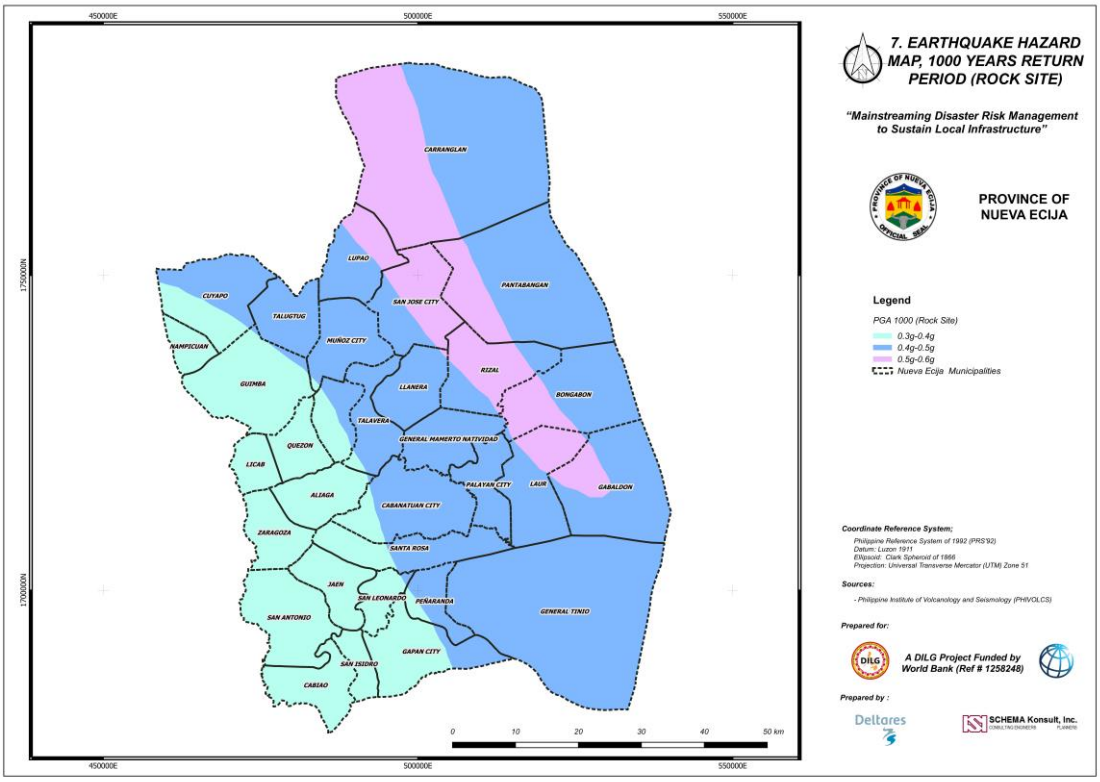


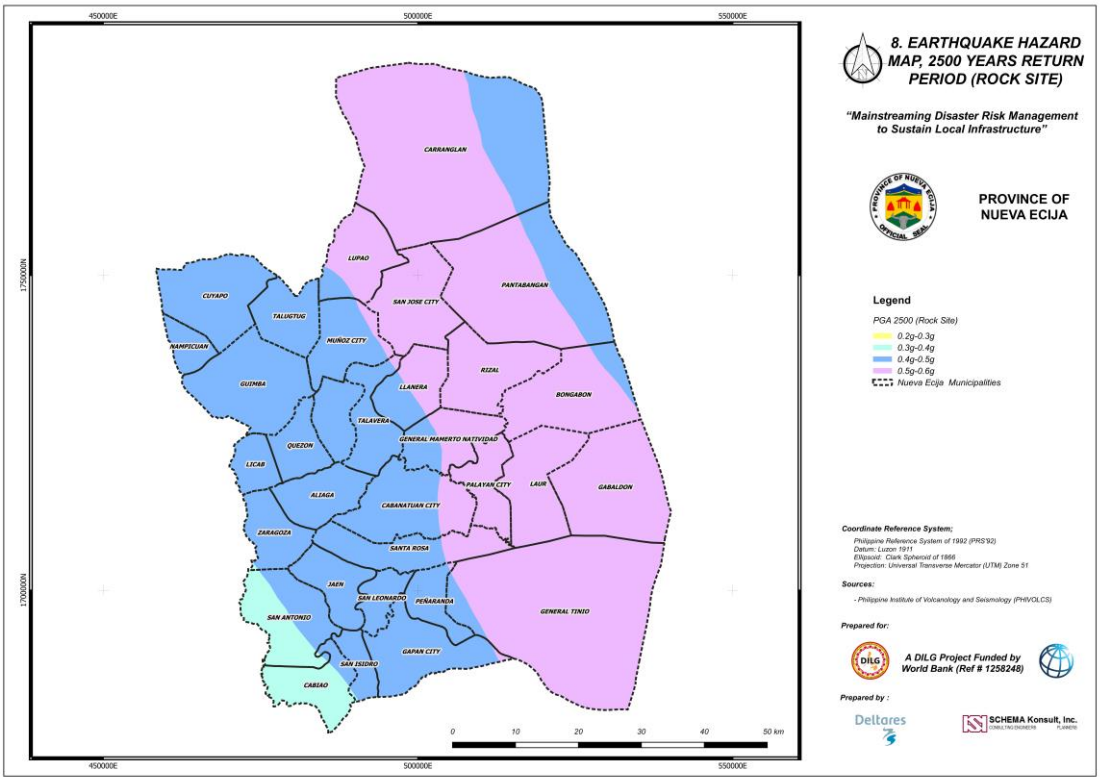

*Figure 3.3. Earthquake Hazard Map 500-year return period for Stiff Soil*




a)




b)




c)

*Figure 3.4. Earthquake Hazard Map for Rock Site with a) 500-year return period b) 1000-year return period c) 2500-year return period*

#### 3.1.4.1 *Flood hazard*

Figure 3.1 and maps 1-3 in Annex I present the generated flood hazard maps. Each map indicates the expected flood depth, at any given location in Nueva Ecija that is expected to be observed with a recurrence given by the return period. Three classes have been identified:

*Table 3.1. Flood Hazard Classes*

| Height (m) | Level |
|---|---|
| 0 - 0.5 | Low |
| 0.5 - 1 | Medium |
| > 1 | High |

The interpretation of the raw shapefile data collected for the flood hazard maps, however, was difficult at first. The attribute table corresponds to different data that brought confusion. When opening the flood map in QGIS Software in Figure 3.5, it shows values from +2 to -2. Since there was no document for explanations provided, this can be taken in a lot of ways.

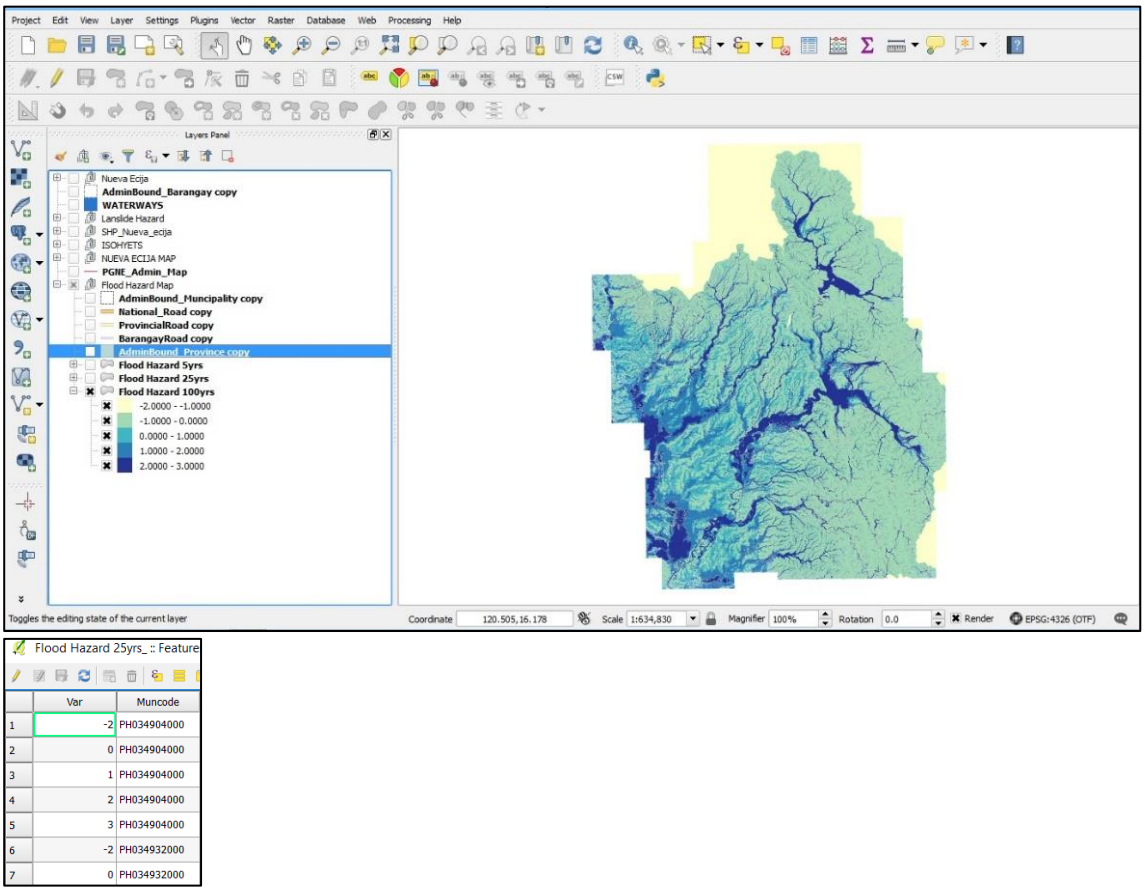



*Figure 3.5. Flood Map shown in QGIS Software*

It was only after further research in LiPAD website (Figure 3.6) that the proper meanings of the legend were clarified. Numbers -2 and -1 correspond to other geometric figures while positive numbers pertain to flood levels as previously presented in Table 3.1. Though given these categories, it would still be better to have the exact calculated flood depths in order to generate more accurate results.

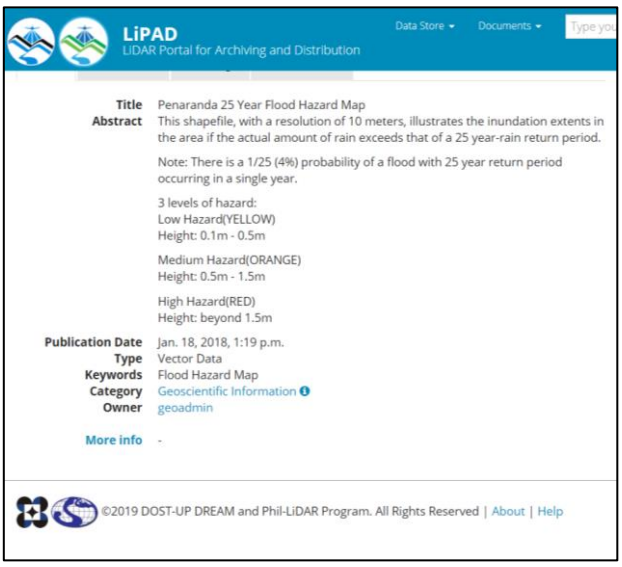



*Figure 3.6. Meanings Researched in LiPAD Website*

Furthermore, it was noticed that there is an overlap of features in the maps. This is not ideal for GIS calculations due to duplication issues when performing overlays. There are also gaps in the flood hazard layer. All in all, there is a lot of cleaning to do in the dataset for it does not conform with GIS Standards.

Going through this process, it can be noted how important it is to have an associated document describing the data mapped. Explanation of assumptions, models, and legends used to establish the hazard maps can help relay the information effectively to other users. This will, then, entail less time and effort for data decoding, and avoid misinterpretation of given information.

#### *3.1.4.2 Landslides*

Figure 3.2 and map 4 in Annex I present the generated landslide susceptibility map. The map identifies landslide susceptible areas and categorizes the susceptibility in: low, medium and high to very high susceptibility.

The interpretation of the collected raw shapefile data, however, was not straightforward. Figure 3.7 shows the data received from MGB as opened in QGIS Software. As can be seen on the legend, there are a lot of colours corresponding to different meanings. This legend does not correspond with the legend in MGB's maps in the website. In Figure 3.8 both the legend from the map in the website and in GIS are visualized for comparison. We have decided to group the classes 'high' and 'very high' into one group, since the only difference seems to come from the fact that the 'very high' class takes the criticality into account. Criticality is something that is assessed elsewhere in the project itself and therefore can be disregarded now with respect to the landslide susceptibility. However, a better documentation would have helped in a better argumentation in this regard.

Lack of documentation also provides confusion for interpretation of data, making it hard to generate assessments. Also, there is no proper explanation on how the data came about. Susceptibility should be properly defined for reference. It is necessary to have a proper background document that explains how the landslide susceptibility map has been put together. The document should at least state the parameters that have been taken into account, the triggers for landslides that have been used, the models or methods that have been applied to produce the susceptibility maps and whether an inventory of landslides has been taken into account.

Furthermore, a degree of susceptibility does not quantify the likelihood of landslides actually occurring. To overcome the fact that a return period is not associated with susceptibility (which on the contrary are available for floods and earthquakes), a landslide inventory could assist in estimating the frequency of landslides. Additionally, the damages caused by landslides are related to the characteristics of the landslide such as volume and proximity to the road.

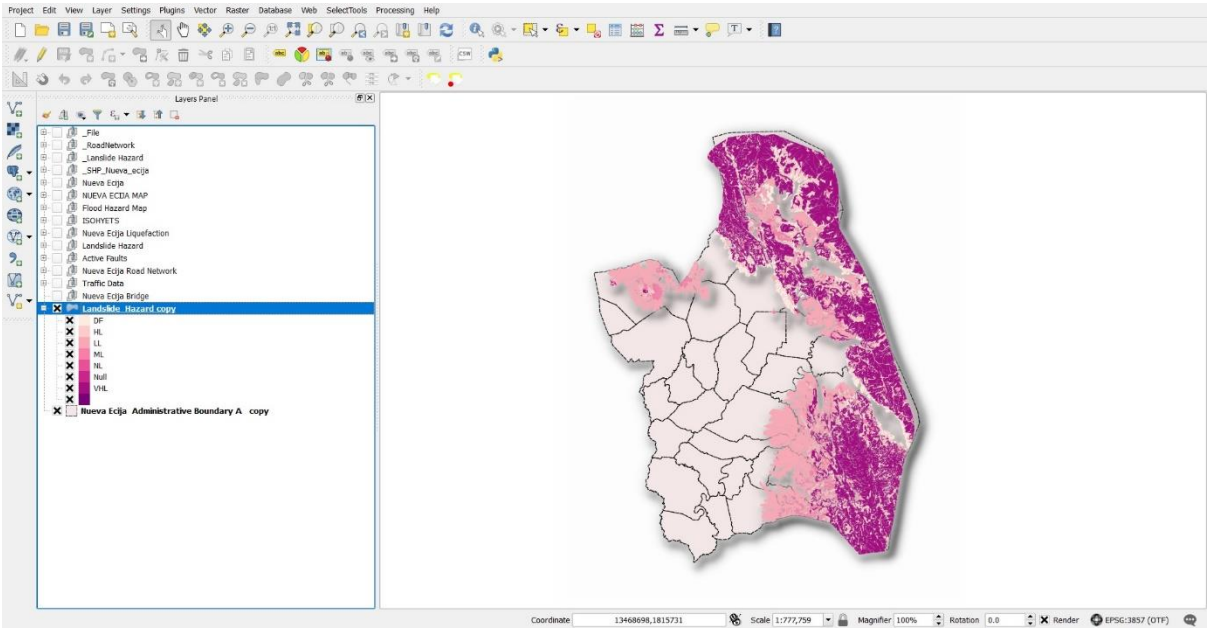
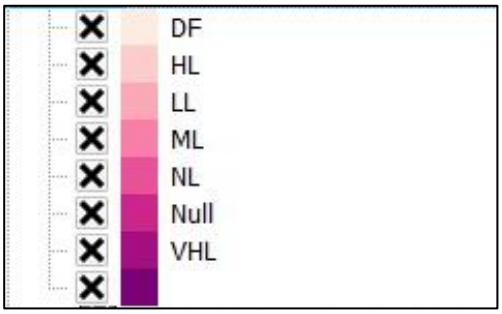
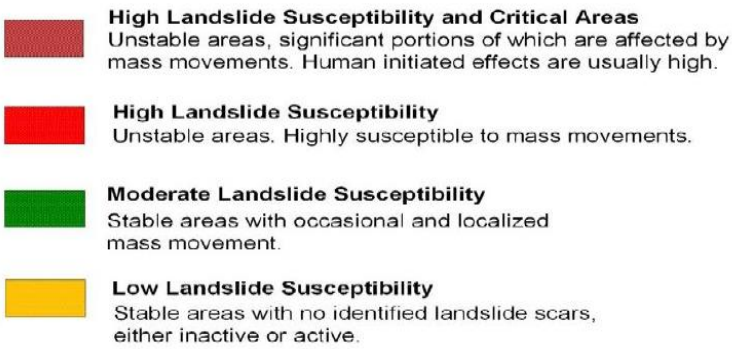



*Figure 3.7. Landslide Susceptibility Map as opened in QGIS Software*




a)




b)

*Figure 3.8 a) Legend from Landslide Susceptibility Maps as opened in QGIS Software b) Legend from Landslide Susceptibility Map from MGB*

#### 3.1.4.3 *Earthquakes*

Figure 3.3, Figure 3.4 and maps 5-8 in Annex I identify the generated earthquake hazard maps that exhibit PGA categories for different return periods in stiff soil and rock sites.
PHIVOLCS provided the raw data in a shapefile format. The collected data showed contour lines of various accelerations that needed to be transformed into area covering characterizations of expected PGA categories. There was, again, no explanation on how the maps were made or what should be best applicable for the province, in relation to the geological conditions. Based on the geological situation in Nueva Ecija it would be best to use the data for Stiff Sites. However, available data for stiff soil only includes a return period for 500 years, whereas the rock site maps include 500-, 1000- and 2500-year return periods. Therefore the information for the rock site was used (assuming that it is applicable for the entire province) which leads to a slight under estimation of the hazard, since PGA levels on the rock site maps are slightly lower.

### 3.1.5 Recommendations

Information gathering is the first critical step in conducting risk assessments. It occupies a large portion of the project planning since it is a process of knowing where to collect data, how to collect data, and how to interpret the data collected. The time period, though, can be shortened if given direct information and procedures to follow.

As initial step in data collection, it is essential to know where the specific data can be obtained. Although the scope of each government agency is properly defined in websites, it is still beneficial to have a clear overview of where data are available with corresponding formats and short descriptions. In this way, it is properly disclosed which data exists and which is lacking. Such a clear overview can also promote usage of the data for other projects or further improvements.

With information sources identified, it is then vital to have a set of effective procedures for data acquisition. For this project, several in-person visits were required to understand the process and collect data. At present, government agencies regulate each of their own process on how to monitor handing-out of data. Even though it is working, there are improvements that can be applied. Ideally, there should be a unified and systematic way of doing it. The step-by-step process should be explained to avoid ambiguity and delay. Like how it is done currently, filling up forms and DUA can still be implemented to ensure proper use and monitoring of data transfer. Providing duration of information relay by the agencies can assist the data gatherer with predicting time of data collection, as well. In this way, project planning can be approximated. Moreover, data transfer can be made rapid if there is already an existing database for all information rather than just producing when requested. This also ensures security and proper monitoring of data at hand.

Even with vast amount of available data, not being able to understand the retrieved information defeats the purpose of data collection. It is important that agencies provide explanations on relayed data. This can include interpretation of legends, scope, limitations, and how the data came about. Through such explanation, the information can be conveyed effectively to the users. This can also provide plan on how to properly manipulate the data.

Though hazard maps in PDF or image formats are good for presentations, possessing spatial data is more practical. Since it includes coordinate references, works can be done easily. Not only projects are executed effectively, but are also accomplished with less time. Moreover, it can be used for different applications. It is, then, of great significance that national agencies and local government units know how to work with this format. Through this, proper data

utilization and transfer can be promoted. However, it should be made certain that gaps and overlaps are avoided, and datasets conform to the standards.
Information are of no use if not being utilized by other users. National agencies have a great quantity of data that can be beneficial for our local government units. These data can assist the LGUs in building capacity for risk assessment ensuring, then, safety of communities. For better coordination, national agencies can provide a separate link on their website, specifically for LGUs open for use at their convenience. Furthermore, discussions on how to interpret and manipulate the data can be implemented, so LGUs can gradually learn how to build one themselves. This also promotes confirmation of data since LGUs can impart experiences on site making the data, then, more reliable. Subsequently, this becomes two-way transfer of knowledge. Through this, not only the data are being utilized and improved, but also relationships and communication.

Based on the lessons learned in the project a separate note 'recommendations for optimal use of data from National Agencies' has been compiled. The note addresses the recommendations made above, but also provides more specific recommendations on how the alignment between agencies and LGUs may be improved. The note is inserted as Annex III in this report.

## 3.2 The road network

### 3.2.1 Introduction and scope

The roads in the province of Nueva Ecija can be categorized into National, Provincial, City/Municipal, and Barangay roads. The DPWH (Department of Public Works and Highways), one of the three departments of the Philippine government undertaking major infrastructure projects, is the one responsible for the inventory of the National roads. The Provincial, City/Municipal, and Barangay roads, on the other hand, are under the responsibility of the LGUs (Local Government Units) and the DILG (Department of Interior and Local Government) can provide financial or technical support to the LGUs under specific programs.
The assessment done for the project, however, covers only the provincial roads.

### 3.2.2 Data needs

For the road infrastructure assessment, it is essential to have, as much as possible, data on culverts, bridges, erosion protection, tunnels, under and over passes and the roads themselves. Presence of such infrastructures in the province will contribute for the possible cost should there be hazards. It is also important to have a road network with distinction of National, Provincial, City/Municipal and Barangay roads since different roads entail different characteristics and cost.

### 3.2.3 Data collection process

Data collection for this portion of risk assessment can be divided into two parts since there are updated data found to be available only after the first workshop of the project:
**Part 1 -** relates to the collection of data prior to the workshop;
**Part 2** - relates to the collection of data post-workshop.

In part 1, road network data in GIS format were initially obtained from the LGU. The data include National, Provincial and Barangay roads. Mapping of the City/Municipal roads were unfinished and might be incorporated in the already existing barangay roads.
There is also an available road inventory from the province that was collected in part 1. A sample of it is presented below in Figure 3.9. It can be noted that there is road information that can be obtained from this inventory such as road name, stations, width no. of lanes, segment length, surface type, pavement type, and segment condition. The stations indicated would have

been helpful if they had been digitalized in a map. Since this data was not spatial, it was not helpful for the assessment.

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Road Name** | | | ALIAGA-BIBICLAT-LA TORRE ROAD | | | | | | |
| **Road ID** | | | | | | | | | |
| **LRP KM post Number** | | **START** | 0+000 | | | | **Station** | | |
| | | **END** | 7+871 | | | | **Station** | | |
| **Road Class** | | **Environment Code** | | | | **Direction Flow** | | | |
| **Road Importance** | | **RROW** | | | | **Terrain** | | | |
| **CARRIAGEWAY** | | | | | | | | | |
| Chainage | | Segment ID | Width | | No. of Lanes | Segment Length | Surface Type (Concrete, Asphalt, Gravel, Earth, Mixed) | Pavement Type (AMGB, AMAB, AMAP, AMCP,JPCD, JPCO, CRCP, AMCRCP, NONE, Other, Unknown) | Segment Condition (C, A, G,E, M) |
| Start | End | | Left | Right | | | | | |
| 0+000 | 2+832 | | 3.05 | 3.05 | 2 | 2,832 | C | CRCP | F |
| 2+832 | 2+932 | | 3.05 | 3.05 | 2 | 100 | C | CRCP | B |
| 2+932 | 3+300 | | 3.05 | 3.05 | 2 | 368 | C | CRCP | F |
| 3+300 | 3+329 | | 3.05 | 3.05 | 2 | 29 | C | CRCP | F |
| 3+329 | 3+363.7 | | 3.05 | 3.05 | 2 | 34.7 | C | CRCP | B |
| 3+363.70 | 3+950 | | 3.05 | 3.05 | 2 | 586.30 | C | CRCP | F |
| 3+950 | 4+518.5 | | 3.05 | 3.05 | 2 | 568.50 | A | AMCRCP | B |
| 4+518.5 | 7+871 | | 3.05 | 3.05 | 2 | 3,352.50 | C | CRCP | F |
| | | | | | | 7,871.00 | | | |

*Figure 3.9. Sample of Road Inventory – part 1.*

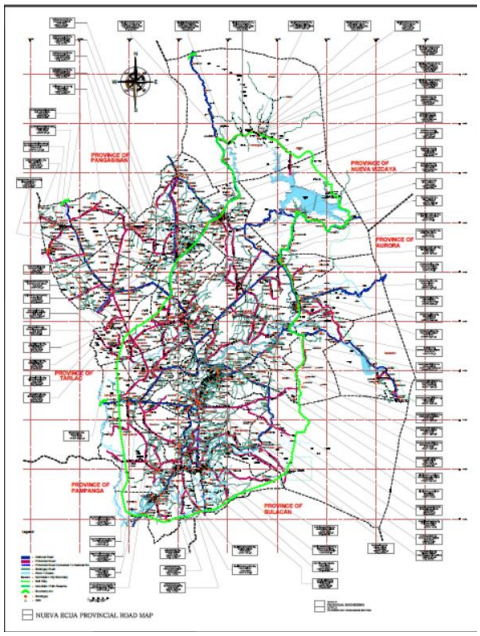
| **CULVERT** | | |
|---|---|---|
| Start | End | Type ID (Pipe, Box, Arch, Others, Unknown) |
| 0+500 | 0+521 | BO (IB) |
| 7+300 | 7+313.5 | BO (IB) |
| 7+350 | 7+354 | BO (IB) |
| 2+650 | 2+635.5 | RCP (1L) .60Ø |
| 3+384.25 | 3+385.25 | CRC (1L) .60Ø |

*Figure 3.10. Sample of Culvert Inventory – part 1.*

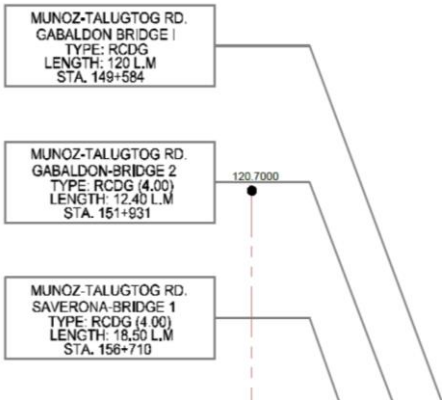
| PROJECT: ESTABLISHMENT OF PROVINCIAL AND CITY LOCATIONAL REFERENCING SYSTEM AND CONDUCT OF ROAD INVENTORY SURVEY | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| EXISTING BRIDGE INVENTORY DATA SHEET | | | | | | | | |
| **BRIDGE NAME:** | Victoria Bridge,Licab N.E. | | **Date of Survey:** | May 11,2017 | | | | |
| **GENERAL:** | | | | | | | | |
| **ROAD ID:** | | | **Road Name:** | | | **Year Built:** | | |
| **LRP Start Displacement:** | | | **Station No:** | | | **Load Limit (tons):** | | |
| **LRP End Displacement:** | | | **Coordinates:** | **Lat:** | **Long:** | **Cost of Construction:** | | |
| **RIVER NAME:** | | | **River Width (m):** | | | | | |
| **ENVIRONMENT:** | | | | | | | | |
| **Terrain:** | ☐ **Flat** | ☐ **Rolling** | ☐ **Mountainous** | | | | | |
| **Alternative Route:** | ☐ **Yes** | ☐ **No** | **Land Use:** | ☐ **Residential/Commercial** | | ☐ **Agricultural Use** | ☐ **Forest** | ☐ **Waste land** |
| **Structures/Houses in ROW?:** | ☐ **Yes** | ☐ **No** | **Utilities on Bridges:** | ☐ **Water** | ☑ **Sewerage** | ☐ **Electricity** | ☐ **Telephone** | ☐ None |
| **SUPER-STRUCTURE:** | | | | | | | | |
| **Structure Type:** | ☐ **Bailey** | ☐ **Timber** | ☐ **Steel Truss** | ☐ **RC Slab** | ☑ **RC Girder** | ☐ **PS Girder** | ☐ **Others:** | |
| **Type ID** | ☐ **Concrete - C** | ☐ **Steel - S** | ☐ **Temporary - T** | | | | | |
| **Surfacing:** | ☑ **Concrete** | ☐ **Asphalt** | ☐ **Wood** | ☐ **Others:** | | | | |
| **Number of Span:** | 1 | **Span Length:** | | | | | | |
| **Bridge Length (m):** | | **No. of Lanes:** | 2 | **Bearing Type:** | ☐ **Elastomeric Pad** | ☐ **Steel Plate** | ☐ **Others:Unknown** | |
| **No. of Girders:** | 4 | **Total Width (m):** | | **Surfacing:** | ☑ **Concrete** | ☐ **Asphalt** | | |
| **Sidewalk Width Left (m)0.50** | | **Carriageway Width (m):** | | **Railing Type:** | ☐ **RC** | ☐ **Steel** | ☐ **Others:** | |
| **Sidewalk Width Right (m)0.50** | | **Super Structure Length (m):** | | | | | | |
| **Exp. Joint Type:** | ☐ **None** | ☑ **Steel Plate Type** | ☐ **Finger Joint** | ☐ **Steel Type** | ☐ **Others:** | | | |
| **SUB-STRUCTURE:** | | | | | | | | |
| **Abutment Type:** | ☐ **Pile Bent** | ☐ **Cantilever** | ☐ **Gravity** | ☐ **Others:Two Column** | | ☐ **None** | ☐ **Unknown** | |
| **Abutment Foundation Type:** | ☐ **Spread Footing** | ☑ **RC/PC Concrete Pile** | ☐ **CIP Concrete:I Pile** | ☐ **Others:** | | ☐ **None** | ☑ **Unknown** | |
| **Abutment Protection:** | ☐ **Gabion** | ☐ **Grouted Riprap** | Concrete Lining | | ☐ **None** | ☐ **Unknown** | | |
| **Pier Type:** | ☐ **Pile Bent** | ☐ **Wall Type** | ☐ **1-Column** | ☐ **Rigid Frame** | ☐ **Others:Steel Pile** | | ☐ **None** | ☐ **Unknown** |
| **Pier Foundation Type:** | ☐ **Spread Footing** | ☐ **RC/PC Concrete Pile** | ☐ **CIP Concrete** | ☐ **Others:** | | ☐ **None** | ☐ **Unknown** | |
| **Pier Protection:** | ☐ **Gabion** | ☐ **Riprap** | ☐ **None** | ☐ **Others:Concrete** | | ☐ **None** | ☐ **Unknown** | |
| **No. of Pier:** | | | | | | | | |
| **HYDRAULIC CONDITION** | | | | | | | | |
| **Max. Flood Level:** | ☐ **Overflowed** | ☐ **At the Girder Level** | ☐ **Under the Girder** | ☐ **Others:** | | ☐ **Unknown** | | |
| **Navigation Clearance:** | ☐ **Insufficient - I** | ☐ **Sufficient - S** | ☐ **Unknown** | | | | | |
| **REMARKS: Fair Condition** | | | | | | | | |

*Figure 3.11. Sample of Bridge Inventory – part 1.*

Same with the roads, culverts and bridges are also found to have inventories. Figure 3.10 and Figure 3.11 show a sample for each. Information like bridge name, environment, superstructure, substructure, and hydraulic condition can be found in this inventory. Since both inventories were not spatial either, they were not beneficial for the assessment. Layout of bridges for Nueva Ecija, though, is available and is presented below in Figure 1.4. There is also other information indicated such as the road name, bridge name, type, length and station. In order to include the bridges in the assessment, these were manually inputted in GIS.




a)




b)

*Figure 3.12. a) Layout of Bridges in Nueva Ecija b) Detail of available information*

It is important to note that the inventories available in the LGU, collected in part 1, are the ones submitted for the RBIS (Roads and Bridges Inventory System) that is used in part 2 of the data collection. RBIS is a system that was developed by DILG that showcases information of infrastructures at a provincial level. Since it was under further improvements, RBIS data for Nueva Ecija was not available at the time the first workshop was conducted. It was only obtained by the project team in first week of April after being validated by the LGU. Figure 3.13 gives a peek of the website . This can only be accessed given a username and password. Data in GIS format were extracted from RBIS through the DILG. Information for bridges, culverts, ditches and roads is now readily available. This information is presented in this report.

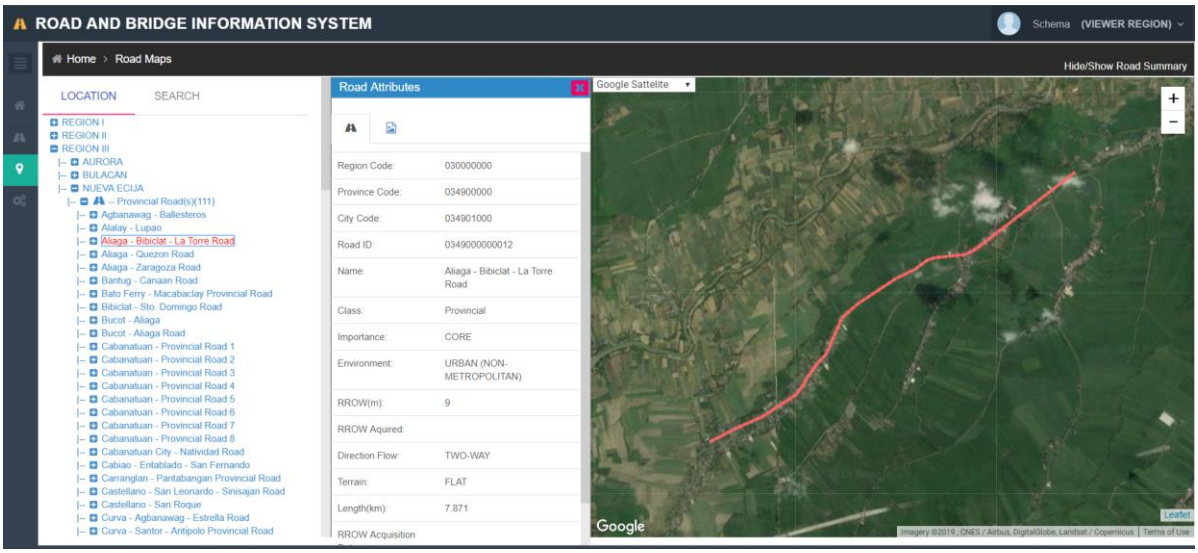



*Figure 3.13. RBIS Website*

### 3.2.3.1 *Road Infrastructure maps*

The Road Infrastructure Map shown in Figure 3.14 presents Nueva Ecija divided into districts, and infrastructure in the province such as roads (with distinction of National, Provincial, and Barangay), culverts, and bridges. For a clear visual representation of the assets format, map 9 in adequate size and resolution is attached in Annex I.

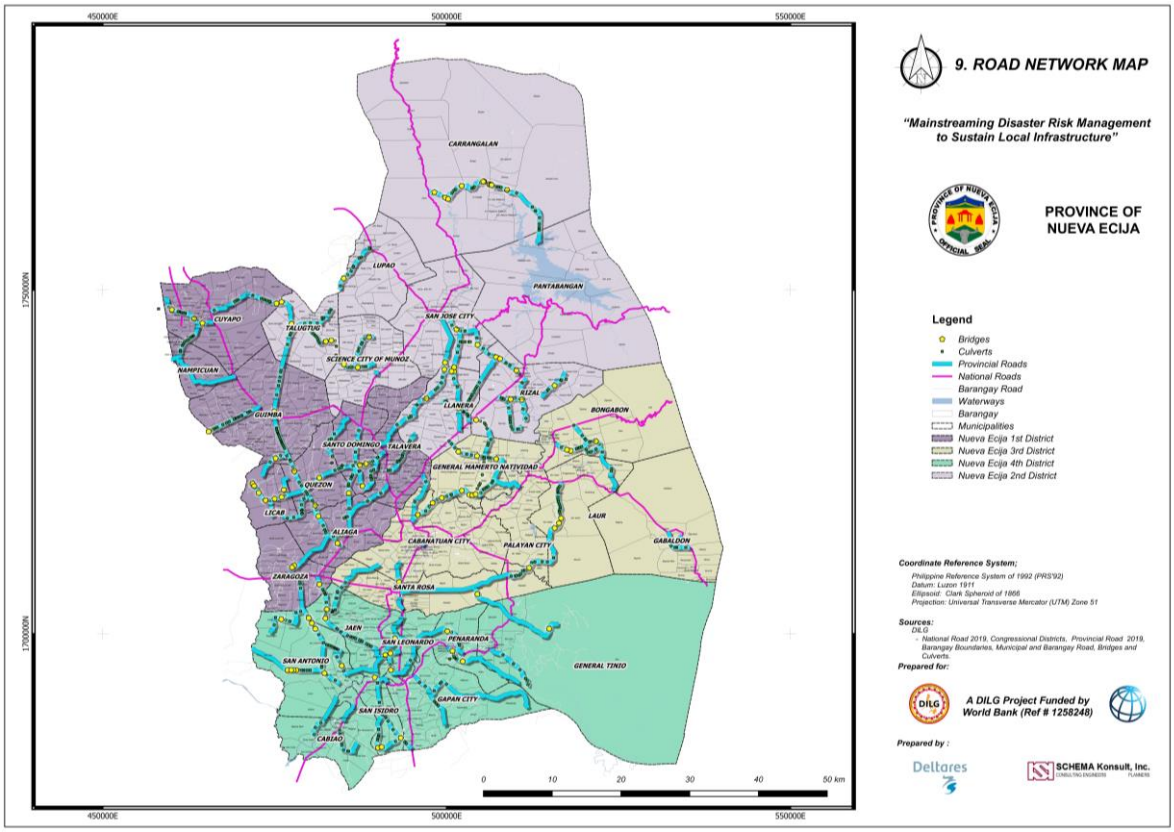



*Figure 3.14. Road Infrastructure Map*

### 3.2.3.2 *Road data*

During the data collection in part 1, the road network for Nueva Ecija was incomplete. Even with the availability of road inventories, data are not incorporated with the shapefile since the attributes show little information about the road as seen in Figure 3.15.

ProvincialRoad :: Features total: 121, filtered: 121, selected: 0

| | ROADNAME | ROADCLASSI | SURFACETYP | ROADIMPORT | WIDTH | LENGTH | BARANGAYNA | MUNICIPALC | REMARKS | R_Conditio |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | | CONCRETE | NOT SPEFICY | 0 | 0.00 | | | | GOOD |
| 2 | Agbanawag-Balle... | Provincial Road | CONCRETE | NOT SPEFICY | 6 | 6.68 | Cabucbucan | Rizal | | GOOD |
| 3 | Aliaga-Bibiclat-La... | Provincial Road | CONCRETE | NOT SPEFICY | 6 | 1.83 | Bibiclat | Aliaga | | GOOD |
| 4 | Aliaga-Bibiclat-La... | Provincial Road | CONCRETE | NOT SPEFICY | 6 | 7.70 | Bibiclat | Aliaga | | GOOD |
| 5 | Aliaga-Bibiclat-La... | Provincial Road | CONCRETE | NOT SPEFICY | 6 | 3.62 | Mamandil | Talavera | | GOOD |

*Figure 3.15. Attributes*

Roads RBIS :: Features total: 111, filtered: 111, selected: 0

| | CityMunCod | DirFlow | Environmen | Length | ProvinceCo | RROW | RROWAcquir | R_CLASS | R_ID | R_Importan | R_NAME | RegionCode | Terrain |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 034923000 | Two-Way | N | 6.370000000000... | 034900000 | 9 | Y | Provincial | 0349000000009 | Core | Agbanawag - Ball... | 030000000 | F |
| 2 | 034916000 | Two-Way | N | 9.000000000000... | 034900000 | 9 | Y | Provincial | 0349000000061 | Core | Alalay - Lupao | 030000000 | F |
| 3 | 034901000 | Two-Way | N | 7.871000000000... | 034900000 | 9 | Y | Provincial | 0349000000012 | Core | Aliaga - Bibiclat - ... | 030000000 | F |
| 4 | 034901000 | Two-Way | N | 3.447000000000... | 034900000 | 9 | Y | Provincial | 0349000000013 | Core | Aliaga - Quezon ... | 030000000 | F |
| 5 | | Two-Way | N | 8.160000000000... | 034900000 | | | Provincial | 0349000000089 | Core | Aliaga - Zaragoz... | 030000000 | F |

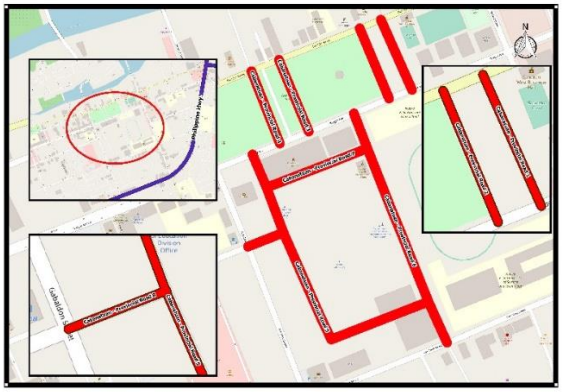
Roads RBIS :: Features total: 111, filtered: 111, selected: 0

| | ProvinceCo | RROW | RROWAcquir | R_CLASS | R_ID | R_Importan | R_NAME | RegionCode | Terrain | oldid | RROW_usefu | status | RROW_acq_c |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 034900000 | 9 | Y | Provincial | 0349000000009 | Core | Agbanawag - Ball... | 030000000 | F | 03NUE050 | 10 | validated | |
| 2 | 034900000 | 9 | Y | Provincial | 0349000000061 | Core | Alalay - Lupao | 030000000 | F | 03NUE040 | 10 | validated | |
| 3 | 034900000 | 9 | Y | Provincial | 0349000000012 | Core | Aliaga - Bibiclat - ... | 030000000 | F | 03NUE001 | 10 | returned | |
| 4 | 034900000 | 9 | Y | Provincial | 0349000000013 | Core | Aliaga - Quezon ... | 030000000 | F | 03NUE002 | 10 | returned | |

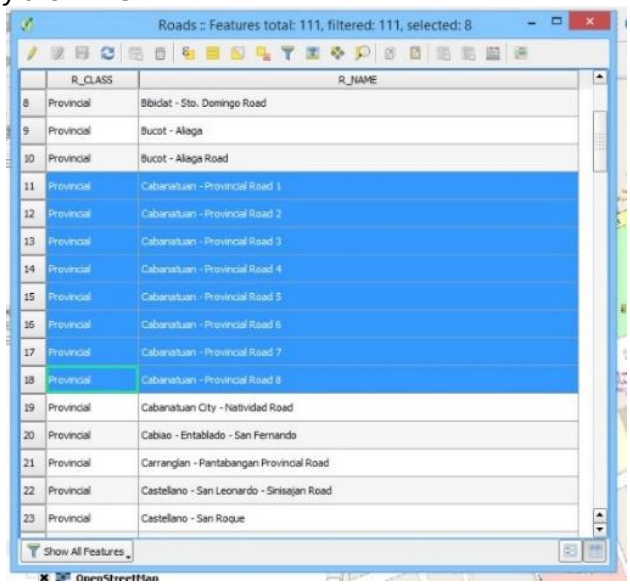
*Figure 3.16. Attributes in RBIS*

Road network data from RBIS, collected in part 2, on the other hand, are more updated and informative. More attributes (Figure 3.16) are available when compared with part 1. However, there are still errors found. These errors are not directly visible and are only identified when analyses and calculations start while using the data. These remarks are enumerated as follows:

**Remark 1.** 8 roads from the 111 that were obtained were not properly named and should be considered as one road, according to remarks by the DILG.



a)



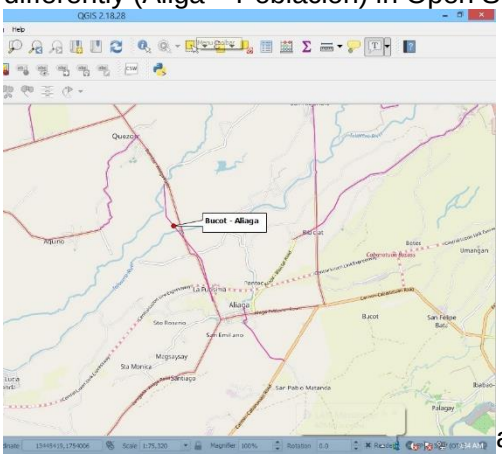

b)

*Figure 3.17. a) 8 roads in nueva ecija that should be considered as one; b) name of the 8 roads*

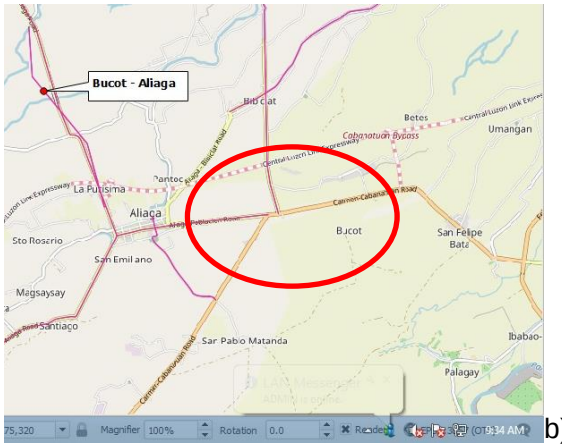
**Remark 2.** There are 3 roads namely Guimba-Banitan-Victoria, Munoz-Lupao, and Rizal – Bongabon that are still labelled as provincial road whilst they have already been converted to national roads. Some provincial roads are even superimposed with national roads.


*Figure 3.18. Provincial road superimposed in National road*

**Remark 3.** Some roads are positioned on wrong locations. One example is the Bucot – Aliaga road. In the RBIS, Bucot – Aliaga was positioned on the top of another road. It was also named differently (Aliga – Poblacion) in Open Street Map.




a)




b)

*Figure 3.19. a) Misplaced Bucot Aliaga Road (b) Real Bucot-Aliaga Road Named as Aliaga Poblacion in Open Street Map*

**Remark 4.** There are roads that appear to cross a river, but show no bridge or crossing in the RBIS.

*Figure 3.20. Roads Crossing River (From satellite imagery)*

**Remark 5.** Duplicate segments exist which cause a number of intersections, represented by points in Figure 3.20, which should not occur.


*Figure 3.21. Sample of duplicated roads*

**Remark 6.** Intersecting roads do not meet

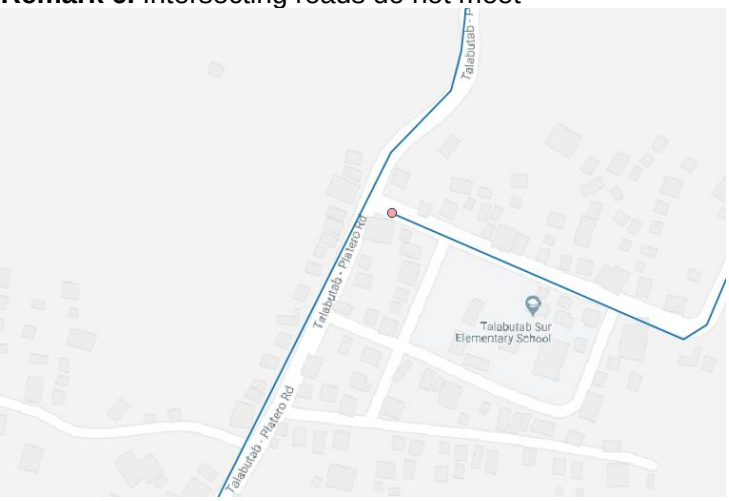



*Figure 3.22. Sample of intersection on a road that does not meet*

**Remark 7.** Road ends at intersections are lengthened with minor extensions

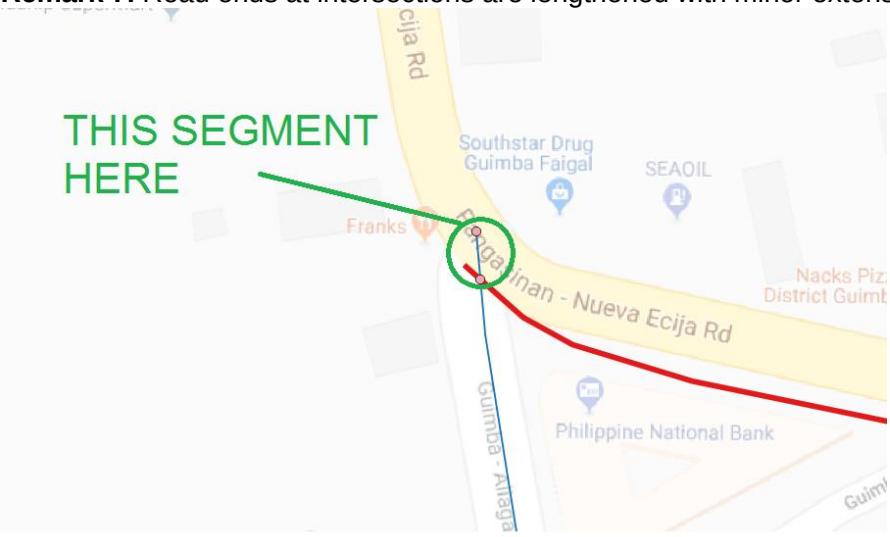



*Figure 3.23. Sample of intersections with minor extensions*

**Remark 8.** One road is, sometimes, divided to separate segments

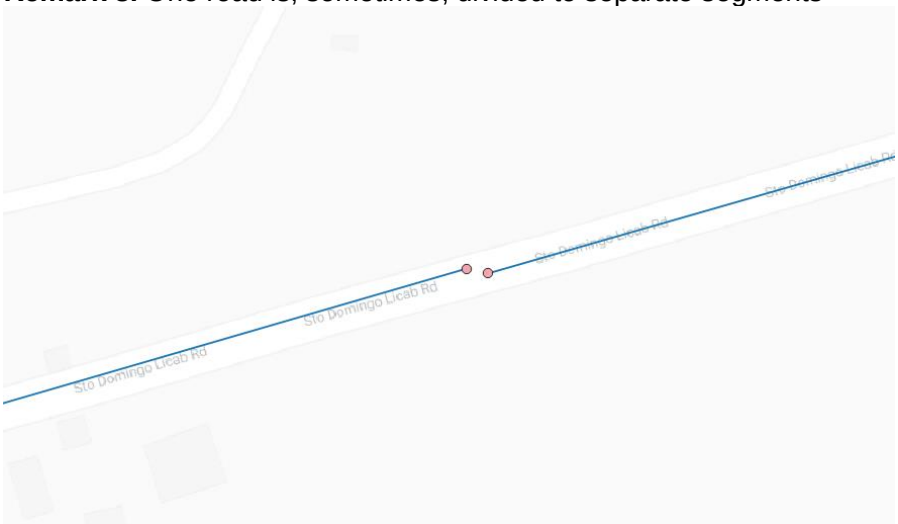



*Figure 3.24. Sample of one road divided into segments*

**Remark 9.** Boundaries are inconsistent for different agencies that result to inaccurate overlaying. Provincial roads are also outside the boundaries of the provincial limits provided.

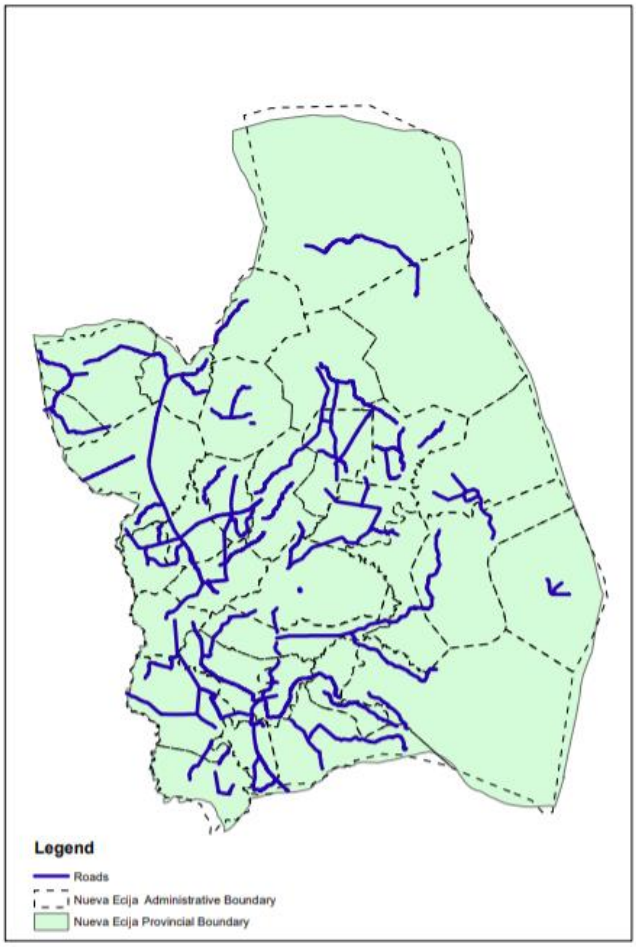



*Figure 3.25. Inconsistent Boundaries*

**Remark 10.** When the RBIS is run in GIS software, there are multiple errors that are encountered. This shows that the dataset is not clean enough to provide a proper GIS analysis. Encountered errors are:

- Multipart is a feature that has more than one physical part but pertains to one set of attributes.
- Dangling end error is similar with Remark 8 that there are lines that should be connected, but are not.
- Pseudo node error happens when a line connects with itself or when 2 polylines intersect.

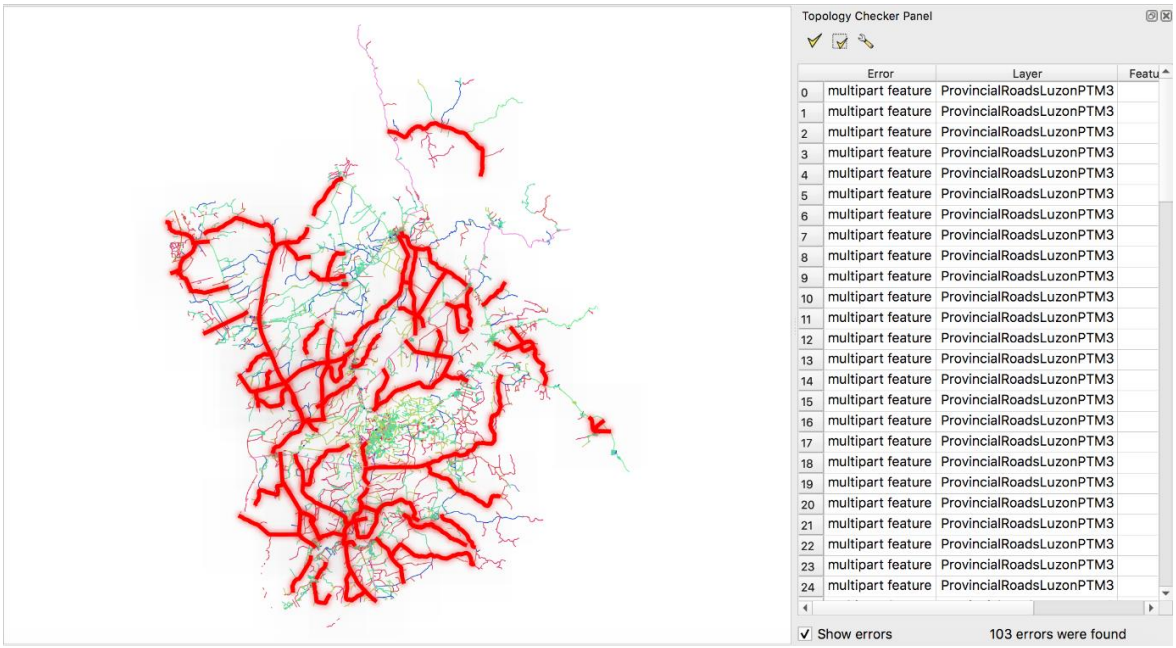



*Figure 3.26. Multipart Feature Error*

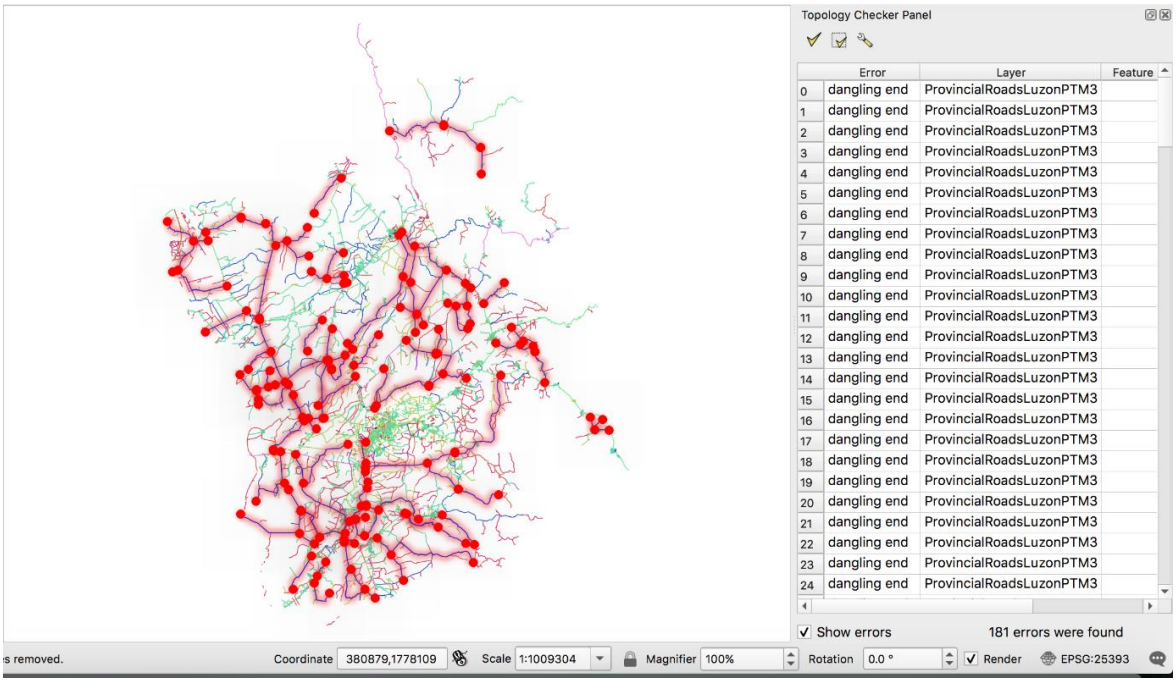



*Figure 3.27. Dangling End Error*

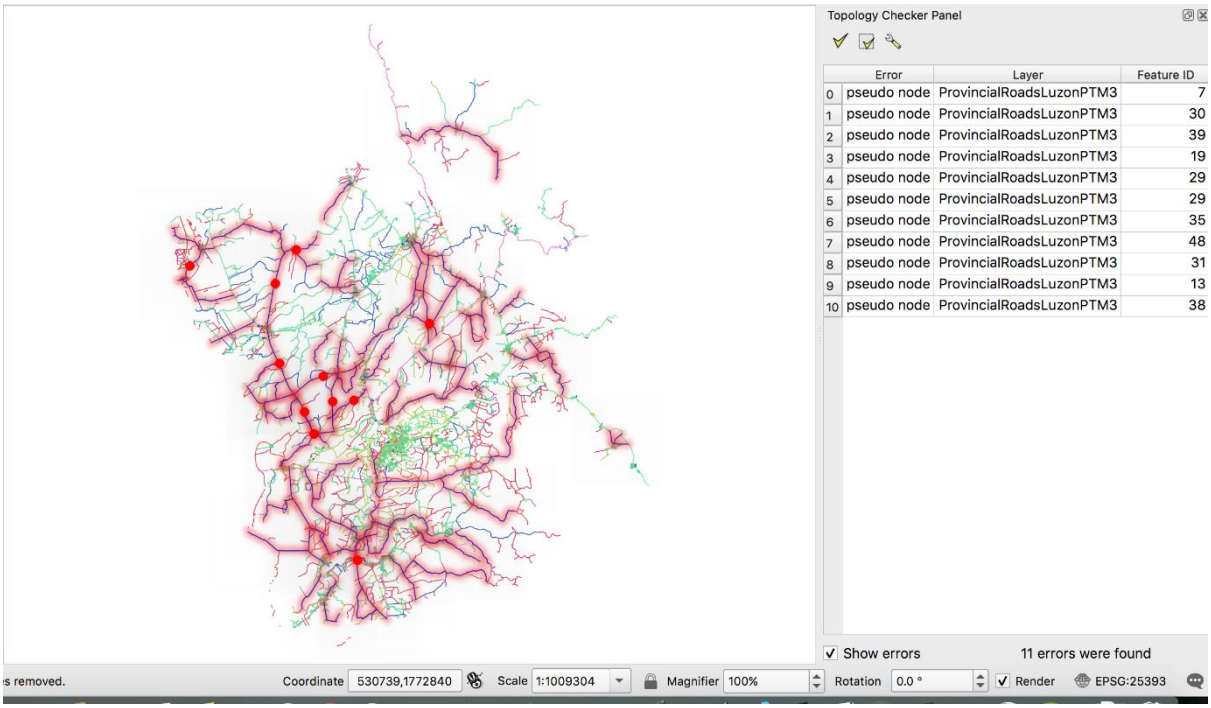



*Figure 3.28. Pseudo Node Error*

**Remark 11.** List of roads in the LGU's inventory of provincial roads are not synonymous with the list of roads in the RBIS data. Some roads in the inventory are not mapped in the RBIS.

**All remarks.** These inconsistencies have implications for the risk assessment outcome. Incomplete or inaccurate provincial road data lead to inaccurate network damage assessments and also the determination of the network redundancy is compromised, with implications for the assessment of the effects of disruption of road sections from natural hazards.

#### 3.2.3.3 *Bridges*

Since there were no coordinates for the start and end point of the bridge, from data collected in part 1, the bridges were initially inputted manually in GIS represented as a point (instead of a line) as shown in Figure 3.29. The placing of each point on the road was not accurate as well, thus affecting the initial assessment done based on data collected in part 1. Inspection was also performed through Google Earth. As it can be noted in Figure 3.30, there were inconsistencies in the placement of the bridges in the GIS and available imagery information. Moreover, a random site visit in Nueva Ecija has also proven that there are existing bridges that are not mapped in the layout and vice versa.

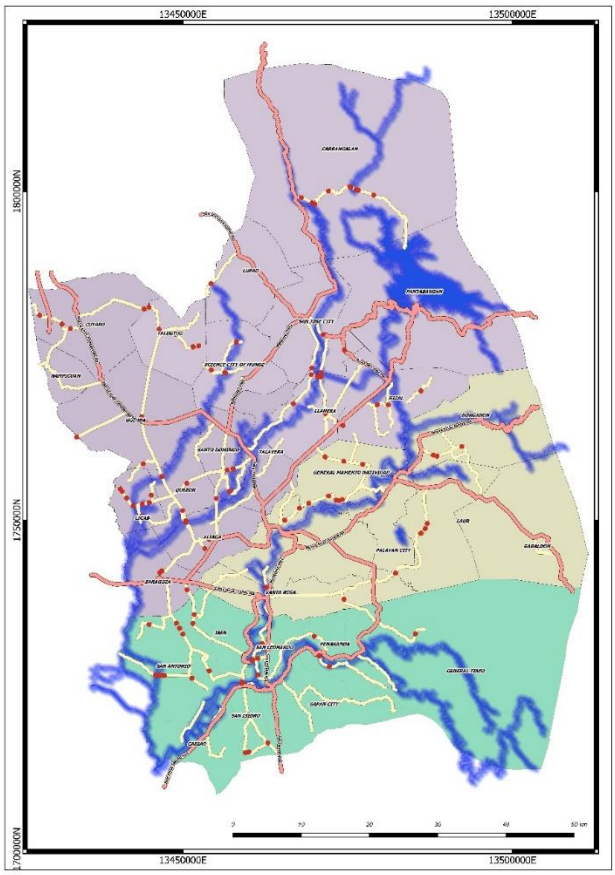



*Figure 3.29. Roads with Bridges Presented as Points*


*Figure 3.30 Bridges represented as points and Google Street View showing no bridge or a culvert*

With the acquisition of the RBIS data, bridges are now available as line segments. In Figure 3.14 the bridges are however visualized as points for reading purposes. The calculations are however done with the line segments. There are more attributes included, as well. This can be better visualized in Figure 3.31. From 73 bridges from the first data gathered, there are now 109 bridges for whole Nueva Ecija.

RoadBridges_LuzonPTM3 :: Features total: 109, filtered: 109, selected: 0

| | CarriageWi | NoOfLanes | BridgeUtil | LandUse | Structures | Alternativ | Terrain | AbtProtect | AbutmentFo | AbutmentTy | Constructi | DeckDime_1 | DeckDime_2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 7.500000000000... | 2 | WATER | RESIDENTIAL/C... | N | N | F | GROUTED RIPRAP | PC/RC CONCRET... | Unknown | | | |
| 2 | 6.700000000000... | 2 | WATER | RESIDENTIAL/C... | N | N | F | GROUTED RIPRAP | Unknown | Cantilever | | | |
| 3 | 7.200000000000... | 2 | WATER | RESIDENTIAL/C... | Y | N | F | GROUTED RIPRAP | PC/RC CONCRET... | Cantilever | | | |
| 4 | 7.400000000000... | 2 | WATER | RESIDENTIAL/C... | N | N | F | Grouted Riprap | Unknown | Cantilever | | | |
| 5 | | | | | | | | Grouted Riprap | Unknown | Cantilever | 0 | 7.400000000000... | 0.000000000000... |
| 6 | | | WATER | AGRICULTURAL ... | | Y | F | GROUTED RIPRAP | Unknown | Cantilever | | | |

RoadBridges_LuzonPTM3 :: Features total: 109, filtered: 109, selected: 0

| | DeckDime_2 | DeckDime_3 | DeckDimens | ExpansionJ | LRPEndDisp | LRPEndKmPo | LRPStartDi | LRPStartKm | Length | LoadLimit | MaximumFlo | Name | Navigation |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | | | STEEL PLATE | 425.0000000000... | 142 | 160.0000000000... | 142 | 265.0000000000... | | AT THE GIRDER L... | Hinukay River Pr... | INSUFFICIENT |
| 2 | | | | STEEL PLATE | 774.0000000000... | 149 | 750.0000000000... | 149 | 24.00000000000... | | UNDER THE GIR... | Ilog Baliwag | INSUFFICIENT |
| 3 | | | | Steel Plate | 570.0000000000... | 97 | 550.0000000000... | 97 | 20.00000000000... | | AT THE GIRDER L... | Presidential Bridge | SUFFICIENT |
| 4 | | | | Steel Plate | 362.7500000000... | 130 | 338.0000000000... | 130 | 24.75000000000... | | Under the Girder ... | San Isidro Bridge II | U |
| 5 | 0.000000000000... | 0.000000000000... | 2 | Steel Plate | 1537.994899999... | 0 | 1506.994899999... | 0 | 31.00000000000... | 0 | Under the Girder ... | Lawang Kupang ... | U |

RoadBridges_LuzonPTM3 :: Features total: 109, filtered: 109, selected: 0

| | Navigation | NoOfPier | NoOfSpan | NumGirders | PierFounda | PierProtec | PierType | R_ID | RailingTyp | RiverName | SpanLength | SuperStruc | Surfacing | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | INSUFFICIENT | 5 | 4 | 2 | OTHERS | UNKNOWN | PILE BENT | 0349000000013 | S | Talavera River | 281 | STEEL TRUSS | Asphalt | C |
| 2 | INSUFFICIENT | 1 | 2 | 4 | UNKNOWN | RIPRAP | PILE BENT | 0349000000029 | RC | Ilog Baliwag Creek | 20 | RC SLAB | Concrete | C |
| 3 | SUFFICIENT | | | | Unknown | NONE | Unknown | 0349000000070 | Other | Unknown | 20 | Steel Truss | Asphalt | C |
| 4 | U | 2 | | | PC/RC Concrete ... | Unknown | Wall Type | 0349000000067 | RC | Unknown | 60 | RC SLAB | Concrete | C |
| 5 | U | 0 | 0 | 0 | Unknown | Unknown | Unknown | 0349000000041 | Steel | Unknown | 31 | Steel Truss | Concrete | S |

RoadBridges_LuzonPTM3 :: Features total: 109, filtered: 109, selected: 0

| | Surfacing | TypeID | YearBuilt | oldid | status | TotalWidth | SideWalkWi | BearingTyp | SecondAppS | FirstAppSl | RightRaili | LeftRailin | RightSideW | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Asphalt | C | | 03NUE002 | validated | 7.500000000000... | | Steel Plate | F | F | | | | |
| 2 | Concrete | C | | 03NUE022 | validated | 6.700000000000... | | Steel Plate | F | F | B | B | | |
| 3 | Asphalt | C | | 03NUE098 | validated | 8.699999999999... | 0.750000000000... | | F | F | F | F | F | F |
| 4 | Concrete | C | | 03NUE070 | validated | | | | | | | | | |
| 5 | Concrete | S | 0 | 03NUE090 | | | | | | | | | | |

RoadBridges_LuzonPTM3 :: Features total: 109, filtered: 109, selected: 0

| | TotalWidth | SideWalkWi | BearingTyp | SecondAppS | FirstAppSl | RightRaili | LeftRailin | RightSideW | LeftSideWa | Deck | DebrisFlow | RiverAlign | RiverWidth |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 7.300000000000... | | Elastomeric Pad | G | B | G | G | G | G | G | FEW | STRAIGHT | |
| 2 | 8.300000000000... | | | F | G | F | G | F | G | G | MANY | STRAIGHT | |
| 3 | 9.500000000000... | 0.800000000000... | | F | F | G | G | G | G | F | FEW | STRAIGHT | |
| 4 | 9.600000000000... | 0.800000000000... | | G | G | G | G | G | G | G | FEW | STRAIGHT | |
| 5 | 6.000000000000... | 0.600000000000... | | F | F | F | F | F | G | G | | | |

*Figure 3.31. Bridges Attributes in RBIS*

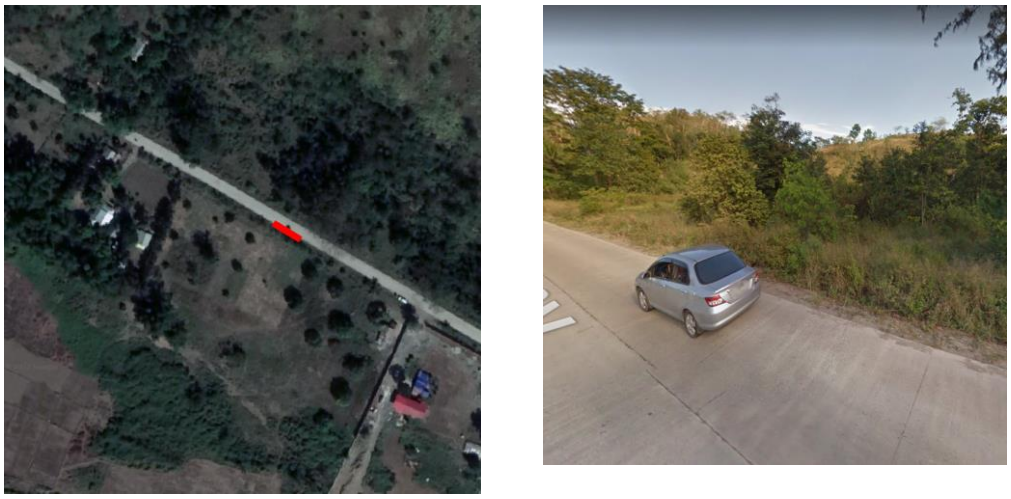
An overlay of the RBIS bridges and Google Maps still revealed some potential inconsistencies in length and/or location of bridges. These are documented in Figure 3.32, based on their GIS ID.

a)

b)

c)


d)



e)

f)

*Figure 3.32. Inconsistencies in bridge information by showing bridges in RBIS overlaying Google Maps (left-hand side) and corresponding Street view: a) FID 100, b) FID 73, c) 91, d) FID 90, e) FID 89, f) FID 94*

### 3.2.4 Recommendations

RBIS is a system formulated by DILG to showcase information from the LGU to be of use for different needs. However, to be utilized, the data should be reliable and accurate.

Collection of data starts with the listing of important information to gather. It is essential that LGU is aware of the data's function, use, and application to avoid over-gathering of data that will not be of use after. In this way, data will be simplified and straightforward. Also, data is difficult to manipulate if not spatial. Consequently, validation should be made. Comprehensive survey or checking for roads and culverts should be done to authenticate the data at hand. This can be performed by both LGU and DILG. Since LGU submits data to DILG, they can first examine it for errors. DILG, then, can inspect the data, as well, after receiving it from LGU. Checking can be made in a variety of ways such as random survey on site or even through Google Earth. This way, not only it strengthens understanding between the two government agencies, but it also ensures reliability of data.
Data can only be considered reliable if it is accurate. It should be close to the actual situation, if exact recordings cannot be presented. Reliability can be ensured by validation and counter-checking. Consistency is of great importance especially with names, stations, and boundaries since this can affect the results of the analyses that are to be performed with the data. One small discrepancy can lead to a different outcome. This can be applied both in manual collection of data, and inputting of data in GIS. The boundaries, especially, should be uniform for different agencies. One common projection should be practiced to avoid unmatched confines.

## 3.3 Traffic data

### 3.3.1 Introduction

The data of the most recent traffic survey conducted is a good measure of road usage in the province. A good understanding of the road usage is necessary to accurately measure the impacts to society when the road is disrupted or impassable, as can be the consequence of natural hazards.

### 3.3.2 Traffic Survey Data

There were two sets of traffic data obtained from the Local Government Unit of Nueva Ecija as a result from the traffic count surveys that they conducted. The first set of traffic data was the result of traffic count having 2 directions, direction 1 and 2 (Figure 3.33), and the other set of traffic data was the result of the traffic count at the intersection of the specific road section. Both sets of traffic data were obtained as scanned copies of the actual accomplished traffic count forms as presented in figures below.

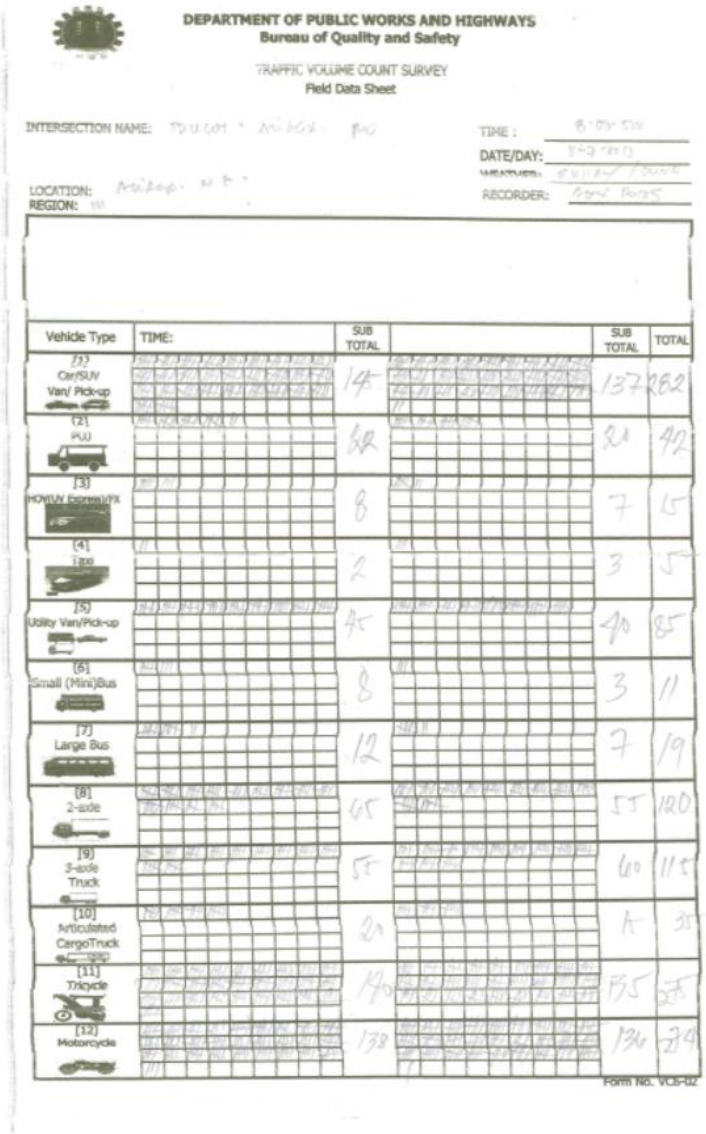

*Figure 3.33. Schematic Diagram of First Set of Traffic Survey*

The first set of traffic data were categorized into 4 provincial districts. As it can be seen in Figure 3.34, included in the traffic survey forms utilized in the traffic count survey are details such as intersection (road) name, location, region, time, date/day, weather, name of recorder, and traffic counts (in tally form) for different type of vehicles.

The vehicles are categorized into 12 vehicle types which include:

- Vehicle Type 1 - car/suv/van/pick-up;
- Vehicle Type 2 – Public Utility Jeepneys (PUJ);
- Vehicle Type 3 - HUV(UV Express)/FX;
- Vehicle Type 4 – taxi;
- Vehicle Type 5 - utility van/pick-up;
- Vehicle Type 6 - small bus;
- Vehicle Type 7 - large bus;
- Vehicle Type 8 - 2-axle truck;
- Vehicle Type 9 - 3-axle truck;
- Vehicle Type 10 - articulated cargo truck;
- Vehicle Type 11 - tricycle,
- Vehicle Type 12 - motorcycle.

According to the head of the Engineering Office in Nueva Ecija, the traffic counts were undertaken for two directions (Figure 3.33). The first column corresponds to vehicle counts going direction 1, while the second column pertains to the vehicle counts going direction 2.



DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS
Bureau of Quality and Safety

TRAFFIC VOLUME COUNT SURVEY
Field Data Sheet

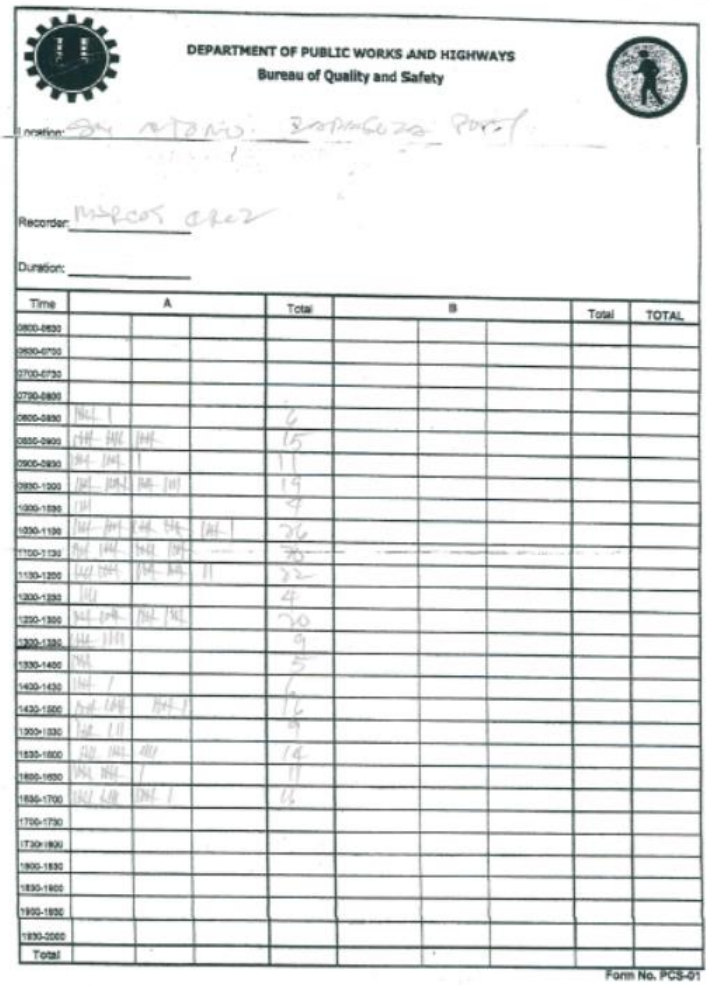
INTERSECTION NAME:
TIME:
DATE/DAY:
WEATHER:
RECORDER:
LOCATION:
REGION:

| Vehicle Type | TIME: | SUB TOTAL | | SUB TOTAL | TOTAL |
|---|---|---|---|---|---|
| [1] Car/SUV Van/ Pick-up | | 14 | | 137 | 282 |
| [2] PUJ | | 22 | | 21 | 42 |
| [3] HUV(UV Express)/FX | | 8 | | 7 | 15 |
| [4] Taxi | | 2 | | 3 | 5 |
| [5] Utility Van/Pick-up | | 45 | | 40 | 85 |
| [6] Small (Mini)Bus | | 8 | | 3 | 11 |
| [7] Large Bus | | 12 | | 7 | 19 |
| [8] 2-axle | | 65 | | 55 | 120 |
| [9] 3-axle Truck | | 55 | | 60 | 115 |
| [10] Articulated CargoTruck | | 20 | | 4 | 35 |
| [11] Tricycle | | 19 | | 15 | 34 |
| [12] Motorcycle | | 138 | | 136 | 274 |

Form No. VCB-02

*Figure 3.34. Traffic Counts at the Beginning and End of Road*

The second set of traffic data pertains to the traffic counts undertaken at the intersection of the roads (Figure 3.35). Unlike the first data set, this focuses more on the traffic counts per 30 minutes duration and does not take into account the types of vehicles. This traffic survey was performed for East to West (and vice versa) directions, and North to South (and vice versa) directions. This traffic survey was found to be done from the month of May to August 2018.



DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS
Bureau of Quality and Safety

Location:

Recorder:

Duration:

| Time | A | | | Total | B | | | Total | TOTAL |
|---|---|---|---|---|---|---|---|---|---|
| 0600-0630 | | | | | | | | | |
| 0630-0700 | | | | | | | | | |
| 0700-0730 | | | | | | | | | |
| 0730-0800 | | | | | | | | | |
| 0800-0830 | | | | 6 | | | | | |
| 0830-0900 | | | | 15 | | | | | |
| 0900-0930 | | | | 11 | | | | | |
| 0930-1000 | | | | 19 | | | | | |
| 1000-1030 | | | | 4 | | | | | |
| 1030-1100 | | | | 26 | | | | | |
| 1100-1130 | | | | 35 | | | | | |
| 1130-1200 | | | | 22 | | | | | |
| 1200-1230 | | | | 4 | | | | | |
| 1230-1300 | | | | 20 | | | | | |
| 1300-1330 | | | | 9 | | | | | |
| 1330-1400 | | | | 5 | | | | | |
| 1400-1430 | | | | 6 | | | | | |
| 1430-1500 | | | | 16 | | | | | |
| 1500-1530 | | | | 9 | | | | | |
| 1530-1600 | | | | 14 | | | | | |
| 1600-1630 | | | | 11 | | | | | |
| 1630-1700 | | | | 16 | | | | | |
| 1700-1730 | | | | | | | | | |
| 1730-1800 | | | | | | | | | |
| 1800-1830 | | | | | | | | | |
| 1830-1900 | | | | | | | | | |
| 1900-1930 | | | | | | | | | |
| 1930-2000 | | | | | | | | | |
| Total | | | | | | | | | |

Form No. PCS-01

*Figure 3.35. Traffic Counts at Intersection of the roads*

### 3.3.3 Traffic Survey Data Summarization and Analysis

Since the traffic count data were obtained as scanned copies only of the original, it had to be inputted in excel format for summarization. Some of the survey forms lacked certain information like the date/time it was conducted, weather, or location. Some were also found to be illegible. Moreover, total number of counts were sometimes incorrect or lacking. These encounters made the data summarization for traffic counts to take longer and be more difficult.

In the data summarization exercise, it was noted that some roads have more than one traffic count entry compared to others. It was also observed that the roads with multiple entries have drastic differences in traffic counts for the same road. Figure 3.36 presents a sample of both problematic instances. As it can be seen, there are unequal number of entries for 3 different roads; 3 entries for San Fabian – Dolores – Sto Domingo road, 4 entries for Tramo – Sto.

Rosario road, and 6 entries for Sto. Domingo – Poblacion road. These traffic count entries show large discrepancies, as well, considering that traffic count was conducted on the same day and for the same time duration. Further, it was also observed that there were the same road sections but which were captioned in reverse format, for example, San Antonio-Jaen road has a total traffic count of 2,145 while Jaen-San Antonio road has a total traffic count of 2,360, this cannot be interpreted as opposite direction traffic counts for the same road since the traffic count format already indicate opposite direction counts.
In the sample result of the data summarization (Figure 3.36); the first row per road shows the number of vehicles going direction 1 while the second row represents the number of vehicles going direction 2 of each specific road.

| | | | |
|---|---|---|---|
| | 210 | | |
| San Fabian - Dolores - Sto. Domingo | 154 | July 10, 2018 | 8 to 5 |
| | 169 | | |
| San Fabian - Dolores - Sto. Domingo | 137 | July 10, 2018 | 8 to 5 |
| | 653 | | |
| San Fabian - Dolores - Sto. Domingo | 606 | July 10, 2018 | 8 to 5 |
| | 439 | | |
| Tramo - Sto. Rosario | 404 | July 12, 2018 | 8 to 5 |
| | 325 | | |
| Tramo - Sto. Rosario | 262 | July 12, 2018 | 8 to 5 |
| | 311 | | |
| Tramo - Sto. Rosario | 305 | July 12, 2018 | 8 to 5 |
| | 253 | | |
| Tramo - Sto. Rosario | 323 | July 12, 2018 | 8 to 5 |
| | 837 | | |
| Sto. Domingo - Poblacion | 791 | July 11, 2018 | 8 to 5 |
| | 84 | | |
| Sto. Domingo - Poblacion | 63 | July 11, 2018 | 8 to 5 |
| | 30 | | |
| Sto. Domingo - Poblacion | 24 | July 11, 2018 | 8 to 5 |
| | 658 | | |
| Sto. Domingo - Poblacion | 623 | July 11, 2018 | 8 to 5 |
| | 508 | | |
| Sto. Domingo - Poblacion | 486 | July 11, 2018 | 8 to 5 |
| | 639 | | |
| Sto. Domingo - Poblacion | 598 | July 11, 2018 | 8 to 5 |

*Figure 3.36. Sample of Traffic Counts in Nueva Ecija*

It should be noted that the first set of traffic counts (going in 2 directions) were the ones used in the analysis for the estimation of the losses due to road disruption and not the traffic counts at the intersections. This was due to the reason that even though traffic survey for the intersection was conducted for 4 different directions, it was not indicated in the traffic survey which direction the traffic counts represent; furthermore, counts were not categorized by vehicle type. Thus, this cannot be used as basis for the criticality and losses analysis, which is presented in Section 6.
From the tally sheet, traffic count data are summarized in an excel spreadsheet format for each road section. The spreadsheet shows a separate column for hours and vehicle types for each direction.
After the summary by road section, a separate spreadsheet should be prepared for all the provincial roads. In the case of actual data gathered, traffic counts are summarized for each of the four administrative districts of the province. However, as previously discussed, there are various traffic count entries for each of the specific road section for each direction. Both directions are put in the spreadsheet. This was done for each of the traffic survey data entries for a specific road section. Then, these total traffic counts by road section are grouped for each specific road section as shown in Table 3.2.

*Table 3.2. Sample of Grouped Data by Road Section*

| District 1 - Nueva Ecija | Vehicle Type | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Road Name and Location | [1] Car, SUV, Van and Pickup(IN) | [2]PUJ(IN) | [3]HOV(UV express)/FX(IN) | [4] Taxi(IN) | [5] Utility Van/ Pick-up(IN) | [6] Small (mini) bus(IN) | [7] Large Bus(IN) | [8] 2-axle(IN) | [9] 3-axle(IN) | [10] articulated cargo truck(IN) | [11] Tricycle(IN) | [12] Motorcycle(IN) | TOTAL | TOTAL (IN + OUT) |
| **ALIAGA** | | | | | | | | | | | | | | |
| | 162 | 78 | 12 | 0 | 73 | 0 | 0 | 72 | 68 | 0 | 171 | 138 | 774 | |
| Aliaga-Bibiclat-La Torre | 137 | 58 | 2 | 0 | 58 | 0 | 0 | 57 | 53 | 0 | 158 | 126 | 649 | 1423 |
| | 138 | 23 | 8 | 0 | 78 | 3 | 0 | 73 | 70 | 5 | 163 | 133 | 694 | |
| Aliaga-Bibiclat-La Torre | 133 | 14 | 6 | 0 | 53 | 1 | 0 | 81 | 53 | 3 | 138 | 112 | 594 | 1288 |
| | 128 | 21 | 0 | 0 | 56 | 19 | 0 | 11 | 8 | 0 | 164 | 126 | 533 | |
| Aliaga-Bibiclat-La Torre | 97 | 13 | 0 | 0 | 49 | 8 | 0 | 18 | 12 | 0 | 147 | 137 | 481 | 1014 |
| | 139 | 14 | 0 | 0 | 36 | 12 | 0 | 19 | 12 | 9 | 138 | 143 | 522 | |
| Aliaga-Bibiclat-La Torre | 114 | 21 | 0 | 0 | 17 | 14 | 0 | 21 | 16 | 5 | 171 | 128 | 507 | 1029 |
| | 127 | 33 | 22 | 0 | 74 | 16 | 3 | 76 | 37 | 12 | 174 | 156 | 730 | |
| Aliaga-Quezon | 163 | 21 | 13 | 0 | 96 | 9 | 6 | 58 | 29 | 16 | 158 | 178 | 747 | 1477 |
| | 168 | 43 | 25 | 0 | 97 | 0 | 0 | 83 | 93 | 6 | 172 | 147 | 834 | |
| Aliaga-Quezon | 148 | 23 | 18 | 0 | 83 | 0 | 0 | 67 | 63 | 3 | 147 | 128 | 680 | 1514 |
| | 142 | 10 | 11 | 0 | 73 | 0 | 0 | 63 | 68 | 6 | 137 | 118 | 628 | |
| Aliaga-Quezon | 132 | 22 | 6 | 0 | 57 | 0 | 0 | 42 | 43 | 3 | 119 | 109 | 533 | 1161 |
| | 138 | 28 | 12 | 0 | 81 | 13 | 14 | 49 | 26 | 16 | 154 | 156 | 687 | |
| Aliaga-Quezon | 159 | 22 | 16 | 0 | 57 | 11 | 6 | 36 | 37 | 8 | 172 | 143 | 667 | 1354 |
| | 115 | 17 | 0 | 0 | 62 | 12 | 0 | 41 | 27 | 0 | 170 | 142 | 586 | |
| Sto.Tomas-San Pablo | 102 | 11 | 0 | 0 | 37 | 7 | 0 | 28 | 13 | 0 | 148 | 128 | 474 | 1060 |
| | 148 | 40 | 0 | 0 | 57 | 7 | 0 | 26 | 33 | 0 | 180 | 162 | 653 | |
| Sto.Tomas-San Pablo | 122 | 17 | 0 | 0 | 37 | 3 | 0 | 28 | 22 | 0 | 163 | 146 | 538 | 1191 |
| | 86 | 11 | 0 | 0 | 39 | 9 | 0 | 11 | 2 | 0 | 159 | 131 | 448 | |
| Sto.Tomas-San Pablo | 99 | 9 | 0 | 0 | 29 | 3 | 0 | 9 | 4 | 0 | 139 | 137 | 429 | 877 |
| | 103 | 8 | 0 | 0 | 46 | 5 | 0 | 16 | 3 | 0 | 168 | 117 | 466 | |
| Sto.Tomas-San Pablo | 121 | 12 | 0 | 0 | 28 | 2 | 0 | 12 | 6 | 0 | 146 | 157 | 484 | 950 |

Among these data entries, the Transport Planner chose the highest traffic count result as the traffic volume for the specific road section and the other traffic counts were disregarded. From the above 12 vehicle categories, the Transport Planner reduced the vehicle categories into 8 types. Then, these selected total traffic counts for each road section are grouped per administrative district as summarized in Table 3.3.

*Table 3.3. Sample of Spreadsheet Showing Total Traffic Count by Road Section*

| District 1 - Nueva Ecija | Vehicle Type | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Road Name and Location | [1] Car, SUV, Van and | [2]PUJ | [3]HOV(UV express)/FX | [4] Taxi | [5] Utility Van/ Pick-up | [6] Small (mini) bus | [7] Large Bus | [8] 2-axle | [9] 3- axle | [10] articulated cargo truck | [11] Tricycle | [12] Motorcycle | TOTAL |
| **ALIAGA** | | | | | | | | | | | | | |
| Aliaga-Bibiclat-La Torre | 299 | 136 | 14 | 0 | 131 | 0 | 0 | 129 | 121 | 0 | 329 | 264 | 1423 |
| Aliaga-Quezon | 316 | 66 | 43 | 0 | 180 | 0 | 0 | 150 | 156 | 9 | 319 | 275 | 1514 |
| Sto.Tomas-San Pablo | 270 | 57 | 0 | 0 | 94 | 10 | 0 | 54 | 55 | 0 | 343 | 308 | 1191 |
| Bucot - Aliaga | 316 | 108 | 63 | 0 | 141 | 53 | 30 | 153 | 171 | 14 | 303 | 285 | 1637 |
| Bibiclat-Sto.Domingo | 138 | 32 | 0 | 0 | 56 | 4 | 0 | 81 | 65 | 0 | 151 | 158 | 685 |
| **CUYAPO** | | | | | | | | | | | | | |
| Cuyapo-Nampicuan | 335 | 125 | 65 | 3 | 165 | 26 | 10 | 178 | 175 | 21 | 360 | 360 | 1823 |
| Cuyapo-San Manuel | 272 | 89 | 40 | 0 | 110 | 24 | 0 | 149 | 89 | 0 | 360 | 360 | 1493 |
| Malineng-Paitan | 210 | 54 | 2 | 0 | 131 | 0 | 0 | 105 | 94 | 9 | 319 | 323 | 1247 |
| Paitan Baloy-Talugtug | 223 | 71 | 0 | 0 | 90 | 0 | 0 | 135 | 105 | 11 | 260 | 269 | 1164 |
| **GUIMBA** | | | | | | | | | | | | | |
| Nagpadayan Guimba | 34 | 0 | 0 | 0 | 19 | 0 | 0 | 0 | 0 | 0 | 193 | 128 | 374 |
| Guimba - Pasong Instik Pura | 290 | 30 | 9 | 0 | 96 | 41 | 74 | 95 | 99 | 65 | 275 | 272 | 1346 |

These traffic count results are converted into Annual Average Daily Traffic (AADT) for each road section through the application of the 24-hour expansion factors, factors for daily variations in a week; and seasonal factors, the monthly variation in a year. These Daily Factors (DF) and Seasonal Factors (SF) were obtained from DPWH through its National Road Traffic Survey Program (NRTSP) which are annually being updated, the latest values are as presented in Table 3.4.

*Table 3.4. Traffic Conversion Factors*

| Daily and Seasonal Factors by Vehicle Class | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Factors** | **VT1** | **VT2** | **VT3** | **VT4** | **VT5** | **VT6** | **VT7** | **VT8** |
| **Daily** | 1.395 | 1.252 | 1.395 | 1.406 | 1.395 | 1.239 | 1.267 | 1.267 |
| **Seasonal** | 1.043 | 1.037 | 1.043 | 1.02 | 1.311 | 1.311 | 1.074 | 1.074 |

The following formula is employed:

AADT = 16-hr count day1 * 24-hr factor day1 * DF * SF

Where:

AADT = Annual Average daily traffic
16-Hr Count = Daily Traffic (based on survey count)
24-Hr Factor = 24 Hour Factor (based on actual count)
DF = Daily Factor
SF = Seasonal Factor

Based on this method, the computed AADT for each road section is given in Table 3.5.

*Table 3.5. Example of converted AADT by Road Section*

| District 1 - Nueva Ecija | AADT by Vehicle Type | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Road Name and Location** | **[1] Car, SUV, Van and Pickup** | **[2]PUJ** | **[3] Utility Van/ Pick-up** | **[4] Motorcycle** | **[5] Tricycle** | **[6] bus** | **[7] Truck 2-axle** | **[8] Truck 3-axle and above** | **TOTAL** |
| **ALIAGA** | | | | | | | | | |
| Aliaga-Bibiclat-La Torre | 455 | 177 | 191 | 379 | 602 | 0 | 176 | 524 | 2,502 |
| Aliaga-Quezon | 522 | 319 | 324 | 0 | 604 | 497 | 225 | 650 | 3,142 |
| Sto.Tomas-San Pablo | 393 | 196 | 151 | 14 | 271 | 193 | 75 | 540 | 1,834 |
| Bucot - Aliaga | 551 | 323 | 374 | 119 | 593 | 612 | 293 | 640 | 3,505 |
| **CUYAPO** | | | | | | | | | |
| Cuyapo-Nampicuan | 586 | 380 | 372 | 56 | 646 | 616 | 280 | 761 | 3,697 |
| Cuyapo-San Manuel | 454 | 258 | 253 | 34 | 474 | 426 | 121 | 693 | 2,713 |
| Malineng-Paitan | 308 | 240 | 194 | 0 | 432 | 323 | 140 | 589 | 2,226 |
| Paitan Baloy-Talugtug | 324 | 209 | 131 | 0 | 411 | 390 | 158 | 552 | 2,176 |

The AADT by road section were then inputted to the GIS road representation. From the road data from the RBIS digital platform, as discussed in ‘Section 3.2 The road network’, 8 attributes were created for discriminating the AADT for each vehicle type 1 to 8. Figure 3.37 illustrates the distribution of the most and least trafficked roads, by showing the sum of the AADT of all traffic types in each road. This map can be found in higher resolution as map 10 in Annex I.

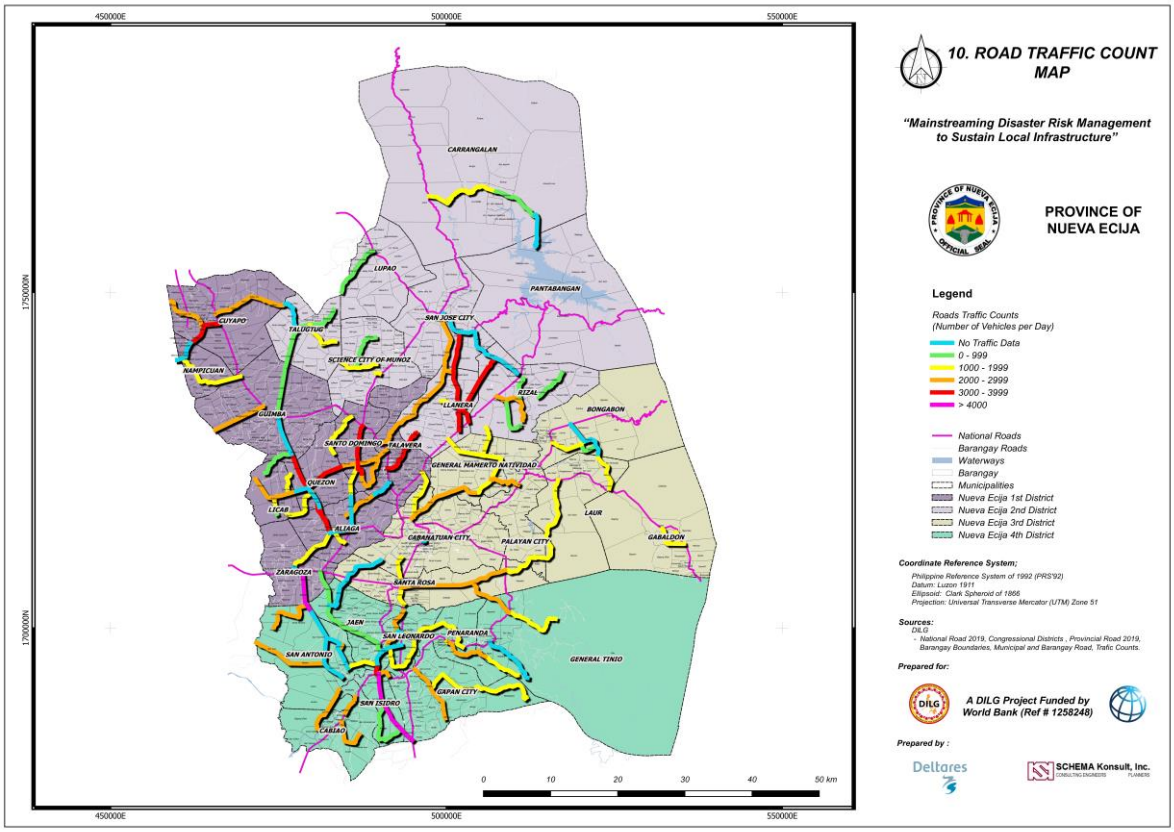



*Figure 3.37. Provincial road network displaying the traffic intensity.*

### 3.3.4 Recommendations

Traffic survey is useful in establishing the criticality of the roads which, then, becomes the basis for prioritization of their improvement or expansion. This is also used as basis in determining the probable cost of disruption in case of occurrence of disaster such as flooding along the road. However, to obtain useful estimates, accurate and reliable survey data should be obtained through the proper conduct of the traffic count survey.

First, appropriate traffic survey formats should be used which should include all the needed information that can be helpful in the analysis. Since counting by sight is fast pacing, the survey formats should be made straightforward, that is, with more simplified vehicle categories. The types of vehicles to be considered shall be picked carefully and should only cover the types usually encountered in the area. The LGU should therefore use a simplified traffic count survey format or consider automated counting.

Before the conduct of the survey, the location of the traffic survey stations should be identified and located in strategic and safe places. The surveyors should be briefed on how to appropriately fill in the information in the survey format, so they will be reminded not to leave portions unanswered. Two count persons per road per direction can be sufficient. This will insure redundancy of entries per road. The direction of vehicle flow should always be indicated since this is a significant part of the survey.

In addition, other recommendations to the LGU regarding the proper conduct of the Traffic Count Survey are given as follows:

1 The types of vehicle must be properly defined, in this case, attached in Annex A is the traffic count format in which the description of each types of vehicle groups are illustrated in picture for clearer vehicle type description, which should be adopted for consistency;

2 The direction from one place to another place (as much as possible the nearest and distinguishable name of place should be given) should be properly described for clearer flow description. There should be traffic count by directional flow (2 directions);

3 Traffic count stations should be located in the middle of a specific road segment (i.e., between junction to junction). If the survey is considering only the provincial roads, then, the road segment to be considered should be from junction of provincial road to the junction of another provincial road or national road. This means that junction to Barangay roads are not considered as a segment divider since the traffic flow to this road is local in nature, going only to a specific Barangay;

4 The established traffic count stations should be located on a safe and conducive area for conducting traffic count and should be maintained as much as possible for the purpose of conducting yearly traffic count to monitor the impact of disaster risks per year;

5 For the analysis of disaster risks of road infrastructure, only segment counts are considered and therefore intersection counts should not be considered since this type of vehicle count is done for the purpose of assessing the intersection capacity or the saturation flow at intersection and is not the accurate basis of a segment traffic flow analysis;

6 When traffic counts are done once every 3 years, the following approach should be followed:

6.1 Traffic counts are done on hourly basis to determine the peak hour flow along the specific road section/segment and for a minimum of 16 hours in a day from 6:00 a.m. to 10:00 p.m. It should be undertaken for 2 days during normal days in a week. This is later averaged and converted to a daily basis by applying the 24-hour expansion factor and consequently to Average Annual Daily Traffic (AADT) by using the seasonal expansion factor which can all be obtained from the DPWH;

6.2 Better results are obtained though, by using DPWH BQS, which suggests that the Provincial Engineering Office (PEO) should conduct a continuous (24-hour) 7-day traffic count once a year, preferably during the dry season when classes are held and around the harvest season. The PEO should then use the applicable DPWH seasonal factor for the nearest National Road in order to convert the 7-day provincial road traffic into AADT;

7 For traffic data processing, the LGU staff should be trained on the methodology of encoding and processing for converting the count data into AADT.

8 After the traffic survey, it is essential to undertake data validation to avoid unreliability of results. Huge distinction between traffic counts made for the same road and same day should be verified and repeated, if necessary. Furthermore, the results shall be tabulated in excel worksheet format to make it more understandable and readily available for utilization in the analysis. However, there are now advanced ways of vehicle counting that might be more efficient than manual surveying that the LGU may consider. However, this might entail higher cost, but will be faster and more efficient, thus, minimizing human error.

9 Traffic counting should be a regular activity of the Provincial Engineering Offices and the generated traffic data should be included in the RBIS.

10 Indeed, it is important that Local Government Units have sufficient knowledge about traffic surveying so that they can execute it properly. But it is also of great significance that they know how to utilize and apply these data for more effective and reliable road improvement/rehabilitation plans.

# 4 Road Exposure

## 4.1 Introduction

This section discusses the identification of the Nueva Ecija provincial road exposure to different natural hazards. The exposure maps aim at identifying, for each hazard intensity, which are the elements exposed, i.e., at risk. For the data available for the Nueva Ecija provincial road network, this means identifying which road stretches, bridges and tunnels are subject to the natural hazards and which hazard level that is.

## 4.2 Data needs

The road exposure assessment builds on the hazard mapping, as discussed in section 3.1, and the mapping of the road network assets, as discussed in section 3.2. The source of each map is discussed in the respective section.

## 4.3 Methodology

In general, the determination of the exposure, having both the hazard maps and the road network assets in a GIS format and accurately represented, requires a straightforward intersection the assets and hazard GIS layers.

For the Provincial Roads Network and the Hazard Maps available for Nueva Ecija, however, this procedure requires all layers to be “cleaned” individually. There should not be any gaps, overlaps, feature duplicates and invalid geometries. This is not always the case. For example, using qGIS Topology Checker, the following layers were assessed and the results for invalid geometries:

- Flood Hazard Layer, Return Period 5 yrs with 174 features - 124 errors invalid geometries
- Flood Hazard Layer, Return Period 25 yrs with 174 features - 124 errors invalid geometries
- Flood Hazard Layer, Return Period 100 yrs with 174 features - 124 errors invalid geometries
- Landslide Susceptibility with 4032 features - 3 errors invalid geometries

Such invalid geometries, among other inconsistencies, prevent the use of qGIS, a free and open-source cross-platform desktop GIS application, to perform the required intersection. And the “cleaning” of the input data to be able use qGIS, is very time consuming. A different approach was taken, using ESRI’s ArcMap Identity tool that creates a new coverage/shapefile by overlaying two sets of features/layers. For the purposes of representation, the identity tool was used to generate the required exposure maps.

## 4.4 Exposure maps

Figure 4.1 and Figure 4.2, illustrate the exposure maps for floods and earthquakes for return periods of 5 and 500 years respectively. Maps 11-13 in Annex I show all flood exposure maps and maps 15-18 in Annex I show all earthquake exposure maps.

In the case of landslides, Figure 4.3 shows the local susceptibility for landslides along the road network, because the available hazard information is of landslide susceptibility and not hazard level. Map 14 in Annex 1 shows the landslide susceptibility in larger format.

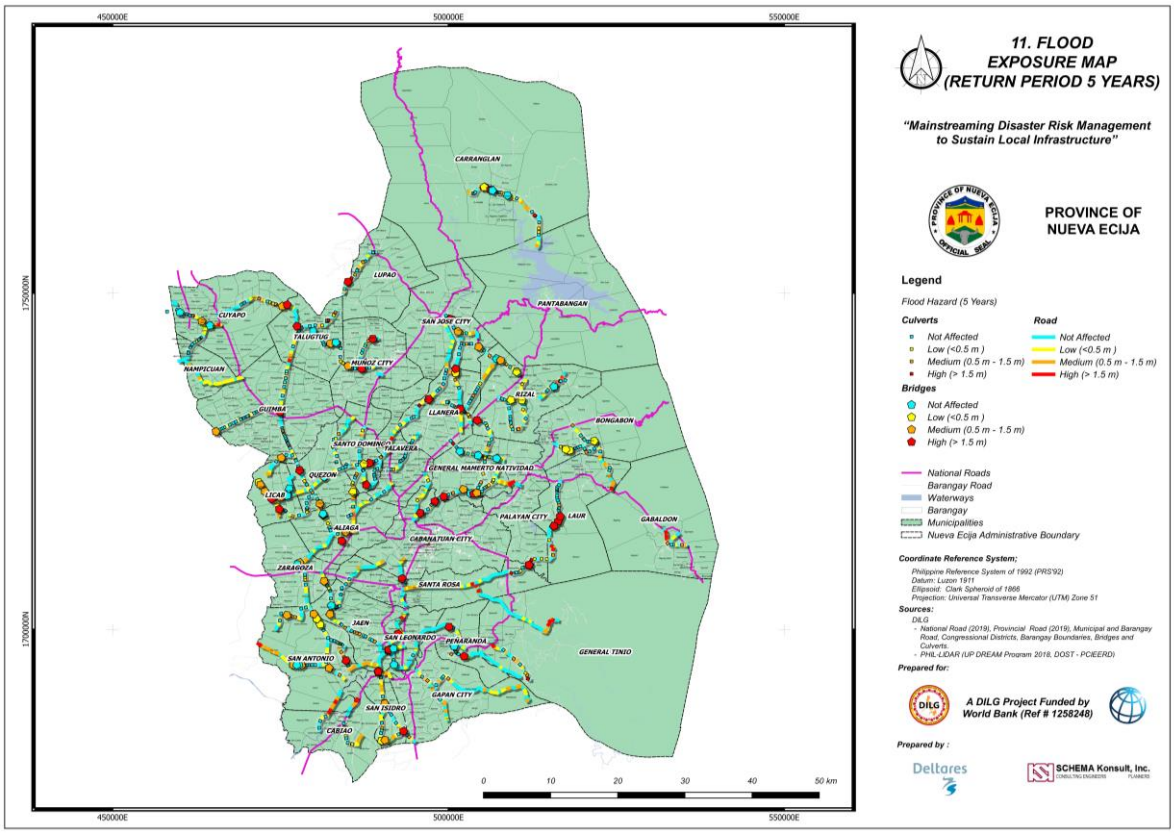



Figure 4.1 Flood Exposure Map, 5 Years Return Period

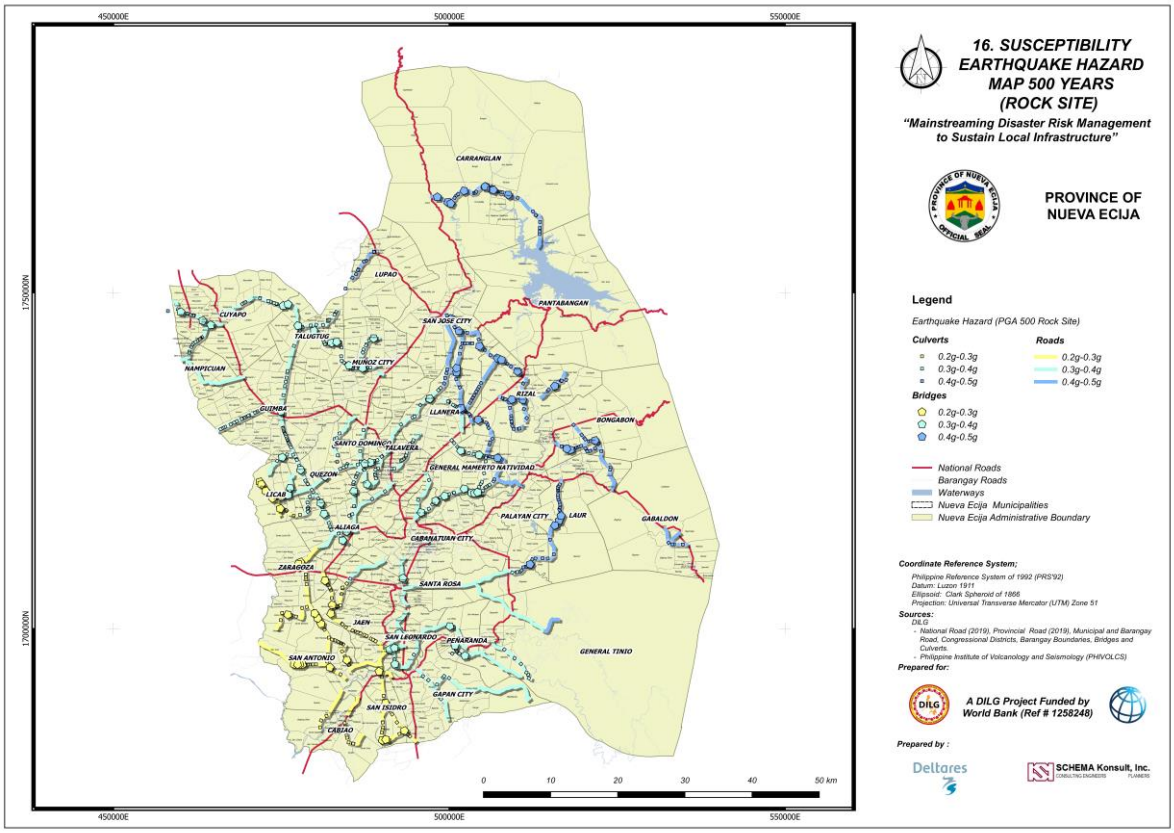



Figure 4.2. Earthquake Exposure Map, 500 Years Return Period

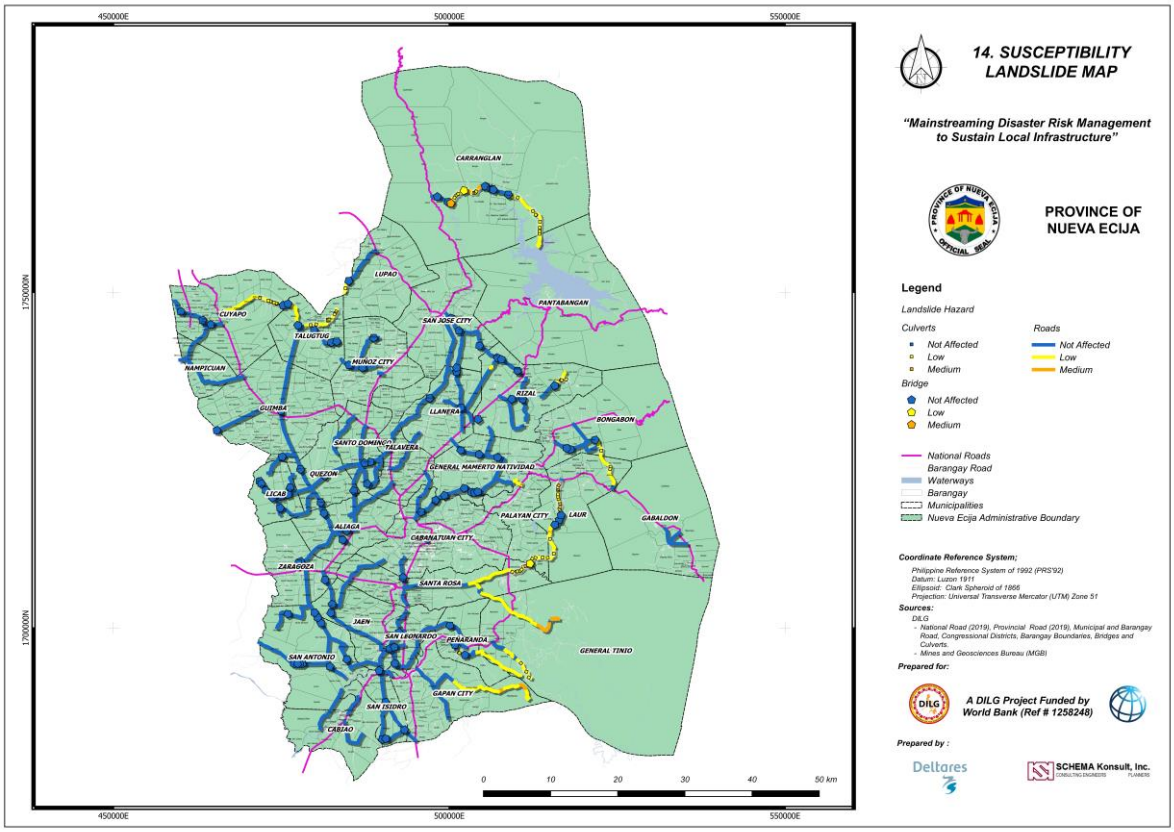



*Figure 4.3. Landslide susceptibility map along the provincial roads.*

# 5 Road Damages

## 5.1 Introduction

This section discusses the physical damage assessment to the road infrastructure and assets, due to floods and earthquakes. The damage is expressed in terms of costs per hazard scenario in Philippine Pesos. This information constitutes one of the elements that will be used to evaluate risks and prioritize actions. As discussed in Chapters 3.1 and 4, we do not have sufficient information to estimate damages for landslides. The Nueva Ecija Landslide map is a susceptibility map, indicating high to low susceptibility, and thus lacks the characterization of the hazard level in terms of the size/run-out of the landslides and the respective probabilities of occurrence. Therefore vulnerability cannot be calculated for landslides.

## 5.2 Data needs

The road physical damage assessment builds on the mapping of the road exposure, as discussed in section 4, and further input on the vulnerability and repair costs for each road asset type, for the different hazards, for each hazard level.

## 5.3 Data collection process

Data gathering on vulnerability and repair costs started after the first workshop was held in February and was completed by the month of April. Since the LGU was doing a number of activities during those times, travelling to Nueva Ecija was necessary for swift assembling of data. Clarifications were also occasionally done through phone calls.

### 5.3.1 Construction Costs and Repair Costs

Actual project costs of road infrastructure and assets were collected from the LGU. This was given as reference by the head of the engineering office in Nueva Ecija. Costs were handed as hard copies, so it was necessary to input it for processing. These are actual costs from projects in the province and thus adjusted for the local reality and the analysis performed.

### 5.3.2 Vulnerability

The vulnerability of the different assets reflects the estimated degree of damage inflicted to the infrastructure by the varying hazard levels. Vulnerability is herein expressed as a percentage of the construction costs.

Repair cost estimations were done based on the collected data for the infrastructure assets including small and large culverts, small and large bridges, paved and unpaved roads subject to each hazard and discriminated by hazard level, such as floods (flood depth less than 0.5m, 0.5 to 1.5m, and above 1.5m of normal water level), landslides (low, medium, high hazard), and earthquakes (0.2g-0.3g, 0.3g to 0.4g, 0.4g to 0.5g, and 0.5g to 0.6g Peak Ground Acceleration - PGA).

Table 5.1 details the vulnerability of the road network, expressing the repair costs in each case as a percentage of construction costs. The LGU provided costs for repair of floods for various roads that were damaged due to different flood levels. The raw data were analysed. By dividing the experienced costs with the estimated construction costs from Table 5.2, the percentages in Table 5.1 have been calculated. Costs were only provided for repairs due to flooding. No data were available for earthquake damages since these are infrequently occurring. For earthquakes, estimations were made by the LGU.

| Repair costs as a percentage of construction costs, per hazard, per asset type | | Culverts | | Bridges | | Provincial road | |
|---|---|---|---|---|---|---|---|
| | | Small | Large | Small | Large | Paved | Unpaved |
| | | (PHP/unit) | (PHP/unit) | (PHP/m) | (PHP/m) | (PHP/m) | (PHP/m) |
| Flood hazard | <0.5 | 49% | 7% | 2% | 2% | 122% | 283% |
| | 0.5m-1.5m | 44% | 10% | 2% | 5% | 122% | 280% |
| | >1.5m | 66% | 13% | 5% | 12% | 122% | 278% |
| Earthquake hazard | 0.2g-0.3g | 10% | 15% | 8% | 16% | 15% | 4% |
| | 0.3g-0.4g | 15% | 20% | 16% | 24% | 25% | 6% |
| | 0.4g-0.5g | 20% | 25% | 24% | 32% | 35% | 8% |
| | 0.5g-0.6g | 25% | 30% | 32% | 40% | 45% | 10% |

*Table 5.1* Vulnerability: repair costs as a percentage of construction costs, per hazard, per asset type

| | Culverts | | Bridges | | Provincial road | |
|---|---|---|---|---|---|---|
| | Small | Large | Small | Large | Paved | Unpaved |
| | (PHP/unit) | (PHP/unit) | (PHP/m) | (PHP/m) | (PHP/m) | (PHP/m) |
| Construction costs of asset | 40.000 | 410.000 | 850.000 | 850.000 | 14.000 | 1.000 |

*Table 5.2 Construction costs of assets*

It is highlighted that the percentages for repair costs have been carefully collected. The LGU has provided real costs of past events which we have used to make the table. We consider it very important that local information based on experiences and records is used in this respect. Note that these percentages will also change when the construction costs are different (higher construction costs will lead to lower percentages), since the percentages are calculated based on real costs. Given the lack of sufficient data, we have not further classified the repair costs for various circumstances like the road condition (good, fair, poor).

The vulnerability percentages are a critical input into the calculations of damage and risk. Though carefully collected, we therefore highly recommend that the numbers are further validated by building a database of events. Such a database should consist information of the following:

- The type of hazard occurring
- Exposure data (flood depth, PGA, amount of volume of landslide)
- Road characteristics of the exposed road (embankment, culvert/bridge, road condition, maintenance status)
- Recorded damages in short description
- Repair costs expressed in Pesos
- Duration of the event

It is important that the database will include all situations of impacted roads; also when no or very little damage is to be reported. It may be the case that the current numbers for floods are based on high damage events only, leading to possibly too high vulnerability estimates.

## 5.4 Damage Calculation Methodology

Damage maps for each flood, landslide and earthquake scenario can be calculated by combining the information obtained in road exposure maps with the vulnerability functions from

Table 5.1. As discussed, damages are only calculated for the flood and earthquake scenarios due to the limitations of the available landslide maps. The Nueva Ecija Landslide map is a susceptibility map, indicating high to low susceptibility, and thus lacks the characterization of the hazard level in terms of the size/run-out of the landslides and the respective probabilities of occurrence. Therefore vulnerability and losses cannot be calculated for landslides.

The methodology employed to calculate the damages is exemplified in Figure 5.1.

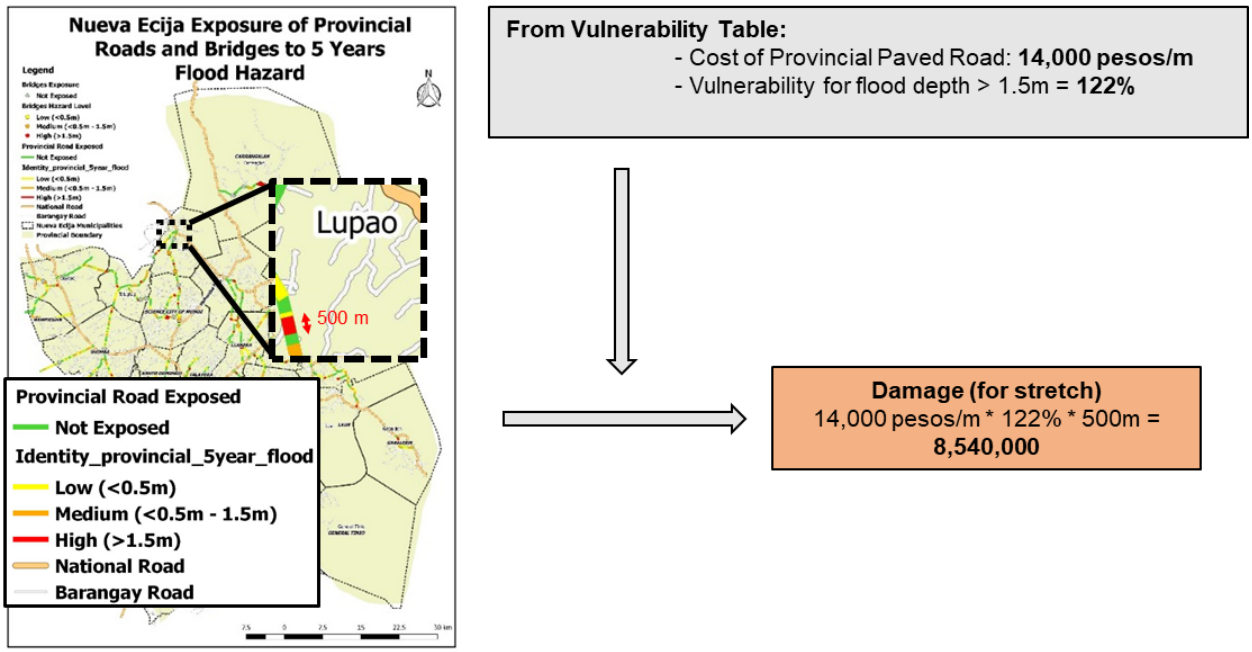



*Figure 5.1. Calculation of damages – example for road flood damage.*

The process exemplified Figure 5.1 is repeated for all exposed road stretches and then summed to obtain the damages for each road in the RBIS road network.
The damages for each bridge are obtained in an identical manner as for roads, given that both have costs in Table 5.1 expressed in PHP per linear meter. Based on the project costs obtained, large bridges are considered to be those longer than 20m, and small bridges otherwise.
The costs of culverts, however, are expressed per unit culvert. The corresponding exposure was determined by the maximum hazard level along the culvert. The maximum hazard level is then used in Table 5.1to determine the corresponding degree of damage and calculate the damage. Based on the project costs obtained, large culverts are considered to be those larger than 3m, and small culverts otherwise.

## 5.5 Damage Maps

Based on the above considerations, physical damages could be calculated individually for roads, bridges and culverts, as shown in Figure 5.2. The individual damage costs per asset type were then aggregated for all the assets belonging to the same road, as identified in the RBIS data. This is exemplified in Figure 5.3. Damage maps for all flood and earthquake scenarios are presented in Annex I, maps 19-21 for flooding and maps 23-25 for earthquakes.

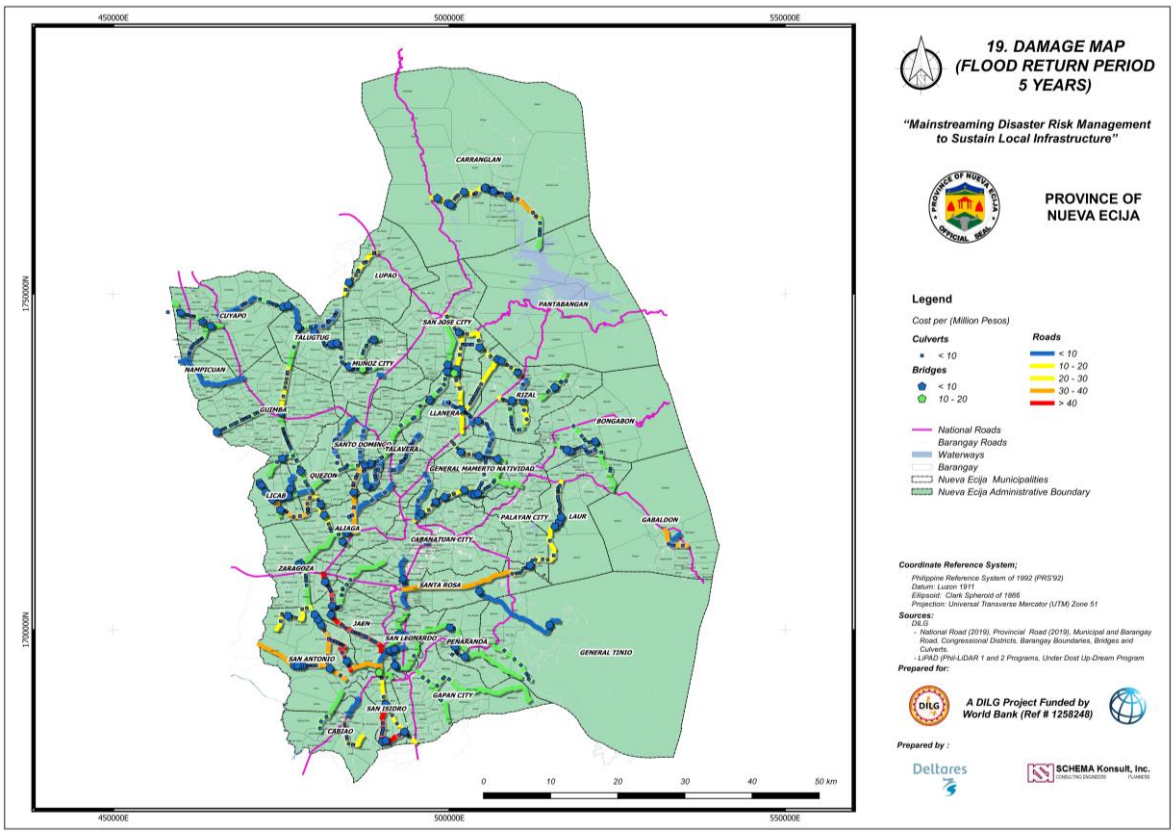



*Figure 5.2. Example damage results per RBIS road segment, bridge and culvert, for a flood scenario with a return period of 5 years*

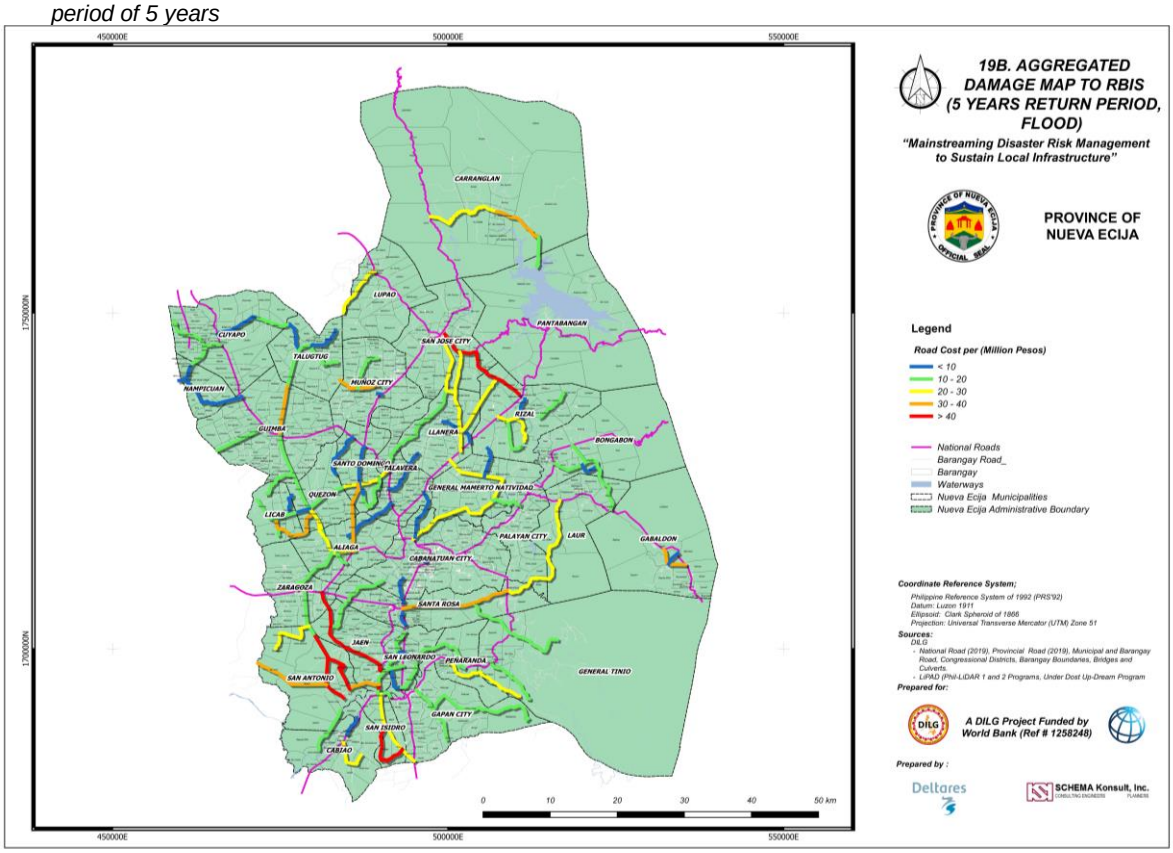



*Figure 5.3. Example damage results aggregated (damages of road, culvert and bridge are summarized) per RBIS road segment, for a flood scenario with a return period of 5 years.*

## 5.6 Recommendations

The calculation of damages builds on the determination of the road network exposure and the vulnerability of the road assets to the hazard actions. As such, recommendations from section 1 for hazard mapping, from section 3.2 for the road network data and from section 4 for the road network exposure, apply.

The ability to estimate the value of the exposed assets and the expected degree of damage, i. e. vulnerability, for different hazard levels is central to the estimation of the physical damages. It is thus recommended that the information on the construction costs and repair costs in the event of natural hazards is recorded in a database. Ideally, such an inventory correlates the repair costs and physical damages with the hazard and exposure level and characterization of the road.

# 6 Road Criticality and Losses

## 6.1 Introduction

This section discusses the criticality of the different provincial roads in Nueva Ecija, based on the redundancy of the network and the traffic type and intensity. As a result of this assessment the different RBIS roads can be ranked in terms of criticality: the larger the criticality, the larger the impacts to society when that network asset is out of function. This criticality information is subsequently combined with the exposure of the network, and the associated expected disruption times, to calculate the expected losses for road users for flood and earthquake hazard scenarios. The losses are expressed in terms of costs, in Philippine Pesos, and represent an appraisal of the impact for society of the flood- and earthquake-related road disruptions. As explained in the previous section, it is not possible to calculate damages and losses for landslides due to lack of information. The losses constitute one of the elements that will be used to evaluate risks and prioritize actions.

## 6.2 Data needs

The assessment of the societal losses builds on the traffic intensity of the network, as discussed in section 3.3, on the mapping of the road exposure, as discussed in section 4, and further information on estimate disruption times for each earthquake intensity and flood level. The estimated disruption times were provided by the LGU.

## 6.3 Data collection process

Essential input for calculating the losses are estimations of the duration of events. Data gathering on the expected disruption times started during the first workshop held in February and was completed by the month of April. The collection process involved the LGU engineering department and, although clarifications on the type of data necessary were occasionally done through phone call, travels to the local office were necessary.

### 6.3.1 Duration of interruptions

Data was gathered with the LGU on the estimated duration of the interruptions, for each hazard, per hazard level, per hazard type. Duration estimates by the LGU are shown in the table in **Error! Reference source not found.**.

Various durations (less than 2 hours, 2 hours to 1 day, 1 day to a week, more than a week) were estimated for :

- Different natural hazards:
  - floods (depth less than 0.5m, 0.5 to 1.5m, and above 1.5m of normal water level),
  - and earthquake (0.2g-0.3g, 0.3g to 0.4g, 0.4g to 0.5g, and 0.5g to 0.6g),
- Different infrastructure assets:
  - small and large culverts,
  - small and large bridges,
  - paved and unpaved provincial roads.

| Estimated duration | | | Culverts | | Bridges | | Provincial road | |
|---|---|---|---|---|---|---|---|---|
| | | | Small | Large | Small | Large | Paved | Unpaved |
| Flood hazard | <0.5 | < 2 hours | X | | X | | | X |
| | | 2 hours – day | | X | | X | | |
| | | day – week | | | | | | |
| | | > week | | | | | X | |
| | 0.5m-1.5m | < 2 hours | | | | | | |
| | | 2 hours – day | X | | | | | |
| | | day – week | | | | | | X |
| | | > week | | X | X | X | X | |
| | >1.5m | < 2 hours | | | | | | |
| | | 2 hours – day | X | | | | | |
| | | day – week | | | X | | | |
| | | > week | | X | | X | X | X |
| Earthquake hazard | 0.2g-0.3g | < 2 hours | | | | | X | X |
| | | 2 hours – day | X | X | X | X | | |
| | | day – week | | | | | | |
| | | > week | | | | | | |
| | 0.3g-0.4g | < 2 hours | | | | | | |
| | | 2 hours – day | X | X | X | X | | X |
| | | day – week | | | | | | |
| | | > week | | | | | X | |
| | 0.4g-0.5g | < 2 hours | | | | | | |
| | | 2 hours – day | | | | | | |
| | | day – week | X | X | | | | X |
| | | > week | | | X | X | X | |
| | 0.5g-0.6g | < 2 hours | | | | | | |
| | | 2 hours – day | | | | | | |
| | | day – week | | | | | | X |
| | | > week | X | X | X | X | X | |

*Table 6.1 Duration estimates collected from the LGUs: a cross identifies the matching provided by the LGU between hazard disruption and asset.*

It is highlighted that the estimations for duration of events have been carefully collected. Still, a rational behind the provided information by the LGU is lacking, explaining why in some cases a longer or shorter duration is estimated. However, we consider it very important that local information based on experiences and records is used in this respect. Since the estimates are a critical input into the calculations of losses and risk, we highly recommend that the numbers are further validated by building a database of events.

Such a database should consist information of the following:

- The type of hazard occurring
- Exposure data (flood depth, PGA, amount of volume of landslide)
- Road characteristics of the exposed road (embankment, culvert/bridge, road condition, maintenance status)
- Recorded damages in short description
- Repair costs expressed in Pesos
- Duration of the event

## 6.4 Methodology

The losses for road users are appraised by estimating the redundancy of the network. The redundancy of the network is firstly assessed and subsequently combined with the traffic intensity to obtain criticality, expressed as the impact to road users per unit time. The actual estimated losses per hazard scenario are then calculated by combining the impacts per unit time with the actual expected interruption times (**Error! Reference source not found.**) for each hazard scenario.

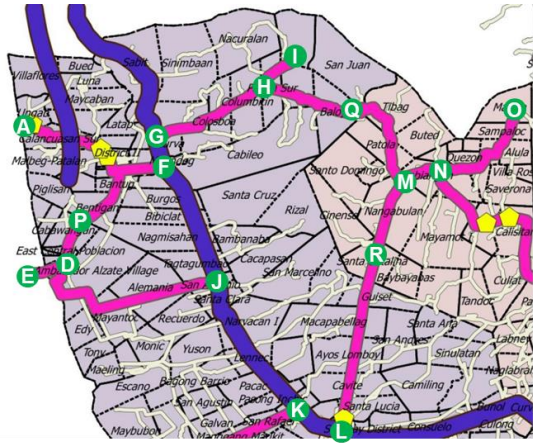
### 6.4.1 Redundancy

A single-link disruption assessment is considered for the evaluation of the redundancy. This is performed by, iteratively, removing each link of the network and calculating the best (shortest-path distance) alternative route to that network link. This approach has been used in similar cases in the literature, for example by Espinet and Rozenberg (2018). An all-or-nothing type of traffic re-assignment is assumed.

The single-link disruption approach was limited to the provincial roads, being the object of this study. This means that alternative routes were evaluated only for each section of the provincial road network, but that traffic could be diverted to any other alternative road type, including national, provincial and Baranguay roads. From workshops it became clear that Barangay roads indeed are used as an alternative route. However, in most cases the detour route is following provincial and national roads, since municipal and especially Barangay roads likely often will not have the desired capacity and state to cover all traffic during times of emergency.

Alternative routes were calculated based on Google Maps for all provincial sections (provincial road segments between intersections with other provincial or national roads). It should be noted that the inconsistencies in the RBIS road network as discussed in section 3.2 influence the analysis of the losses, particularly sections that are identified as misplaced or repeated (roads partially or fully overlapping) or which do not exist in recent Google Maps data. When roads are misplaced or repeated, double-counting was avoided.

The result of the single-link disruption approach to measure the redundancy of the network is a table indicating the extra distance that the users will need to drive when the link is disrupted. In some cases, alternative routes do not exist for given links and such situations are noted, in order to be taken into account assessing the criticality and losses.




| ID | Provincial road section | Length of section | Length of alternative |
|---|---|---|---|
| 1 | PD | 2.57 km | 10.6 km |
| 2 | DJ | 11.5 km | 17.1 km |
| 3 | GH | 7 km | 30.9 km |
| 4 | FP | 5.8 km | 11 km |
| 5 | HQ | 4.9 km | 33 km |
| 6 | Etc. | Etc. | Etc. |

*Figure 6.1- Example of provincial road sections (in pink), defined as road segments between intersections with other provincial or national (in blue) roads (displayed as the green dots on the maps). Baranguay roads are represented in white and city/municipal roads are assumed as being included in the provincial dataset (see section 3.2 for discussion). Examples are provided in the table on calculated segment lengths and detour lengths*

### 6.4.2 Redundancy-based criticality

Redundancy-based criticality aims at ranking the road sections by order of magnitude of the impacts of their disruption. This is done by estimating the expected losses per unit time of disruption. Two main situations are considered: when detour routes exist and when detour routes do not exist.

#### *6.4.2.1 Road sections with detour routes*

Road user costs incurred by each vehicle (AADT) are estimated on the basis of the estimated (present price level) basic vehicle operating cost (BVOC) by vehicle type as given in Table 6.2.

*Table 6.2 Basic vehicle operating cost (BVOC) by vehicle type*

| BASIC TRANSPORT COSTS : Costs/Km | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| COST ITEMS | VEHICLE TYPE | | | | | | | |
| | CARS | JEEPN | VANS | M'CYC | T'CYC | BUSES | 2-axle TRUCK | 3-axle TRUCK |
| RUNNING COSTS | 8.839 | 7.226 | 7.732 | 1.581 | 2.527 | 23.657 | 18.022 | 29.948 |
| FIXED COSTS | 0.445 | 2.176 | 0.445 | 0.124 | 1.422 | 2.634 | 3.092 | 3.092 |
| TIME COSTS | 6.753 | 7.387 | 2.549 | 1.473 | 2.290 | 27.614 | 1.022 | 1.441 |
| **TOTAL** | **16.037** | **16.790** | **10.725** | **3.178** | **6.240** | **53.905** | **22.135** | **34.480** |

Basic Vehicle Operating Costs (BVOCs) were originally estimated in 2008 by DPWH which were computed on the basis of the prevailing vehicle prices by type, make and model; the prices of tires, fuel and lubricant prices, crew costs, time value based on prevailing wages, etc., several surveys/data gatherings were conducted for this purpose. However, since then, it was not recalculated but it is just updated every year using the general Consumer Price Index.
The cost of disruption per day, for each section, is obtained by multiplying the AADT of all traffic types in that section with the corresponding unit BVOCs and multiplying these by the length of the detour route. This operation was performed for all sections (intersection to intersection) of the provincial road network with existing detours.
With this approach we do not explicitly take the effects of business disruption into account. We assume that this impact is low, since an alternative route is available, and the effects of a disruption will only lead to a delay of maximum some hours without real business impacts. This

is different for road sections without detour routes. Therefore these are treated differently as is explained in the next chapter.

#### 6.4.2.2 *Roads sections without detour routes*

In cases where there is no alternative route in the event of disruption of the road, the normal approach for calculating redundancy-based criticality and damages through assessing additional time spend and distance travelled does not apply. However, there is an obvious need to make an assessment of impacts for these cases. We propose to use a proxy for the assessment of losses from the interruption of services from the road in these cases where no alternative routes exist.

The assumption for the proxy is that a loss of production will occur from the interruption of the road, equal to the size of the added value from the persons that cannot make use of the road, measured in the regional GDP per capita.

This assumption constitutes both the loss of production within the area that cannot be reached, as well the loss of production outside the area due to the inability of the workers from within the cut-off area to arrive at their place of production outside this area.

In order to establish the loss of production we take as proxy the per capita GDP of the project region (Region III). The amount is taken from the website of the Philippines Statistics Authority (https://psa.gov.ph/) from which the data in Table 6.3 is taken. The data from 2017 is extrapolated to 2018 using average annual growth over the past 5 years (6,25 % annual growth).

*Table 6.3. GDP per capita for Region III from Philippines Statistics Authority*

| Year | 2017 | 2018[3] |
|---|---|---|
| GDP/Cap Region III | 127.734 | *135.717* |
| WD/year | 220 | *220* |
| GDP/Cap/Day | 581 | *617* |
| GDP/Cap/Hour (24H) | 24,2 | *25,7* |

As the loss of production per capita is taken no further losses are calculated from disruption of cargo transport in order to avoid double counting. Consequently, an estimate needs to be made for the number of persons in the different categories of trucks that used. These are estimated to be 2, 3 and 4 persons for 2, 3 and 5 metric ton cargo trucks respectively. The average passenger occupancy per passenger vehicle (excluding the driver) is given in Table 6.4.

*Table 6.4 Average passenger occupancy per passenger vehicle*

| Vehicle Type | Number of passengers (excluding driver) |
|---|---|
| VT1 (Cars) | 3 |
| VT2 (Jeepn) | 18 |
| VT4 (M'cyc) | 1 |
| VT5 (T'cyc) | 3 |
| VT6 (Buses) | 40 |

The daily loss of productivity for each provincial road section without detour routes, when they are disrupted is then obtained multiplying the traffic intensity AADT by the total occupancy per vehicle type, including drivers, by the daily loss of productivity per capita. As a consequence,

[3] *Estimate for 2018 based on average annual growth over past 5 years*

these routes will appear to have high losses when the level of traffic is high and will as such also show higher losses on the maps (see next paragraph).

### 6.4.3 Results from the redundancy-based criticality

The methodology described for both section with and without detour was applied to all the provincial roads in Nueva Ecija. Figure 6.2 shows the resulting evaluated costs per day of disruption. This provides insight in the criticality of the different road sections, independently of the vulnerability to natural hazards (or other hazards). The map can also be found in higher resolution as map 27 in Annex I.

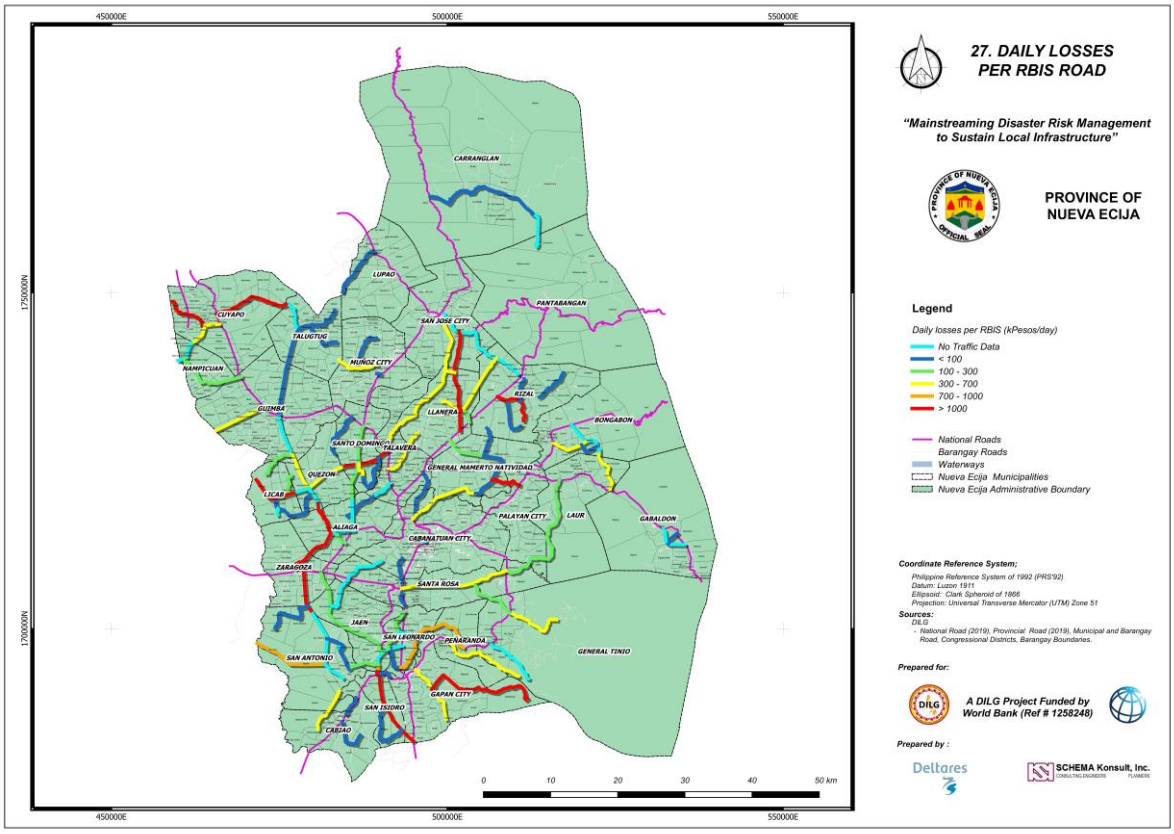



*Figure 6.2 Daily losses displayed per RBIS road*

### 6.4.4 Estimated losses per hazard scenario

To estimate the losses per hazard scenario, an approach similar to the calculation of the physical damages, as described in section 5, is implemented.

A first step consists in associating the intervals of interruption times identified by the LGU into specific duration values. The durations assumed are presented in Table 6.5.

*Table 6.5. Duration of the interruptions considered*

| Interruption Intervals | Duration of Interruption considered |
|---|---|
| < 2 hours | 2 hours |
| 2 hours to 1 day | 1 day |
| 1 day to one week | 4 days |
| > 1 week | 14 days |

Secondly, the maximum value of the hazard intensity for each road segment (intersection to intersection) was evaluated using the exposure maps. This was done by identifying the maximum hazard level for each asset in the road segment: culverts, bridges and road sections. Based on the maximum exposure of each of these elements, their respective traffic disruption time for each hazard scenario was assessed. This was performed by combining the information on the maximum exposure with the information provided by the LGU of expected disruption times (**Error! Reference source not found.**).

It should be noted that the culverts and the bridges are assets integrated in the road network links. As such, for each link (intersection to intersection), the disruption time was taken as the maximum disruption time of any bridge culvert and road section belonging to the same link. This allows one to map the expected disruption time, per hazard scenario, for all provincial road network links.

Finally, the losses per hazard scenario are obtained by multiplying the expected interruption times with the evaluated costs per day of disruption, as assessed for the criticality. To further comply with the RBIS road classification, the losses per section were aggregated into losses per RBIS road. The result is exemplified for floods in the figure below. Annex I provides all maps. Maps 28-30 show the losses due to floods for the various return periods, whereas maps 31-33 show the losses due to earthquakes for the various return period.

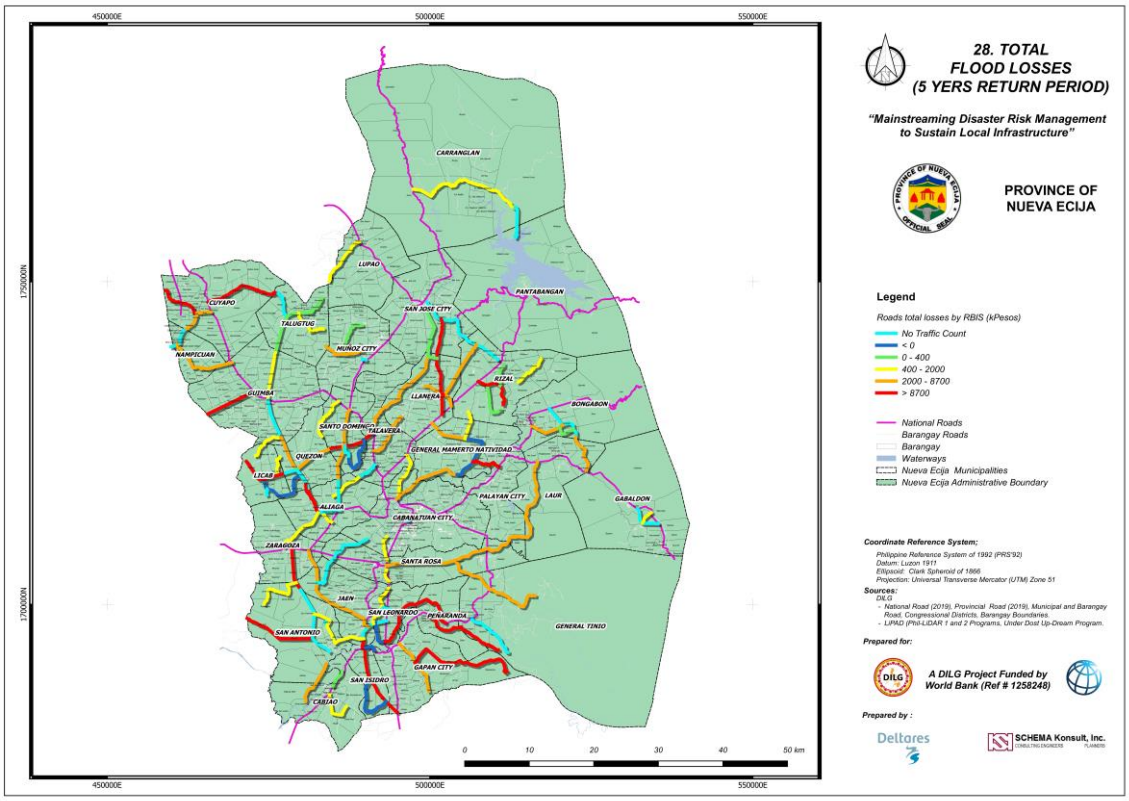



*Figure 6.3* Example of losses map, displaying the expected losses for road users for the scenario of a flood with a 5-year return period

## 6.5 Recommendations

The calculation of losses builds on the determination of the road network exposure and the traffic information. As such, recommendations from section 3.1 for hazard mapping, from section 3.2 for the road network data, section 3.3 for the road traffic information and from section 4 for the road network exposure, apply.

The ability to accurately estimate the duration of interruptions, for each type of asset, for each hazard level is the key to accurate loss estimation. It is thus recommended that the information on such durations, in the event of natural hazards, is recorded in a database. Ideally, such an inventory correlates the disruption duration and asset type and condition with the hazard level. No traffic model was available for the province of Nueva Ecija. Also, no origin-destination traffic data were available. Though it would still be possible to use a traffic model and making use of the traffic counts for the different road sections, we have decided to make use of Google Maps as a simple way to calculate the length of detour routes. This way we consider it much more feasible for other LGU, when they will perform a similar exercise, to determine detour routes themselves without the need to have a complete traffic model.

# 7 Risk Evaluation

## 7.1 Introduction

This section discusses the evaluation of risk caused by flooding and earthquakes to the provincial road network. As discussed in Chapters 3.1 and 4, we do not have sufficient information to estimate risk for landslides. Expected Annual Damages (EAD) were calculated for floods and earthquakes based on the damages calculated in section 5 and Expected Annual Losses (EAL) were calculated for floods and earthquakes based on the losses calculated in section 6. Based on the EAD and the EAL, the different RBIS roads are ranked for the prioritization of future interventions. This prioritization may provide input for the LGU to improve their requirements on road design. The prioritization process itself however is not directly dependent on the design criteria of the roads and solely based on the calculated damages and losses. Of course, the vulnerability functions as derived in section 5 are indirectly dependent on the design criteria.

## 7.2 Prioritization Indicators

The following sub-sections present the calculation of the EAD and the EAL for both floods and earthquakes based on the results of Sections 5 and 6. The EAD and EAL are calculated both in total network aggregated values and per RBIS road.

### 7.2.1 Flood EAD

The total damages are summarized in Table 7.1. These total damages are the sum of the damages to all RBIS roads, for each flood hazard return period that has been analysed in Chapter 5. In that sense, the damages show the expected amount of damage for the entire province, given the flood pattern as shown on the map with the respective return period (5-year, 25-year and 100-year return periods). It may be seen that damages are increasing with an increasing return period. It is to be noted that no judgement or recommendation on design requirements is made based on these total damages. For further explanation and background on calculation of the damages, reference is being made to Chapter 5.

In order to be able to compare different types of hazards in a uniform way we have calculated the on average annually to be expected damages. The respective flood EAD are calculated based on the area under the corresponding chart. Figure 7.1 illustrates the area considered. Estimations have been made for the form of the graph for return periods longer than 100 years and shorter than 5 years. The resulting flood EAD is **534.0 Million Pesos.**

*Table 7.1. Total network damage per flood hazard map.*

| Return period (years) | Exceedance Probability (1/return period) | Damage (Million Pesos) |
|---|---|---|
| 5 | 0.2 | 1866 |
| 25 | 0.04 | 3359 |
| 100 | 0.01 | 4377 |

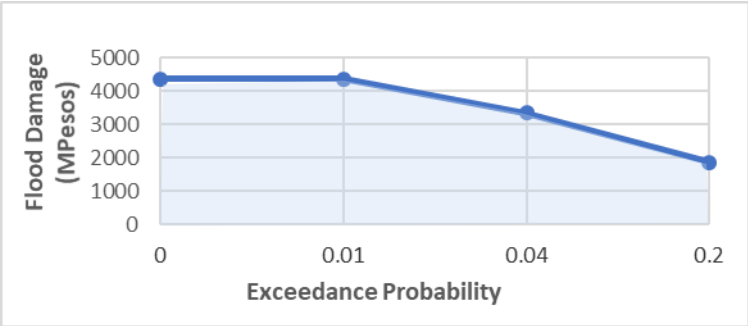



*Figure 7.1. Total flood damage per hazard map and EAD calculation.*

If the analysis is performed individually for each RBIS road, the EAD can be obtained per RBIS road. These are shown in Figure 7.2 and as map 34 in annex I.

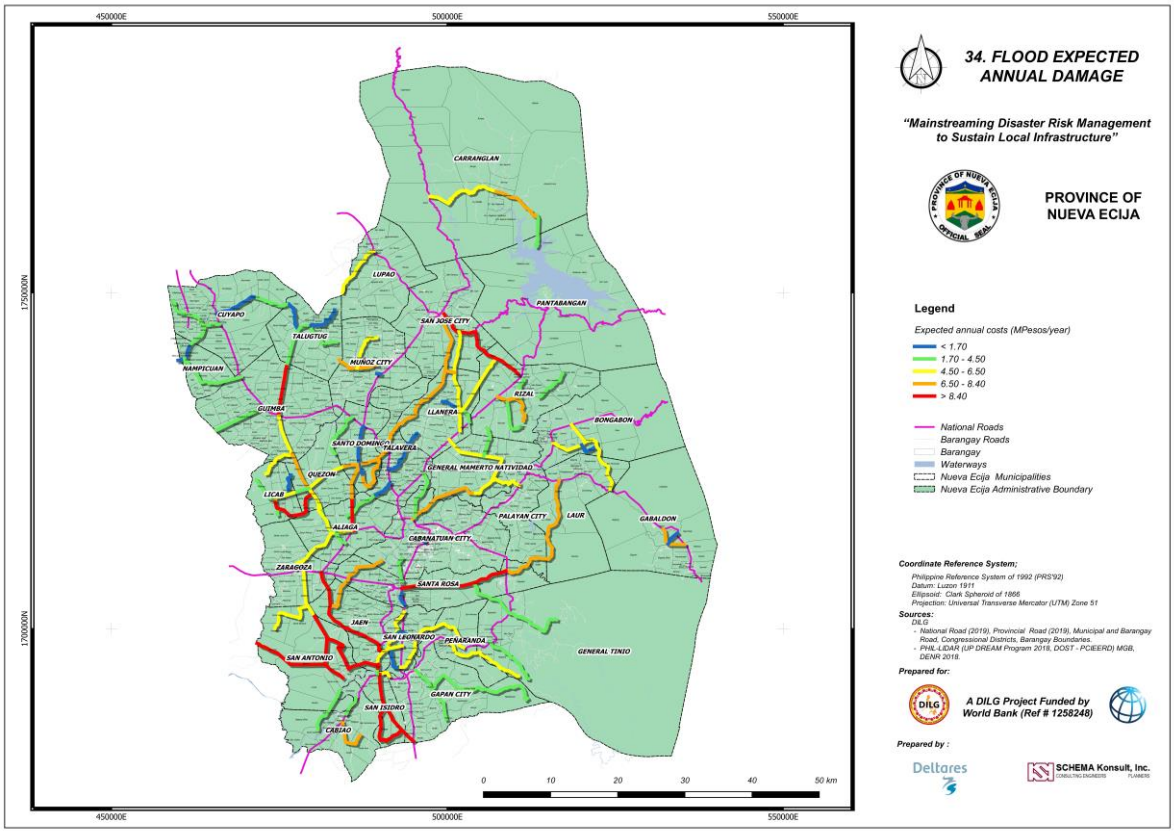



*Figure 7.2. Flood EAD per RBIS road.*

### 7.2.2 Earthquake EAD

The total damages, corresponding to the sum of the damages to all RBIS roads, for each earthquake hazard map (rock site with 500-year, 1000-year and 2500-year return periods) are summarized in Table 7.2. For further explanation on calculation of the damages, reference is being made to Chapter 5.

The respective earthquake EAD are calculated based on the area under the corresponding chart. Figure 7.3 illustrates the area considered. Estimations have been made for the form of the graph for return periods longer than 2500 years and shorter than 500 years. The resulting earthquake EAD is **5.8 Million Pesos.**

*Table 7.2. Total network damage per earthquake hazard map.*

| Return period (years) | Exceedance Probability (1/return period) | Damage (Million Pesos) |
|---|---|---|
| 500 | 0.002 | 2933 |
| 1000 | 0.001 | 3577 |
| 2500 | 0.0004 | 4297 |

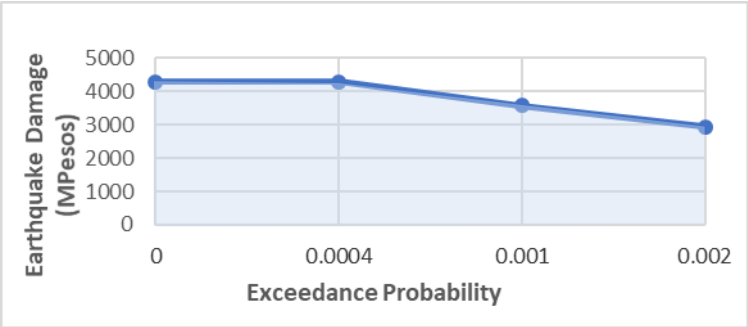



*Figure 7.3. Total earthquake damage per hazard map and EAD calculation.*

If the analysis is performed individually for each RBIS road, the EAD can be obtained per RBIS road. These are shown in Figure 7.4 and as map 37 in annex I.

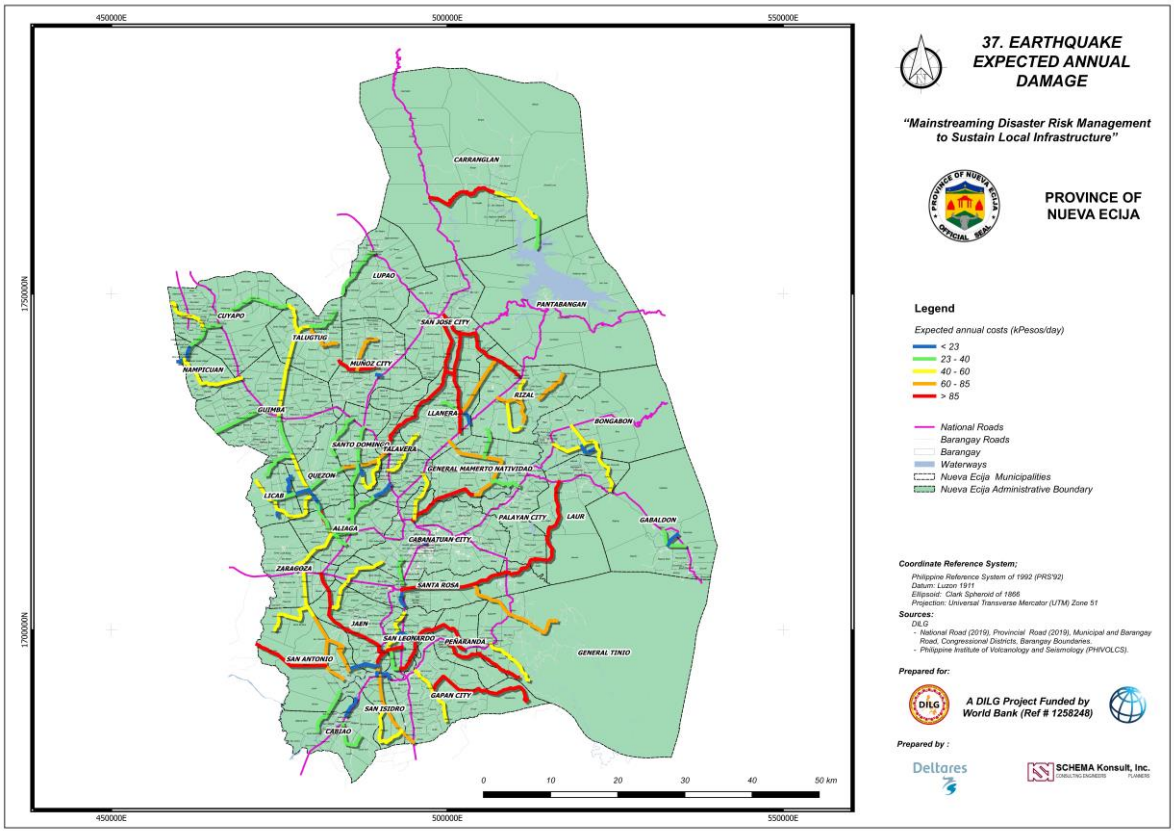



*Figure 7.4. Earthquake EAD per RBIS road.*

### 7.2.3 Flood EAL

The total losses for road users, corresponding to the sum of the losses to all RBIS roads, for each flood hazard map (5-year, 25-year and 100-year return periods) are summarized in Table 7.3. For further explanation and background on calculation of the losses, reference is being made to 6.

The respective flood EAL are calculated based on the area under the corresponding chart. Figure 7.5 illustrates the area considered. The resulting flood EAL is **110.6 Million Pesos.** It can be seen that the calculated losses hardly change for different return periods. This is due to the fact that the duration of failure of the road segments does not change with different associated water levels. Therefore, the water levels may be expected to be higher for higher intensity rainfall (longer return period), but the duration of the flooding of the road is expected to be the same (see also Table 6.1 in which the failure duration of the road itself is normative with respect to the culverts and bridges).

*Table 7.3. Total network losses per flood hazard map.*

| Return period (years) | Exceedance Probability (1/return period) | Losses (Million Pesos) |
|---|---|---|
| 5 | 0.2 | 575 |
| 25 | 0.04 | 587 |
| 100 | 0.01 | 587 |

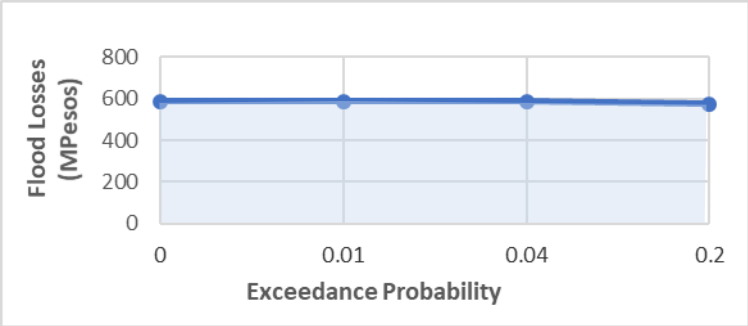



*Figure 7.5. Total flood losses per hazard map and EAL calculation.*

If the analysis is performed individually for each RBIS road, the EAL can be obtained per RBIS road. These are shown in Figure 7.6 and as map 35 in annex I.

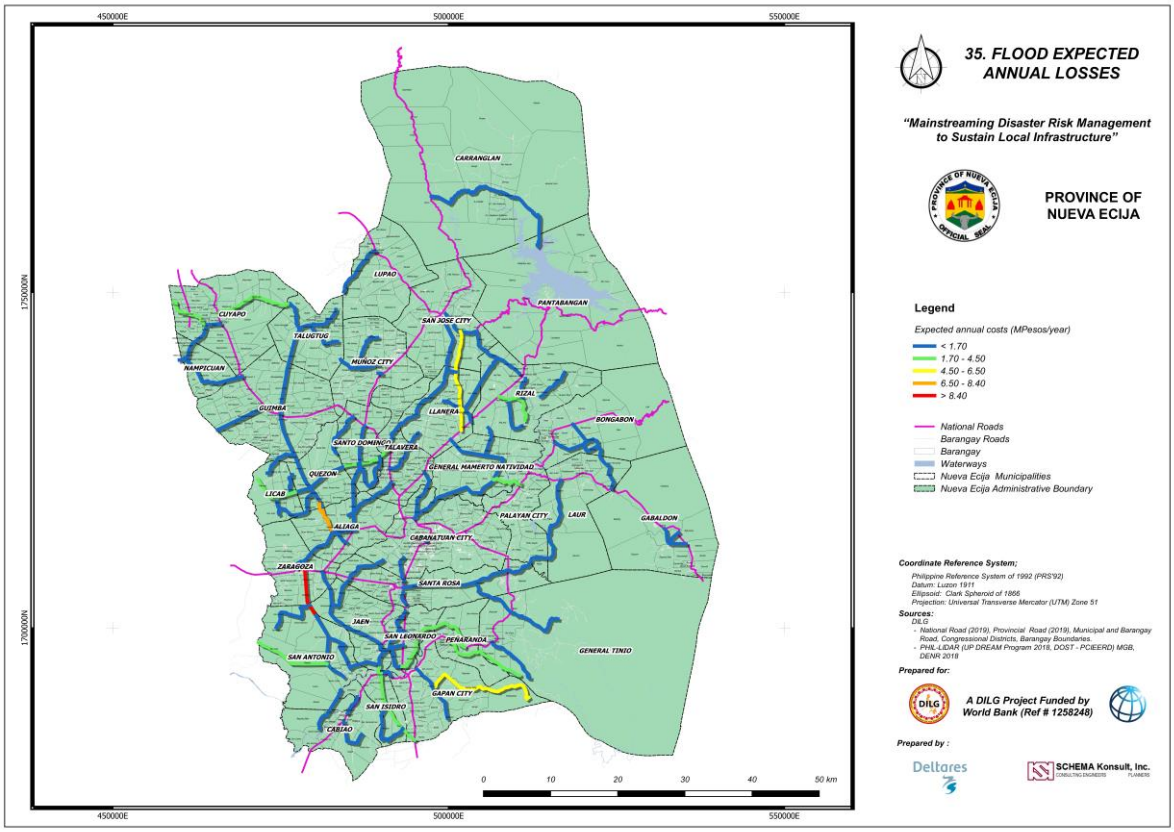



*Figure 7.6. Flood EAL per RBIS road.*

### 7.2.4 Earthquake EAL

The total losses for road users, corresponding to the sum of the losses to all RBIS roads, for each earthquake hazard map (rock site with 500-year, 1000-year and 2500-year return periods) are summarized in Table 7.4. For further explanation and background on calculation of the losses, reference is being made to 6.

The respective earthquake EAL are calculated based on the area under the corresponding chart. Figure 7.7 illustrates the area considered. The resulting earthquake EAL is **0.97 Million Pesos.**

*Table 7.4. Total network losses per earthquake hazard map.*

| Return period (years) | Exceedance Probability (1/return period) | Losses (Million Pesos) |
|---|---|---|
| 500 | 0.002 | 458 |
| 1000 | 0.001 | 605 |
| 2500 | 0.0004 | 605 |

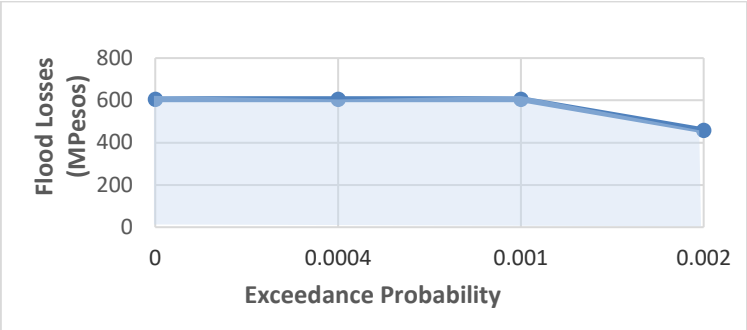



*Figure 7.7. Total Earthquake losses per hazard map and EAL calculation.*

If the analysis is performed individually for each RBIS road, the EAL can also be obtained per RBIS road. These are shown in Figure 7.8 and as map 38 in Annex I.

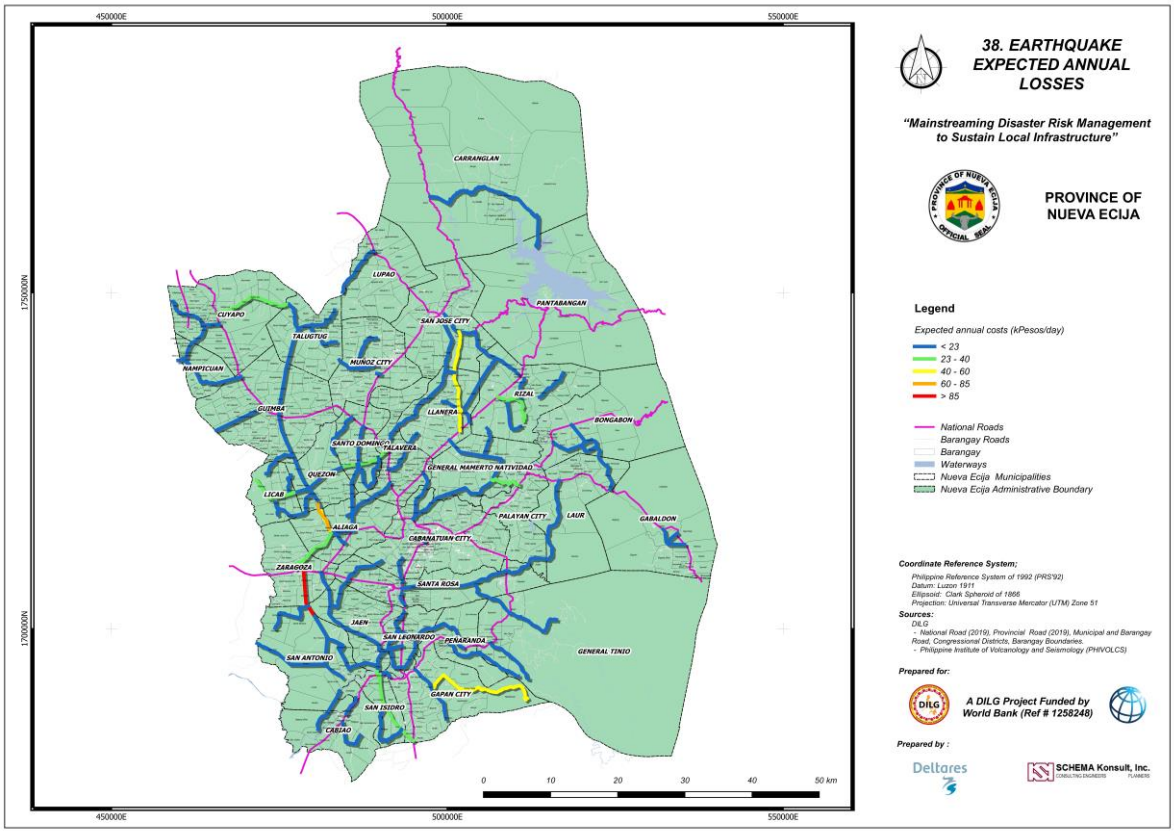



*Figure 7.8. Earthquake EAL per RBIS road.*

7.2.5 Discussion of EAD and EAL per hazard.

Comparing the costs per scenario (i.e. per individual hazard map) from both floods (Table 7.1) and earthquakes (Table 7.2), it can be observed that the costs are of the same order of magnitude. The EAD, however, are much lower for earthquakes due to the larger return periods.

The same observation can be made for losses where costs per scenario are similar (Table 7.3 and Table 7.4) but the EAL for earthquakes are significantly lower than for floods due to the differences in return periods.

Table 7.5 summarizes the EAD and EAL per hazard. It is also observed that the total expected annual costs, given by the sum of EAD and EAL per hazard is significantly larger for floods than for earthquakes.
This highlights the importance of accurately estimating costs associated with damages and losses for different scenarios, particularly if a fully integrated multi-hazard approach to the prioritization of measures is used. Otherwise, it may lead to having certain hazards disregarded.

*Table 7.5. Summary of EAD and EAL per hazard, expressed in Million Pesos*

| Hazard | EAD | EAL | Total (EAD+EAL) |
|---|---|---|---|
| Floods | 533.99 | 110.60 | 644.6 |
| Earthquakes | 5.81 | 0.97 | 6.78 |

## 7.3 Prioritization Matrix

The aim of the prioritization is to rank the roads from an action perspective. The top priority corresponds to roads that are both expected to sustain the highest damage costs and where the disruption will lead to the largest losses. At the bottom of the prioritization ranking are the roads with the smaller expected damages and disruption losses.
The contribution of damages and losses for prioritization, however, is not necessarily linear. Because the EAD are significantly larger that the monetized quantification of EAL, a simple sum of the values would dilute the importance of minimizing the losses for the road users.

As such, we propose the use of a prioritization matrix. The considered matrix is presented in Figure 7.9. This double-entry matrix considers the categorization of the damages and losses into 5 intervals, generically C1 for the lowest cost category to C5 the highest cost category. The priority assigned to each road is then obtained from the matrix depending on that road's category for damages and losses. The priority is also classified from 1 (green) through 5 (red), 1 being the smallest priority and 5 the highest priority.
It can be noted that the priority classification and respective colour scheme is not symmetrical and that the pair (losses=C5, damage=C3) is ranked as top priority 5, whereas the pair (losses=C3, damage=C5) is ranked as priority 4. This aims at representing the larger weight that the impacts for the users have on deciding where intervention is most needed, when compared to damage costs, as expressed during the first workshop session organized in Nueva Ecija on February 2019.

| | | Damage Category | | | | |
|---|---|---|---|---|---|---|
| | | C1 | C2 | C3 | C4 | C5 |
| Losses Category | C1 | 1 | 1 | 2 | 2 | 3 |
| | C2 | 2 | 2 | 3 | 3 | 4 |
| | C3 | 3 | 3 | 3 | 4 | 4 |
| | C4 | 3 | 4 | 4 | 5 | 5 |
| | C5 | 4 | 4 | 5 | 5 | 5 |

*Figure 7.9. Priority Matrix*

In light of the different nature of flood and earthquake hazards and the fact that the implementation of measures, in general, addresses the effects of each hazard type individually, an analysis per hazard type has been performed.
The same prioritization matrix is proposed for both hazards. The cost intervals associated with each category reflect the cost interval of losses and damages for each hazard type and are the same as applied in the legends of maps 34 to 39 that show the EAD and EAL. Table 7.6 presents the cost intervals assumed for each category.

*Table 7.6 Flood and earthquake cost categories for prioritization*

| | | **Expected Annual Costs both EAD and EAL** | |
|---|---|---|---|
| | | **Floods (MPesos)** | **Earthquakes (KPesos)** |
| Category | C1 | < 1.70 | < 23 |
| | C2 | 1.70 to 4.50 | 23 to 40 |
| | C3 | 4.50 to 6.50 | 40 to 60 |
| | C4 | 6.50 to 8.40 | 60 to 85 |
| | C5 | > 8.40 | > 85 |

## 7.4 Prioritization maps

Considering the prioritization matrix proposed in Figure 7.9, and the cost intervals for each category proposed in Table 7.6, priority maps were developed for floods and earthquakes based on the respective EAD and EAL.
Figure 7.10 and Figure 7.11 show that one of the roads stands out by being classified with the highest priority from both a flood hazard and an earthquake perspectives. Although with some differences between hazard types, for both floods and earthquakes some roads have a high priority and the remaining roads are classified into medium to lower priority. Both maps are also shown as maps 40 and 41 in annex I.

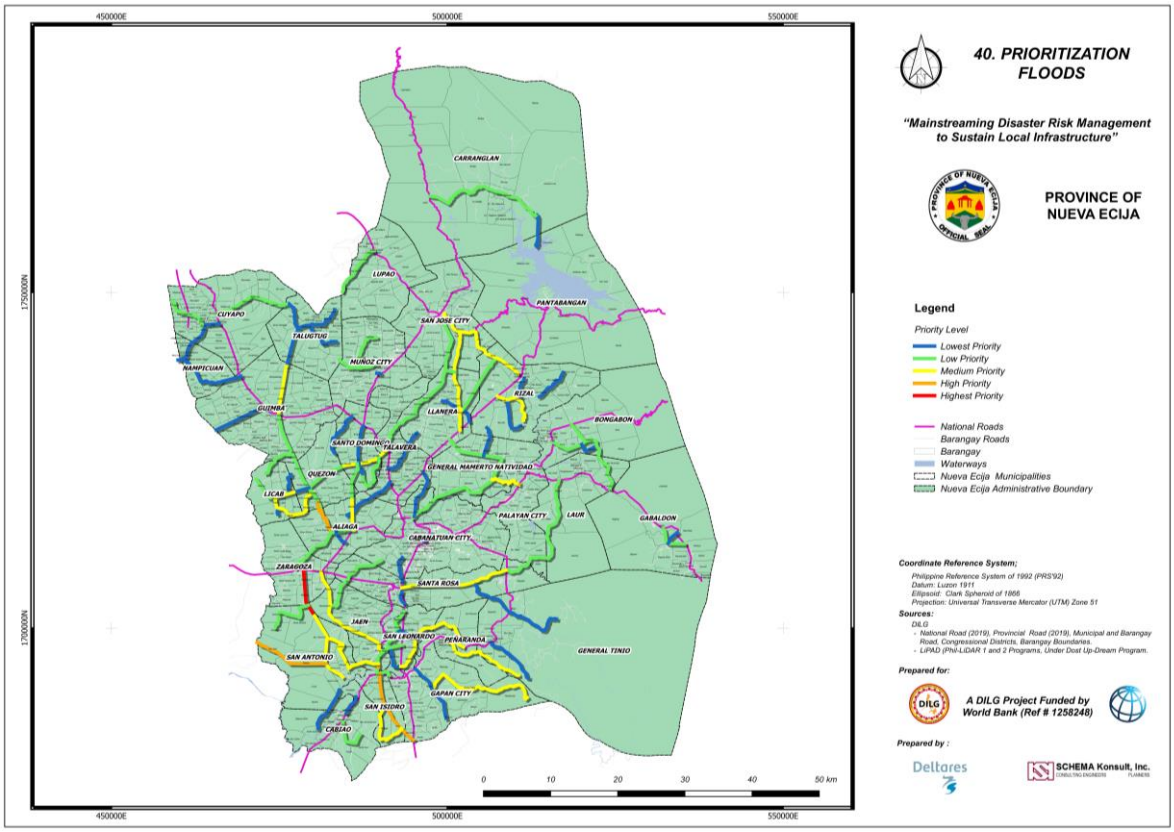



Figure 7.10. Prioritization of RBIS roads for flood-related interventions.

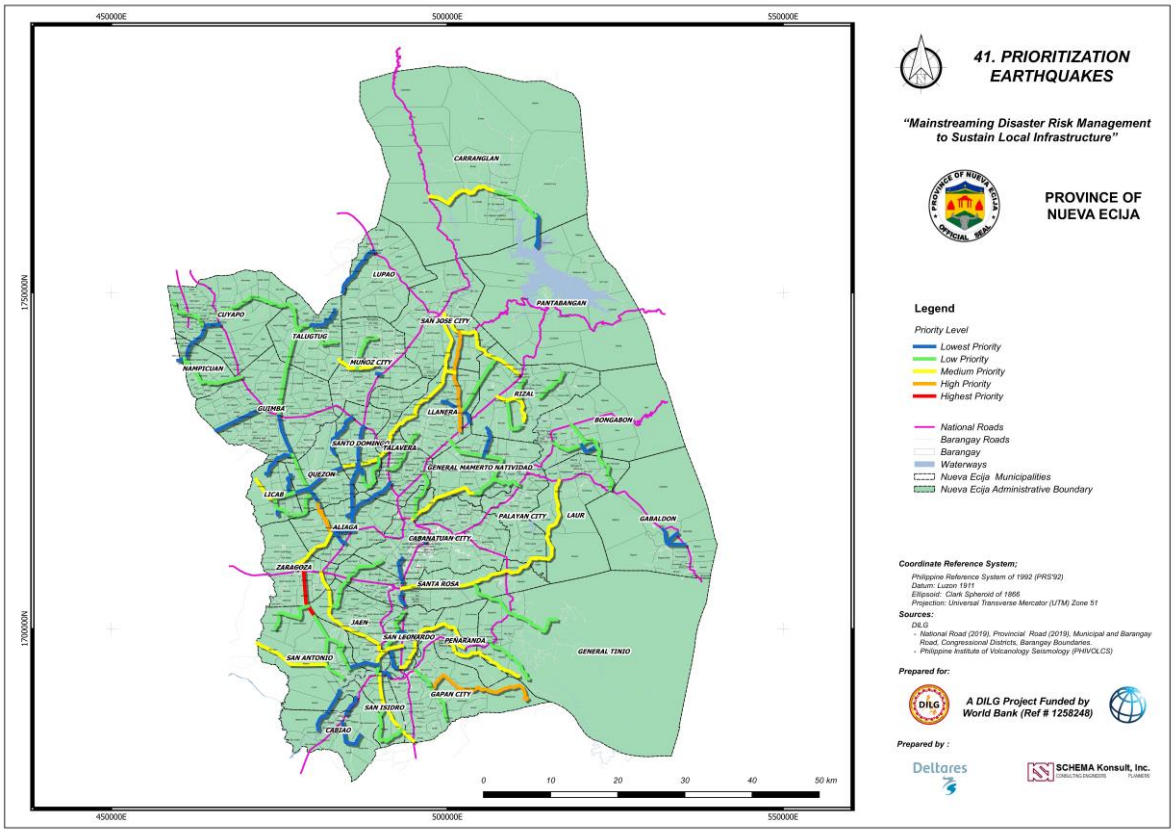



Figure 7.11. Prioritization of RBIS roads for earthquake-related interventions.

## 7.5 Recommendations

The evaluation of risk to the road network and the prioritization of the RBIS roads for future interventions builds on all the preceding information and methods. This means that any uncertainty in previous calculations and data propagates into the risk evaluation. As such, recommendations from section 3.1 for hazard mapping, from section 3.2 for the road network data, section 3.3 for the road traffic information, from section 4 for the road network exposure, from section 5 for road damages, and from section 6 for road criticality and losses, apply.

It is recommended that the prioritization indicators (Table 7.6) are analysed across the different hazards to ensure these represent the weight that each type of hazard should bear. It should be further investigated if earthquakes with return periods of 1000 and 2500 years do in fact have similar costs to floods with return periods of 25 year. Otherwise highly destructive earthquakes run the risk of being disregarded due to their large return periods. One potential approach to prevent this is the definition of priorities separately for floods and earthquakes.

It is also recommended that the prioritization matrix is defined with the involvement of all relevant stakeholders. In this manner an effective prioritization can be achieved, reflecting the most important issues for those affected.

The EAD and EAL may be used as a first indication when comparing costs for possible interventions/measures and the benefits that may be gained. We do however recommend to make location specific cost benefit assessments with the actual costs of measures, to be compared with the benefits in terms of decreased EAD and EAL. This requires some extra analyses that could not be performed within the scope of this TA. Reference is also made to the Adaptation Strategy report in which a methodology is promoted to identify a robust strategy towards an uncertain future, in which also semi quantitatively a comparison between cost and benefit is undertaken.

# 8 Summary Conclusions and Recommendations

This report discusses the risk assessment of the provincial road network of the province of Nueva Ecija, Central Luzon in the Philippines, and the prioritization of roads for future investments.

Detailed conclusions and recommendations are proposed at the end of each section. In general, it can be highlighted that:

- Having accurate and complete mapped information is central for the quality of the results of the risk assessment; this includes having hazard maps with return periods, the road network and assets such as bridges and culverts and the traffic information.
- A good communication with national agencies and appropriate channels for the exchange of information is most valuable. A process of alignment between national agencies, DILG and LGUs has already started and needs to be continued in order to enhance the data gathering process.
- Good Geographic Information Systems capabilities are essential for maintaining and validating information and run the risk assessment analysis. With this respect we refer to a training program currently being undertaken/launched by NAMRIA and DILG expressly designed to build LGU GIS capacity.
- Inventoried data for the estimation of infrastructure damage and disruption times and costs is essential for the realistic quantification of the damages and losses. We have made first steps in this regard, but highly advocate to further improve the damage and duration estimates by starting a proper monitoring of events in a database. Such a database should consist information of the following:
  - The type of hazard occurring
  - Exposure data (flood depth, PGA, amount of volume of landslide)
  - Road characteristics of the exposed road (embankment, culvert/bridge, road condition, maintenance status)
  - Recorded damages in short description
  - Repair costs expressed in Pesos
  - Duration of the event

  It is important that the database will include all situations of impacted roads; also when no or very little damage is to be reported. It may be the case that the current numbers for floods are based on high damage events only, leading to possibly too high vulnerability estimates.
- The evaluation of risk and the prioritization of roads for interventions should be defined in consultation with the relevant stakeholders to reflect the most important issues for decision-making.

With the availability of information and training of personnel, the approach described in this report can be scaled and /or replicated in other provinces by the respective LGUs, especially in combination with consultants. During the workshop in which results of the TA were presented and the LGUs have used the methodology in hands-on exercises it became clear that the approach itself is generally understood and LGUs are able to use the results. Therefore we consider LGUs at least capable of procuring these kind of assessments to consultants.
While DILG is planning for the implementation of the approach in all provinces, it seems to be advisable to first select a few LGUs that are yet planning to update their local infrastructure plans with the support of consultants. The methodology and approach can then be provided to the consultants for possible use and further learning by doing. After a successful application by these first adopters together with additional lessons learned, the methodology may then be

implemented in the rest of the country. UNDP, which is a DILG partner in the capacity building process, is expected to assist DILG in future efforts on LGU capacity building and could also be aligned in the above mentioned process.

The use of the results as presented in this report may be divided in two main direction:

1 For use in planning and asset management
The results of the risk assessment can provide arguments for the planning process in the province. The prioritization maps as well as the EAD and EAL maps can be used in this respect in order to identify road segments that are to be experiencing high damages and/or losses. The exposure maps may then be used to identify specific locations on these segments that should be analysed for further action. In that sense, the risk assessment serves as input for the definition of adaptation strategies that are discussed in a separate report.

2 For use in emergency situations
During an emergency situation many decisions need to be made in a short period of time. The risk assessment provides a wealth of information that can be used for that purpose. Exposure maps can be consulted to identify likely locations that will be affected by intense rainfall leading to flooding and/or landslides. The losses maps provide input which of the exposed roads are expected to experience the highest impact for its users and are therefore the most critical. This is valuable information for preparatory measures, as well as decision on where to go first for response actions after an event. The damages maps provide valuable information for first rough budget estimates for repair and reconstruction allowing for fast fund raising.

The risk assessment has been undertaken for the current climate only. Due to climate change, floods and landslides may occur more often and more severe. Though it is already a first step for LGUs to gain understanding of the current risk, it is to be recommended to analyse the effects of climate change as well, especially when decisions are to be made regarding measures. The best approach would be to redo the hazard analyses with possible future rainfall scenarios. It makes sense to undertake such an assessment on a national level. Still, when LGUs want to gain insight in the effects of climate change it is also possible to use the existing hazard maps but to vary the return periods in the damage and losses assessment. Due to climate change the return period will decrease (it becomes more likely) at which the hazard levels as depicted in the hazard maps occur which will lead to higher EAD and EAL. Besides climate change also other developments may change the risk profile towards the future like economic developments leading to higher traffic volumes. In this respect, reference is also made to the adaptation strategy report of this TA.

# Annex I – Maps

The following maps are presented in this annex:

1 Flood hazard map with 5 years return period
2 Flood hazard map with 25 years return period
3 Flood hazard map with 100 years return period
4 Landslide susceptibility map
5 Earthquake hazard map for stiff soil with 500 years return period
6 Earthquake hazard map for rock site with 500 years return period
7 Earthquake hazard map for rock site with 1000 years return period
8 Earthquake hazard map for rock site with 2500 years return period
9 Road network map
10 Road traffic count map
11 Flood exposure map with 5 years return period
12 Flood exposure map with 25 years return period
13 Flood exposure map with 100 years return period
14 Landslide susceptibility on roads map
15 Earthquake exposure map for stiff soil with 500 years return period
16 Earthquake exposure map for rock site with 500 years return period
17 Earthquake exposure map for rock site with 1000 years return period
18 Earthquake exposure map for rock site with 2500 years return period
19 Flood damage map with 5 years return period
19B Flood damage map with 5 years return period aggregated to RBIS road segments
20 Flood damage map with 25 years return period
20B Flood damage map with 25 years return period aggregated to RBIS road segments
21 Flood damage map with 100 years return period
21B Flood damage map with 100 years return period aggregated to RBIS road segments
23 Earthquake damage map with 500 years return period
23B Earthquake damage map with 500 years return period aggregated to RBIS road segments
24 Earthquake damage map with 1000 years return period
24B Earthquake damage map with 1000 years return period aggregated to RBIS road segments
25 Earthquake damage map with 2500 years return period
25B Earthquake damage map with 2500 years return period aggregated to RBIS road segments
26 Daily losses per road section map – intersection to intersection
27 Daily losses per RBIS road segment map
28 Flood losses map for 5 years return period
29 Flood losses map for 25 years return period
30 Flood losses map for 100 years return period
31 Earthquake losses map for 500 years return period
32 Earthquake losses map for 1000 years return period
33 Earthquake losses map for 2500 years return period
34 Flood expected annual damage map
35 Flood expected annual losses map
36 Flood expected annual total impact map
37 Earthquake expected annual damage map
38 Earthquake expected annual losses map
39 Earthquake expected annual total impact map
40 Prioritization map for floods
41 Prioritization map for earthquakes

# Annex II - Traffic Count Survey Form

## FEASIBILITY STUDY AND DETAILED ENGINEERING DESIGN OF THE PROPOSED BUTUAN CITY FLYOVER AND BUTUAN CITY RADIAL ROAD

### VEHICLE COUNT SURVEY FORM

STATION NO. : _____ ROAD NAME _____ Turn/Direction No.: [ ]

WEATHER: _____ Turn No: _____

SURVEYOR: _____ BARANGAY: _____ CITY/MUN: _____

DIRECTION: From _____ PROVINCE: _____ REGION: _____

To: _____ DATE _____ DAY: _____

TIME From: [ ] : [ ] To: [ ] : [ ]

| MODE | | (Tally Sheet) | TOTAL |
|---|---|---|---|
| ALL PRIVATE CAR/ TAXI/ VAN/ PICK-UP |  | | |
| JEEPNEY |  | | |
| VAN FOR HIRE (AUV, GT EXPRESS) |  | | |
| BUS & MINI BUS |  | | |
| GOODS VEHICLE/ 2-AXLE TRUCK |  | | |
| TRUCK (3 or more axles) |  | | |
| MOTOR CYCLE |  | | |
| TRICYCLE |  | | |
| TOTAL | | | |

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# Annex III – note on 'Recommendations for optimal use of data from National Agencies'

# Memo

Deltares
Enabling Delta Life

To
The World Bank

| Date | Our reference | Number of pages |
|---|---|---|
| July 25, 2019 | 11203028-002-GEO-0026 | 2 |
| **Contact person** | **Direct number** | **E-mail** |
| Thomas Bles | +31(0)88 335 7531 | Thomas.Bles@deltares.nl |

**Subject**
Recommendations for optimal use of data from National Agencies

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During the work on the risk assessment and flood modeling in the project 'Mainstreaming Disaster Risk Management to sustain local infrastructure' many challenges have been identified in obtaining and using the data of the National Agencies in the Philippines. National agencies have a great quantity of data that can be beneficial for local government units (LGU). In this short memo we provide 2 types of recommendations

1 to be able to obtain the data
2 to be able to make effective use of the data

## 1 To improve the obtaining of the data

The following recommendations are being made:

- to know where to obtain the data
  As initial step in data collection, it is essential to know where the specific data can be obtained. Although scope of each government agency is properly defined in websites, it is still beneficial to have in there a form where available data with corresponding formats and short descriptions are presented. In this way, it is properly disclosed which data are existing and lacking. It can also promote usage of the data for projects or further improvements.
- To ensure a fast and fluent acquisition of the data
  With information sources identified, it is vital to have a set of effective procedures for data acquisition. It should not be needed to have in-person visits for understanding the process to collect data. Furthermore, government agencies regulate each of their own different process on how to monitor handing-out of data. Therefore, we advocate for a uniform and systematic way of acquisition of the data for the various agencies via a step-by-step process. Requisition forms and Data Use Agreement can still be implemented to ensure proper use and monitoring of data transfer. Though, it is recommended to provide insight to the requisitioner in the duration of information relay by the agencies. In this way, project planning can be approximated. Moreover, data transfer can be made rapid if there is already an existing database for all information rather than just producing when requested.
- For better coordination, national agencies can provide a separate link in their website specific for LGUs open for use anytime. This may encourage discussions between national agencies and LGUs on how to interpret and implement the data, as well as confirmation of data by LGUs. Subsequently, this two-way transfer of knowledge will not only lead to utilization and improvement of the data but will also build relationships and communication.

Besides the above-mentioned recommendations that are valid in itself, it is also advocated to have a one stop shop for the data from all National Agencies. It is therefore great to see that the initiative has been undertaken to develop the GeoRiskPH portal by DOST-PHIVOLCS for easy

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access to these data. It is noted that all recommendations in this memo also count for this initiative.

## 2 To be able to make effective use of the data

The following recommendations are made:

- To ensure that data are useful in analyses
  Though hazard maps in PDF or image formats are good for presentations, possessing spatial data (GIS data) is essential for performing analysis. PDFs or images are of no use when geospatial analyses like natural hazard risk assessments or a flood risk assessment needs to be executed.
- Continuously improve quality of the data
  During the analyses that have been performed with the data many data issues have been identified. It should be made certain that data gaps as well as overlaps are avoided. It is very inefficient when every LGU itself needs to find a way to overcome these issues. This is also a source of error that can be avoided by the national agencies.
- To ensure correct use of the data
  Datasets need to conform to the standards. Geospatial projections are specifically mentioned in this respect. As a minimum the geospatial projection should be part of the meta data of the data file. However, different geospatial projections for different data sets always are a source of error. This may easily be avoided when the geospatial projection is uniform for all datasets.
- To ensure understanding of the data
  Even with a vast amount of available data, not being able to understand the retrieved information defeats the purpose of data collection. It is important that agencies provide explanations on relayed data. This needs to include:
  - A proper description of the legend of the maps
  - A proper description of the meta data (source, units, geospatial projection)
  - Information on the background of the data (scope, limitations, models and factors used, etcetera) to assist the user in gaining insight in how the data have been made by the agencies. This avoids improper use of the data.
  - Source of the data
  - Uncertainties in the dataset (date of observation, spatial and temporal resolution, etcetera)
- To ensure LGU to use the data
  Through these recommendations, the information can be effectively used by the LGUs.
  It is of great significance that national agencies and local government units know how to work with the GIS data. Since GIS capabilities are generally lacking at LGU it is good to hear that a capacity building programme for use of GIS at LGU exists. The programme is organized by Namria with DILG under the Global Government Academy.

The GeoRiskPH portal is designed to provide the data of National Agencies. Also, it is intended to perform risk analyses in GeoRiskPH. Steps are being made already regarding exposure, but in principle also Damages and Losses could be calculated in GeoRiskPH. Given the low GIS capabilities at LGU this may be a very efficient option. Capacity building and knowledge development then needs to take place on the national level only and LGU can download the specific risk information to improve the DRM in their province. It is therefore recommended to investigate whether the GeoRiskPH could be a good platform to perform all steps of the risk assessment on a central platform for use by LGUs.