A COMPREHENSIVE NATIONAL HAZARD ASSESSMENT AND MAPPING IN TIMOR-LESTE

Synthesis Report on Comprehensive National Hazard Profile

DRAFT VERSION
SEPTEMBER 2012

The Hazard Assessment Report was prepared by ADPC team through coordination,
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LIST OF ABBREVIATIONS

ADPC	Asian Disaster Preparedness Center
ASTER	Advanced Spaceborne Thermal Emission and Reflection Radiometer
AVHRR	Advanced Very High Resolution Radiometer
COMCOT	COrnell Multi-grid COupled Tsunami model
CRM	Climate Risk Management
DEM	Digital Elevation Model
DRM	Disaster Rick Management
DRR	Disaster Risk Reduction
ENSO	El Niño Southern Oscillation
FAO	Food and Agriculture Organization
FEMA	Federal Emergency Management Agency (US government)
FRA	Forest Resource Assessment Program
GDAS	Global Data Assimilation System
GEBCO	General Bathymetric Chart of the Oceans
GIS	Geographic Information System
GLCC	Global Land Cover Characterization
GrADS	Grid Analysis and Display System
GRDC	Geological Research and Development Center
GSHAP	Global Seismic Hazard Assessment Program
GTS	Global Telecommunications System
ICRC	International Committee of the Red Cross
IGBP	International Geosphere Biosphere Programme
INGO	International Non-Governmental Organization
LIDAR	Light Detection and Ranging
MMI	Modified Mercalli Intensity
MSS	Ministry of Social Solidarity
MWD	Mean Wave Direction
NASA	National Aeronautics and Space Administration (USA)
NCEP	National Centre for Environment Prediction
NDMD	National Disaster Management Directorate
NDTPSC	National Directorate of Land and Properties and Cadastral Services
NDVI	Normalized Difference Vegetation Index
NEHRP	National Earthquake Hazards Reduction Program
NGI	Norwegian Geotechnical Institute
NGO	Non-Governmental Organization
NSD	National Statistic Directorate
PCCSP	Pacific Climate Change Science Program
PGA	Peak Ground Acceleration
RDTL	Republic Democratic Timor-Leste
RES	Relative Erosion Susceptibility
SPI	Standardized Precipitation Index
SRTM	Shuttle Radar Topography Mission
TLLEP	Timor-Leste Legal Education Project
TRMM	Tropical Rainfall Measuring Mission
UN	United Nations
UNDP	United Nations Development Program
UNICEF	United Nations International Children's Emergency Fund
UNMIT	United Nations Mission in Timor
USGS	U.S. Geological Survey
WFP	World Food Program
WHO	World Health Organization
WPS	WRF Preprocessing System
WRF	Weather Research and Forecasting

EXECUTIVE SUMMARY

Background

The Republic of Democratic of Timor-Leste is the easternmost and largest island in the Indonesian archipelago. Geographically the country is exposed to several kinds of hazards, which include frequent events such as strong tropical windstorms, heavy rain, drought, and landslides as well as rarer (but potentially be more deadly) events such as earthquakes and tsunamis. Fortunately historical hazard events have been rather localized and have not had widespread devastating impacts. The most prominent and frequent hazard types in recent history include floods, landslides, and drought (prolonged dry spells). These events typically have negative impacts on the people of Timor-Leste due to the fact that they rely heavily on domestic food production that can be affected by such hazards. Additionally, a low-probability but high-consequence event such as a major earthquake or tsunami can cause substantial damage to the country's fragile infrastructure and buildings as well as injury and fatality to residents who may not be prepared for such a disaster.

Project Priorities and Objectives

Realizing the gap in Timor-Leste's national and local disaster risk management systems, the United Nations Development Programme (UNDP) and the National Disaster Management Directorate (NDMD) of the Government of Timor-Leste have launched a project entitled "Strengthening Disaster Risk Management in Timor-Leste" to be implemented between 2011 and 2013. The overall objective of the project is to develop disaster risk management capacity at the national and district levels. The key priority defined under the scope of this project is to undertake a national multi-hazard vulnerability and risk assessment to understand the disaster risk in Timor-Leste.

The Asian Disaster Preparedness Centre (ADPC) was awarded the task of providing consultancy services to develop a Comprehensive National Hazard and Mapping of the Republic of Democratic Timor-Leste (RDTL). The ADPC team worked in close coordination with NDMD the Ministry of Social Solidarity (MSS), United Nations Development Programme (UNDP) Timor-Leste Country Office, as well as other national and international agencies in the study implementation. The assignment covered various technical and management activities including the review of past and ongoing studies and activities related to various hydro-meteorological and geological hazards. The study established assessments for eight types of hazards in Timor-Leste including flood, landslide, coastal erosion, strong wind (cyclone), drought, forest fire, earthquake, and tsunami. The study provided an opportunity to share existing information, data and resources to develop comprehensive hazard assessments. The present study integrated all existing information and studies; developed a robust methodology at the national level which was supported by proven technical tools. The results of the hazard assessment outcome are essential for making decisions about national safety and sustainable development.

Methodology

The methodology has been compartmentalized into several sections depending on the type of hazard addressed. The hazard assessment incorporated data collected from existing regional research, disaster databases, and meteorological, hydrological, and geological data collected from government agencies as well as international sources. The data used in this assignment was screened and validated to ensure the accuracy of the results.

The quantification and mapping of the 8 hazard types involved a combination of historical data analyses and mathematical modeling of the hazard events in terms of their frequency, intensity, and geographical coverage. A variety of well-established scientific tools and techniques were used to assess the hazards and mapping accordingly. In the end, a multi-hazard assessment and mapping was conducted based on the best available data and scientific approaches given the time frame of the assignment.

Summary of Key Findings

Each portion of this comprehensive hazard assessment generated a series of findings that pertains to a particular hazard that either currently or potentially affects Timor-Leste. These outputs begin to illustrate the risk and vulnerability of the nation at the national and district levels. Below is a summary of some of the key findings organized by hazard.

- The flood hazard assessment revealed that, of the 12 districts located in the 7 vulnerable river basins included in the study, Liquiçá district has the highest percentage (2.6%) of flood inundation area that has a flood depth of over 2 meters. This flood inundation area makes up 14.3 km^2 of the area of the district. In Ainaro district, the inundation areas with flood depths less than 0.5 m account for 95.7 km^2 (or 1.1%) of the total 870 km^2.

- The landslide susceptibility analysis was conducted in two main parts. The first part looked at earthquake induced landslides and revealed that 50 percent of the country falls within medium landslide susceptibility zones, 1 percent falls within very high zones and 29 percent falls within high zones. These very high and high susceptibility zones are located along the eastern and northern coast. The second part looked at rainfall induced landslides and found that 33 percent of the country falls within medium landslide susceptibility zones which are spatially distributed evenly across the country. About 2 percent and 23 percent of Timor-Leste is prone to very high and high landslides respectively. These areas are typically located in mountainous regions with relatively soft rock masses that surround harder fragments. High and very high susceptibility zones are prevalent in the western part of Timor-Leste, such as in Bobonaro, Ermera, and Ainaro districts.

- The coastal erosion hazard assessment provides a broad picture of the relative susceptibility of Timor-Leste's coastline to beach erosion. The study found that the stretches of coast that are highly susceptible to erosion are concentrated mostly in the south which is exposed to higher waves than the north. The entire coastline of some districts such as Aileu, Manufahi and Viqueque are highly susceptible to coastal erosion.

- The strong wind hazard assessment identified districts that are susceptible to high wind speeds. The districts that are in danger of experiencing 75 to 85 kilometer per hour (km/hr) winds for the 100 year return period are Ainaro, Covalima and Bobonaro. Additionally, Dili, Ermera and Aileu are at risk of sustaining 65 to 75 km/hr winds.

- The drought hazard assessment utilized the Standard Precipitation Index (SPI) to analyze the susceptibility of Timor-Leste to drought conditions. The SPI was used to quantify the precipitation deficit for multiple time scales and investigate the temporal and spatial variation of drought and its severity. A study of the temporal variation of drought found that moderate drought frequently occurs in all the seasons. However by comparison, severe and extreme droughts are less common. The drought occurrence probability study found that the chances of moderate and severe droughts during the dry season are higher than the wet and main rainy season while the probability of extreme drought is highest in the main rainy season. An analysis of the spatial variations of drought found that the areas that are most susceptible to experiencing moderate to extreme drought vary by season.

- The forest fire susceptibility analysis found that the majority of forest area in Timor-Leste is highly susceptible to forest fires.

Large portions of districts such as Aileu, Ainaro, Baucau, Ermera, Liquiçá, and Viqueque are at high risk while smaller portions of some districts such as Dili, Liquiçá and Manatuto have an even greater risk.

- The earthquake hazard assessment identified most of the eastern part of the country as having an earthquake hazard level of Modified Mercalli Intensity (MMI) VII, while most of the western districts were identified as MMI VI. Hence, the western part of the country could be exposed to a lesser level of earthquake hazard than in the eastern part. There are pockets of areas which were identified as MMI VIII. Those areas are situated along the southern coast of the island, for example, in Covalima, Lautem, and Manufahi districts.

- The tsunami hazard assessment identified the areas of the coastline of Timor-Leste that are susceptible to sustaining the highest tsunami waves. These areas are at the eastern end of Timor Island, including the districts of Lautem, Baucau, Viqueque, Manatuto and Dili, and the island of Atauro.

Applications of the Study Results

The Comprehensive National Hazard Assessment and Mapping in Timor-Leste successfully identified hazard-prone areas and respective hazard zones at the national and district levels based on historic disaster events. This assessment is the first phase of a project designed to develop Timor-Leste's national disaster risk management system. This assessment will be the foundation to develop a comprehensive national risk assessment for Timor-Leste which in the end will be used to identify programming gaps and opportunities that will enable government, humanitarian and development agencies to formulate disaster risk reduction plans and strategies.

The statistical data and hazard maps that were generated as a result of this study can be integrated into the larger national disaster risk management framework in Timor-Leste in the following ways:

- The hazard maps can be used by policy makers, decision makers and planners as a basis for future master plans and safe development. Authorities can take necessary actions to reduce the impacts of hazards on various economic sectors such as agriculture, housing, tourism, industry and production.
- The national government of Timor-Leste and local authorities can use the hazard assessment report to understand the severity of hazards at the national and district levels.
- The hazard maps and statistical data can help policy makers, decision makers, planners and other parties to plan and implement effective disaster management strategies in Timor-Leste.
- Response agencies can use the hazard maps to coordinate response strategies and identify sites for structural and non-structural mitigation projects.
- The hazard maps could aid local governments in introducing and enforcing building codes and permitting regulations to protect homes and infrastructure.
- International and national relief agencies and humanitarian organizations can use the analysis to prioritize hazard disaster preparedness and mitigation interventions and aid allocation to areas that are likely to sustain extreme impacts from hazards.
- The Ministry of Agriculture may use the hazard maps to change crop patterns and develop other non-structural measures to reduce the negative impacts hazards such as flooding have on agriculture.
- The hazard assessment report can be used as a tool to educate the public about hazards and risk.

Organization of Chapters

The first chapter of the hazard assessment report provides an introduction to the concepts of hazard and risk as they are relevant to Timor-Leste. It gives a background of the project entitled "Strengthening Disaster Risk Management in Timor-Leste" (2011-2013) and describes the objectives and scope of the Comprehensive National Hazard Assessment and Mapping in Timor-Leste. It also explains the constraints, challenges, and benefits of the hazard assessment and provides some national baseline information. Chapter 2 describes the hazard assessment methodology. Chapter 3 provides a detailed hazard profile for the eight hazards that effect Timor-Leste (i.e. flood, landslide, coastal erosion, strong winds, drought, forest fires, earthquake, and tsunami. This chapter describes the specific detailed methodology that pertains to each hazard and provides the results of the study. Chapter 4 describes the way forward or next steps. Additional statistical information generated during the hazard assessment and more hazard maps can be found in the appendices.

1 Introduction

1.1 Background

The Asian Disaster Preparedness Center (ADPC) was awarded the task of providing consultancy services to develop a Comprehensive National Hazard and Mapping of Republic Democratic Timor-Leste (RDTL). The ADPC team worked in close coordination with the National Disaster Management Directorate (NDMD) Ministry of Social Solidarity (MSS), United Nations Development Programme (UNDP) Timor-Leste Country Office and other national agencies during the implementation of the study. This assignment is the first phase of a National Multi Hazard Risk and Vulnerability Assessment implemented under the Project entitled "Strengthening Disaster Risk Management in Timor-Leste" (2011-2013) launched by UNDP Timor-Leste Country Office and NDMD MSS. The overall objective of the project is to develop Disaster Risk Management (DRM) capacity at the national and district levels, including communities vulnerable to natural disasters and climate change. In order to achieve this objective, four key priorities were identified: (1) undertaking a National Risk Assessment as a basis for decision-making; (2) mainstreaming DRM and Climate Risk Management (CRM) in government sectoral planning; (3) strengthening institutional and operational mechanisms for the implementation of the DRM policy; and (4) expanding community-based disaster risk reduction with special emphasis on promoting women's participation.

To achieve this, a three-phase approach will be implemented:

- Phase 1 – Development of a comprehensive national hazard profile
- Phase 2 – Development of a comprehensive national risk profile
- Phase 3 – Revision or formulation of National DRR Strategy, which consists of possible country-specific DRR measures, priorities, DRR programming, risk financing mechanism, and institutional arrangement, etc.

The assignment covered various technical and management activities including the review of ongoing studies and activities related to various hydro-meteorological and geological hazards. The study established assessments for eight types of hazards in Timor-Leste. The study provided an opportunity to share existing information including data and resources for use in the development of comprehensive hazard assessments. The present study integrated existing information and studies to develop a robust methodology at the national level which was supported by proven technical tools. The outcomes of the hazard assessment are essential to making decisions concerning national safety and sustainable development.

1.2 Objectives

The main objective of the assignment "A Comprehensive National Hazard Profile" in Timor-Leste is to create a comprehensive hazard profile for Timor-Leste which covers all of the major hazards prevailing in Timor-Leste, including flood, landslide, coastal erosion, strong wind (cyclone), prolonged dry seasons (drought), forest fires, earthquake and tsunami. More specifically, the study objective is to map out hazard prone areas and respective hazard zones at the district level based on historic disaster events and to create a basis for comprehensive national risk assessment for Timor-Leste which in the end will be used to identify programming gaps and opportunities that will enable government, humanitarian and development agencies to formulate disaster risk reduction plans and strategies.

1.3 Scope of Assignment

A normal process for assessing disaster risk starts from (1) characterizing the hazard in terms of its spatial distribution, frequency, and severity, (2) identifying the elements (e.g., housing, people, schools, agricultural lands, etc.) that would be exposed to the hazards, (3) quantifying the degree of vulnerability or damageability for the at-risk elements to the hazards, and finally (4) estimating the impact of the hazard on the at-risk elements. These 4 steps are referred to as hazard, exposure, vulnerability, and risk, respectively. The general process for disaster risk assessment in Timor-Leste is illustrated in Figure 1.1.

However, the focus of this assignment will only be on the hazard part. Specifically, the scope of the assignment is as follows:

- Development of a comprehensive national hazard profile including major hazard-prone areas and a set of major hazard intensity maps.

  The hazard assessment and mapping covered 8 major hazards that prevail in Timor-Leste. The developed comprehensive profile systematically identified all major hazard-prone areas, described the physical characteristics of hazards and various descriptors including sources of threat, magnitude, duration, frequency, probability, extend and intensity field (spatial distribution of intensity) within each hazard-prone areas, built plausible hazard scenarios for the major hazards, and developed hazard intensity maps.

- Enhancement of the national capabilities for risk assessment by engaging national professionals in the exercise.

  Risk assessment is an integral part of decision-making. To ensure a good understanding of the risks Timor-Leste is facing and promote the sustainability of the risk assessment through future updates, it is highly necessary to engage key policy and decision makers, as well as national technical professionals, throughout project implementation.

- Improvement of National Risk Disaster Information System-DRMInfo through the integration of the develop maps.

  A Preliminary National Disaster Information System, called DRMInfo has been established with limited datasets. The scope includes examining the existing information system to find a way to improve its functionality and integrating the new hazard maps into DRMInfo Timor-Leste.

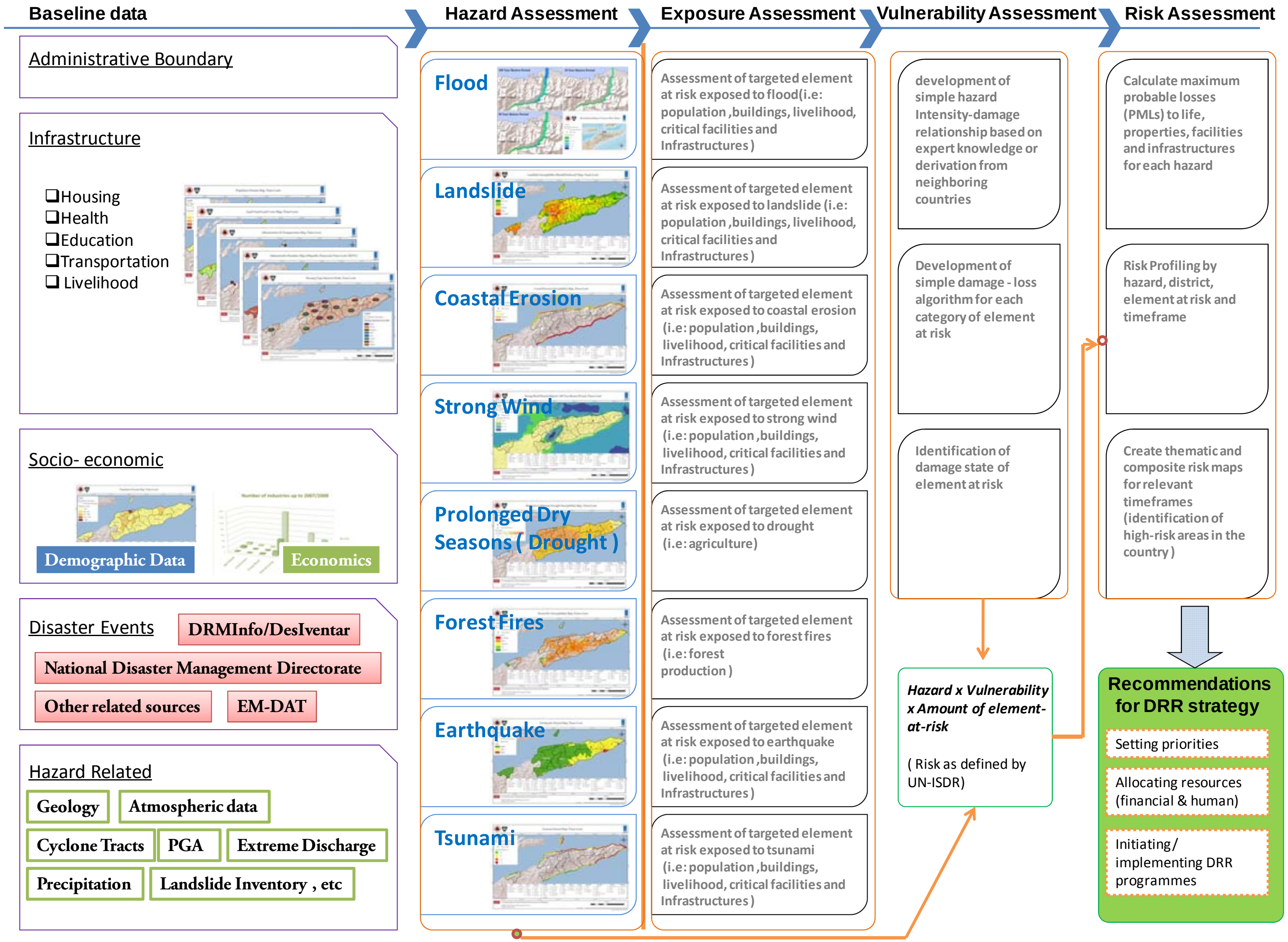

Figure 1.1: Overall Methodology for Hazard and Risk Assessment in Timor-Leste

1.4 Constraints and Challenges

- ***Resource Constraints*****:** The assignment was allocated with limited funding. Not all of the data that was available from various departments and agencies was relevant to the study requirements. The data was not consistent in nature and required rigorous processing. It would have been better if the highest priority disasters were studied in a more detailed manner. With limited resources the Study Team depended largely on secondary sources of data and information. The Study Team collected data from various authentic sources which ranged from government ministries, departments, agencies, and research and technical organizations. The information generated in this study relied on this secondary, existing validated data and not on field-based data collection.

- ***Time Limitation*****:** The time allocated for the assignment was limited to four months. In the stated time frame, extensive hazard analysis was carried out. The study outputs largely depended on the ability of the Study Team to process available data from the national agencies and other secondary sources to meet desired quality levels.

- ***Precision Standards***: In general, the hazard assessments were carried out using scientific tools and other relevant methods and the outcomes were generated to the appropriate scale. Since time and resources were limited, the Study Team validated the outcomes of hazard assessment and mapping with well-established data and information that was available. The outcomes were also validated through stakeholder's workshops.

- ***Availability of Data*****:** For the extensive hazards assessment and mapping, several datasets were required: geological, hydro-meteorological, geo-morphological and other related data. Some information was available; however, a large quantity of data was missing. This restricted the complexity of the hazard modeling. The Study Team modified the data and information based on available data suited to the modeling requirements.

- ***Technical Methodology*****:** Development of methodology for the hazards assessment and mapping was largely dependent on the availability of data and resources.

1.5 Expected Benefits to the Nation

The findings of the Comprehensive National Hazard Assessment and Mapping of RDTL will create the basis for exposure, vulnerability and risk assessment which can then be used to incorporate appropriate risk reduction strategies and to prioritize them into the country's development planning. It is expected that the findings of the study, which will be followed by the comprehensive national risk profile, will allow decision makers to prioritize risk mitigation investments and measures to strengthen the emergency preparedness and response mechanisms for reducing future losses and damages due to natural disasters. It would further assist donor agencies, development partners and so on, in adopting a risk reduction strategy for Timor-Leste through appropriate financing mechanisms.

- At present several agencies have carried out hazard and risk assessments for different parts of the country at different scales. The current study outcomes will enhance the qualitative and quantitative aspects of different agencies' work. The study developed comprehensive national hazard assessment profiles for the whole country at the district level.

- The study will further help identify the most vulnerable sectors and necessary measures to reduce impacts.

- The national sector-specific risk projections will assist concerned stakeholders to prioritize DRR strategies.

- The study will emphasize existing gaps in DRR strategies. The study has also recommended measures to improve decision-making capacity.

- The outcome will be useful for mainstreaming DRR in various sectors at different levels.

- The assessment will help national and district decision makers, policy makers and development agencies to prepare DRR planning.

- Based on the outcome of this study, the government may take necessary actions for capacity building for DRR.

- The study proposed a robust methodology for hazard analysis in close collaboration with national technical department and agencies. The level of assessment is from national to district level and these models can be replicated in other regions and bigger scale whenever data is available.

1.6 Stakeholders

Three types of stakeholders were involved in the assignment: the Study Team, focal institutions, and beneficiaries.

The Study Team included technical staff members from ADPC. Additionally, the Study Team sought guidance and technical advice from national and international professional expertise in hazard and risk modeling.

NDMD MSS was the focal point for advice and coordination with other concerned government departments. The Study Team identified several beneficiaries. The role of beneficiary stakeholders was to provide the necessary data and information used during the hazard assessment. The large group of beneficiary stakeholders included the National Directorate of Land and Properties and Cadastral Services (NDTPSC); National Statistic Directorate (NSD), Ministry of Finance, National Directorate of Geology and Mineral Resources; Meteorological Services; ALGIS Department-Agrometeorologia Section, Ministry of Agriculture and Fisheries; National Directorate of Forestry, Ministry of Agriculture and Fisheries; United Nations Integrated Mission in Timor-Leste (UN-MIT) GIS Unit; and other UN bodies, such as World Food Program (WFP**).**

1.7 Outcomes

Several outcomes resulted from this study, including:

- Hazards Scenario Development:
    - Hazard zonation maps for floods, landslides, coastal erosion, strong wind (cyclone), prolonged dry seasons (drought), forest fires, earthquake and tsunami;
    - Identification of the most hazard-prone areas; and
    - Analysis and interpretation of hazard assessment for various disasters.
- A set of digital hazard datasets in GIS (Geographic Information System) formats, stored in Geo-database, which can be readily be integrated with DRMInfo
- Final Report which included the following:
    - Synthesis report of hazards assessment of Timor-Leste national level; and
    - A set of recommendations on how to apply the outputs in Disaster Risk Management.

2 Hazard Assessment Methodology

This chapter of the report presents the overall methodology of the study entitled "A Comprehensive National Hazard Assessment and Mapping in Timor-Leste" which focuses on the assessment of the priority hazard types in Timor-Leste.

Hazard assessment is an essential first step of the overall risk assessment process. It involves gathering and analyzing basic information and observational data on meteorological, hydrological, and geological hazards in terms of their nature, frequency and magnitude. To assess the hazard, historical records are used to identify critical hazard-prone zones. Furthermore, scientific knowledge, expert judgment and computer simulations often are needed to create hazard scenarios in the case that the historical data is sparse or unreliable.

The result of analysis is usually presented in the form of maps portraying the intensity and probability of hazards in a given geographical location. A hazard map can be applied in many ways, including:

- It serves as information for the public about threats in their living environment
- It can be used as input for land use, strategic and business planning
- It is the basis for civil engineers and town planers to make decisions about safe and sustainable development
- It can work as the basis for developing exposure, vulnerability and risk assessments which can be used to develop risk transfer mechanism through insurance and catastrophic bonds etc.

It is important for practitioners to be able to broadly differentiate between "susceptibility" and "hazard" maps. In general, a susceptibility map provides spatial information on whether a certain terrain is prone to the occurrence of a hazardous event. The term is particularly common for landslides studies, where static parameters such as topography/slope, soil condition and average rainfall can be used to indicate the potential for mass movements. On the other hand, a hazard map additionally takes into account the temporal probability that a hazardous event may occur. For example a flood hazard map is commonly based on the return period of river flooding levels or equivalently the annual probability of exceedance.

2.1 Characteristics of the Hazard Assessment

Hazard is characterized by degree of severity, duration, extent of the impact area and their relationship. There are several ways by which, hazard assessments can be carried out. The comprehensiveness of a hazard assessment depends on following factors:

- Availability of historical event data and geological, geomorphological, hydrological, meteorological data, etc.
- Availability of time and resources
- Type and characteristics of hazards
- Application of hazard assessment to the end users.

There are several ways by which a hazard assessment can be performed which are largely dependent upon availability of data and scientific tools like map analysis, analysis of aerial photography and imagery, field reconnaissance, aerial reconnaissance, drilling, acoustic imagery and profiling, geophysical studies, computerized terrain analysis and instrumentation.

This hazard assessment and mapping in Timor-Leste have been performed using the application of secondary data collected from various nodal agencies, expert judgments and scientific tools. The results were then validated through several workshops which were attended by representatives of related government agencies, International nongovernmental organizations (NGOs), UNDP and other UN bodies.

2.2 Scope of the Hazard Assessment in this Assignment

Considering the hazard and disaster history in Timor-Leste, several priority hazard types that are being considered within the scope of this assignment include:

(1) Flood

(2) Landslide

(3) Coastal Erosion

(4) Strong Wind (cyclone)

(5) Prolonged dry seasons (drought)

(6) Forest Fires

(7) Earthquake

(8) Tsunami

Subsequent sections of this chapter present the results obtained from the hazard assessment.

2.3 Overview of the Methodology

The methodology has been compartmentalized into several sections depending on the types of hazard studied. The exercise incorporated data collected from existing research studies in the region, disaster databases, and baseline meteorological, hydrological, and geological data collected from government agencies as well as international sources. The data used in this assignment have been screened and validated to ensure accuracy of the results.

The overall methodology for the quantification and mapping of the defined 8 hazard types involved a combination of historical data analyses and mathematical modeling of the hazard events in terms of their frequency, intensity, and geographical coverage. The hazard assessment was conducted based on the best available data, scientific approaches, and well-established scientific tools, given the time frame of the assignment. All hazard mapping was done in the Geographic Information System (GIS) environment, which will allow users to easily make changes or update the maps. At the end, multi-hazard assessment was also carried out.

3 HAZARD PROFILE OF TIMOR-LESTE

3.1 Flood

3.1.1 Background

Flood is one of the most common disasters in RDTL, resulting from a combination of heavy monsoon rain, steep topography and widespread deforestation. There are two types of flood in Timor-Leste namely: (1) *flash flood* that occurs when heavy seasonal rain water in high catchment basins converges in tributaries as it descends downward resulting in the rapid rise of discharge along the water courses and (2) *riverine flood* that occurs when water accumulates in lowland or upland flood plains and river banks have insufficient capacity to contain the flow resulting in an overflow of the river. According to the National Disaster Loss Database, floods in RDTL have destroyed infrastructure, damaged livelihoods and displaced residents. The 2010-2011 La Niña weather pattern caused increased rainfall over a prolonged period of time in Timor-Leste resulting in flooding throughout most of those years. According to the Government of Timor-Leste (NDMD, 2010), the flooding destroyed 200 homes and affected 1,400 families. It is predicted that due to climate change, Timor-Leste is likely to become increasingly vulnerable to natural disasters including floods.

In this study, flood hazard mapping for Timor-Leste was carried out at the national level. As a result, the flood hazard maps are not expected to depict any finer detail. A total of 7 river basins have been analyzed across the country of Timor-Leste and will be discussed further in this chapter.

3.1.2 Map Contents

Flood hazard maps were developed for the most flood prone river basins. Seven rivers have been identified and determined for flood hazard assessment in accordance with the past history of flooding as well as in consultation with relevant agencies in Timor-Leste. These rivers are Be Lulic, Comoro, Lois, Laclo, Raumoco, Tono and Vemase. The flood hazard maps show the flood inundation and flood water depth with various return period scenarios. These return periods are 10 years, 50 years and 100 years. It is noted that the bigger the return period, the worst the flood scenario. The flood inundation area for a particular scenario has been indicated in square kilometers. The results of the flood hazard maps are shown in Figure 3.1 to Figure 3.7

Each river flood hazard map shows the following:

- Country, District and Sub-district boundaries
- River network
- Area and depth of inundation for particular return period. Each color of flood inundation area represents different levels of flood depth as shows below:

Color Code	Explanation
(dark green)	Flood depth Less than 0.5 meter
(light green)	Flood depth between 0.5 to 1.0 meter
(cyan)	Flood depth between 1.0 to 1.5 meter
(light blue)	Flood depth between 1.5 to 2.0 meter
(dark blue)	Flood depth above 2.0 meter

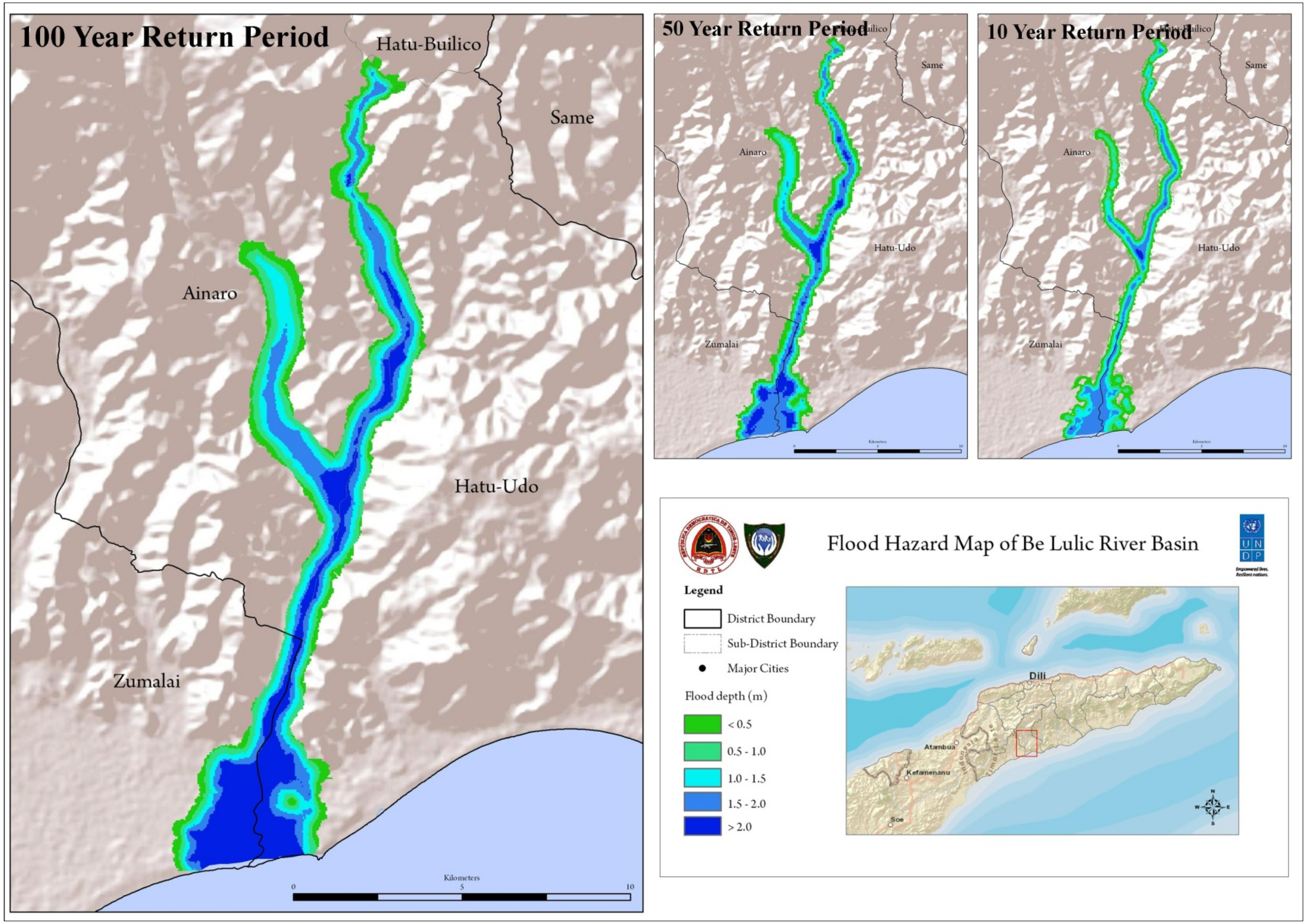

Figure 3.1: Flood hazard map of Be Lulic river basin

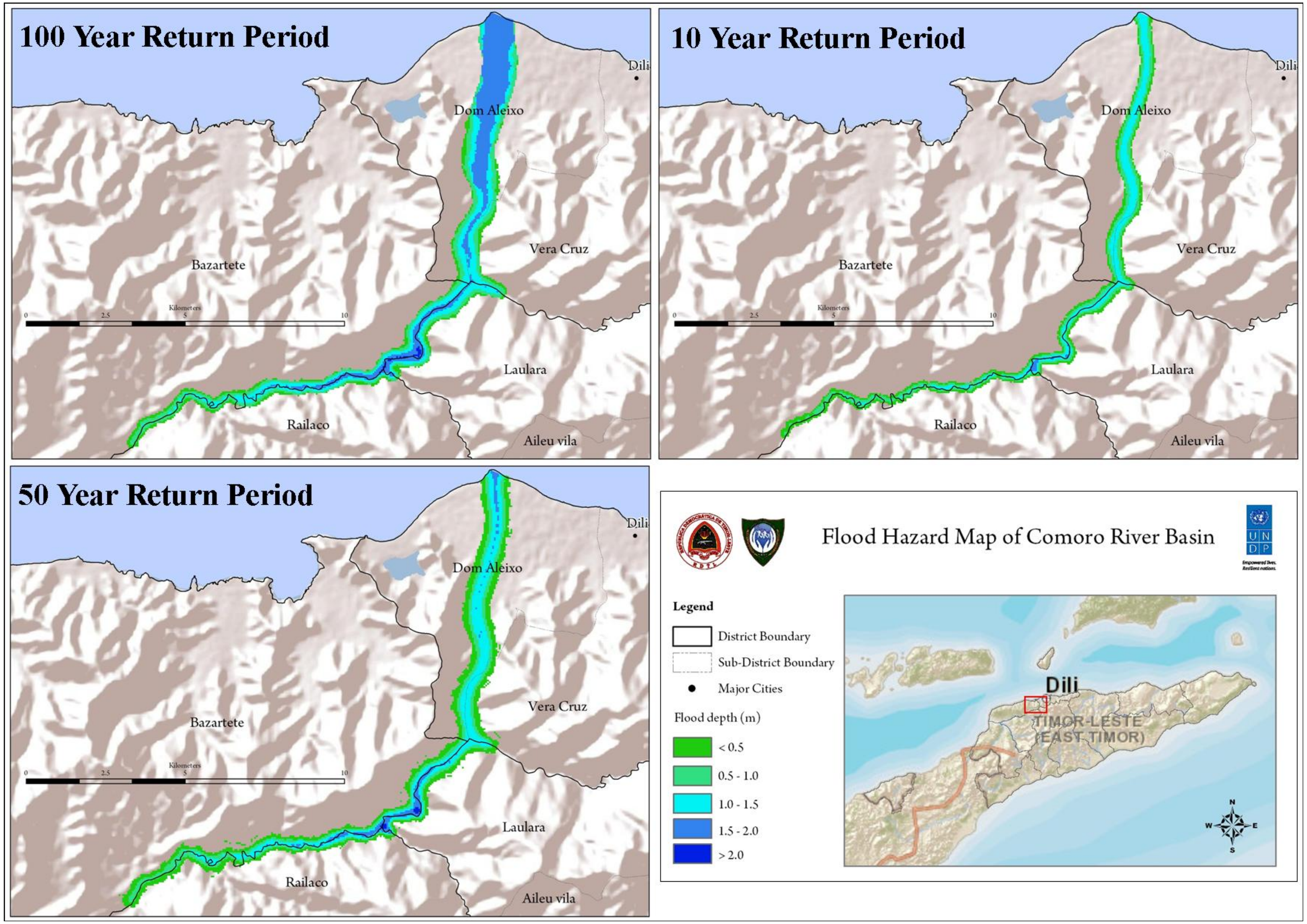

Figure 3.2: Flood hazard map of Comoro river basin

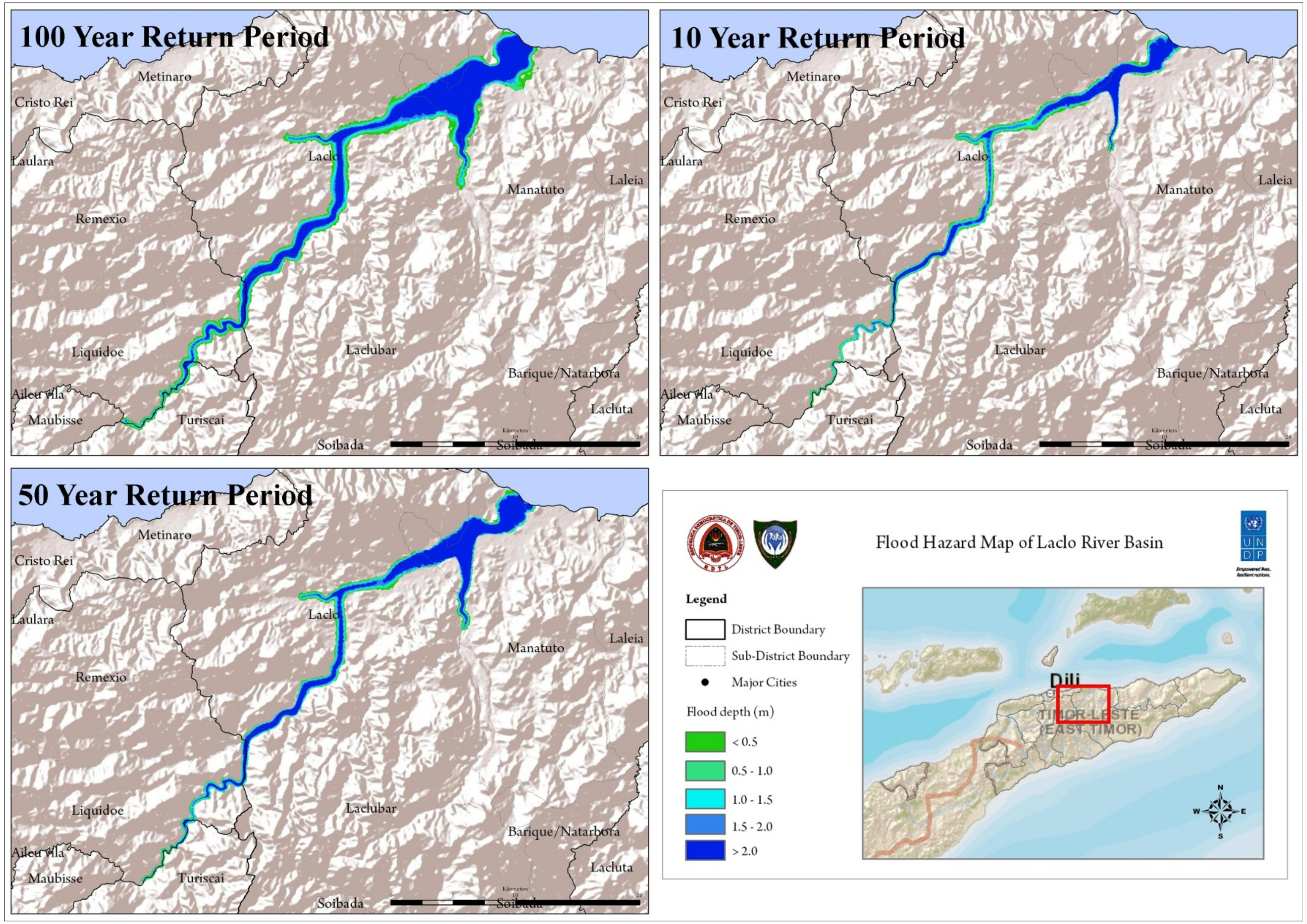

Figure 3.3: Flood hazard map of Laclo river basin

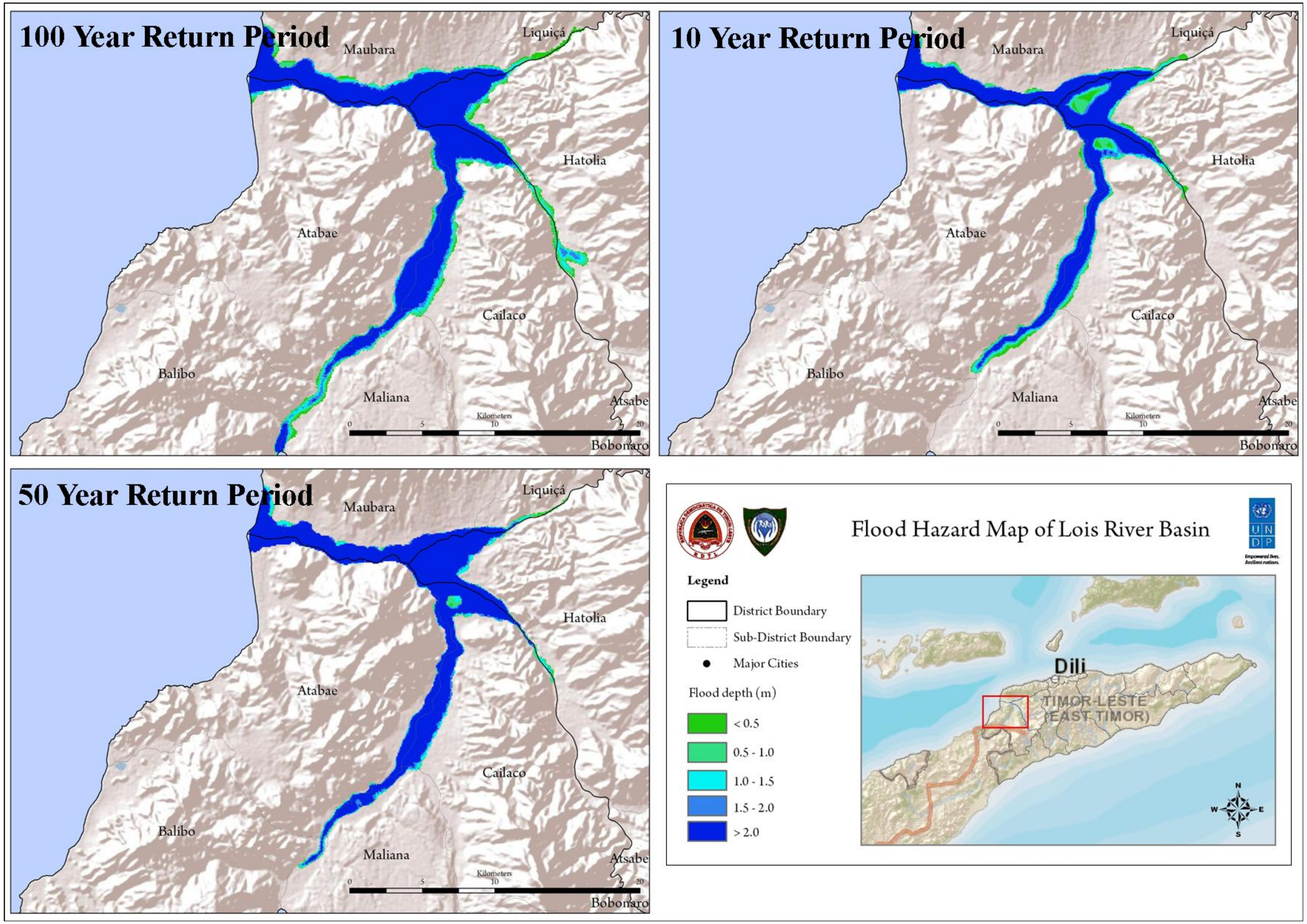

Figure 3.4: Flood hazard map of Lois river basin

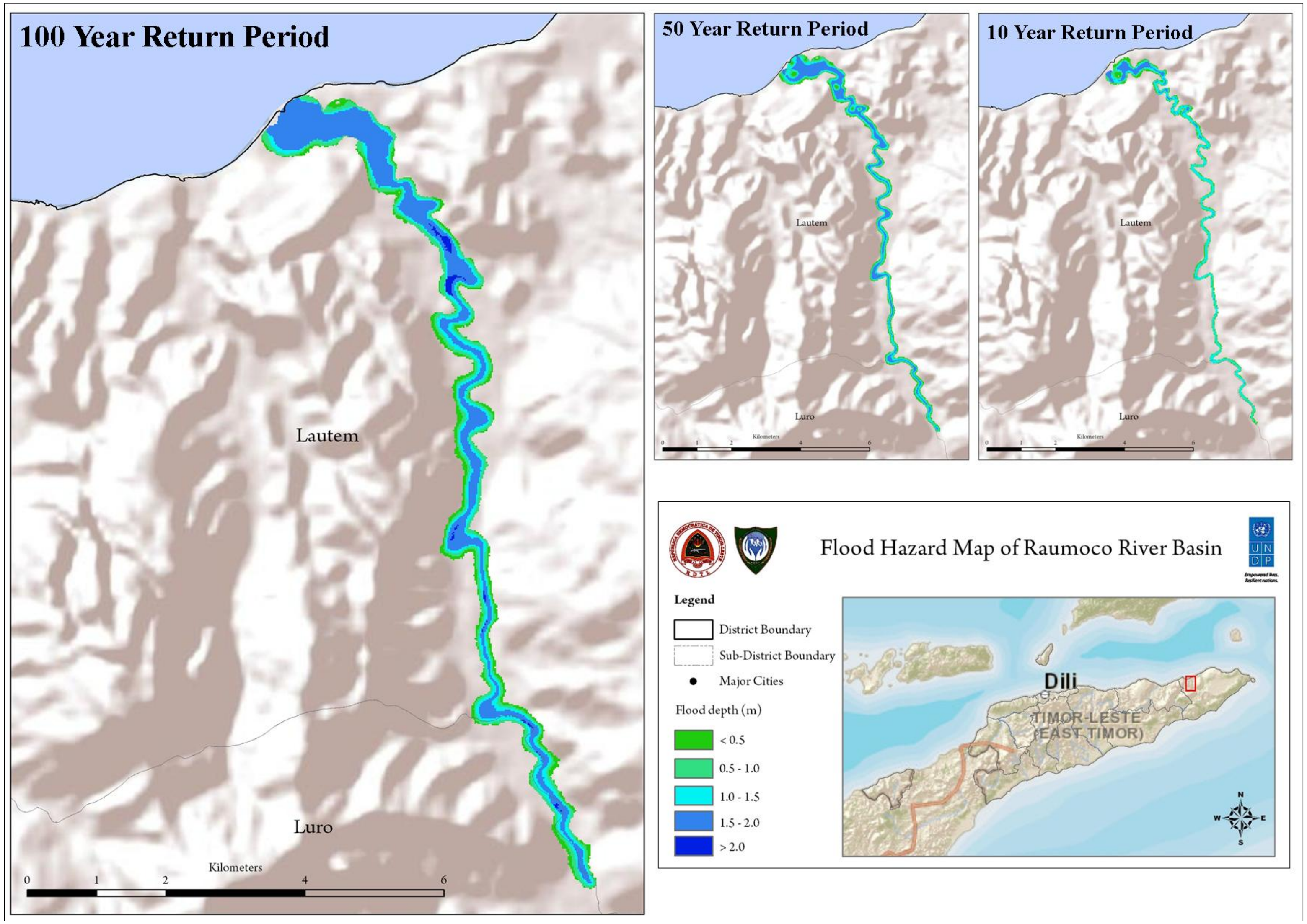

Figure 3.5: Flood hazard map of Raumoco river basin

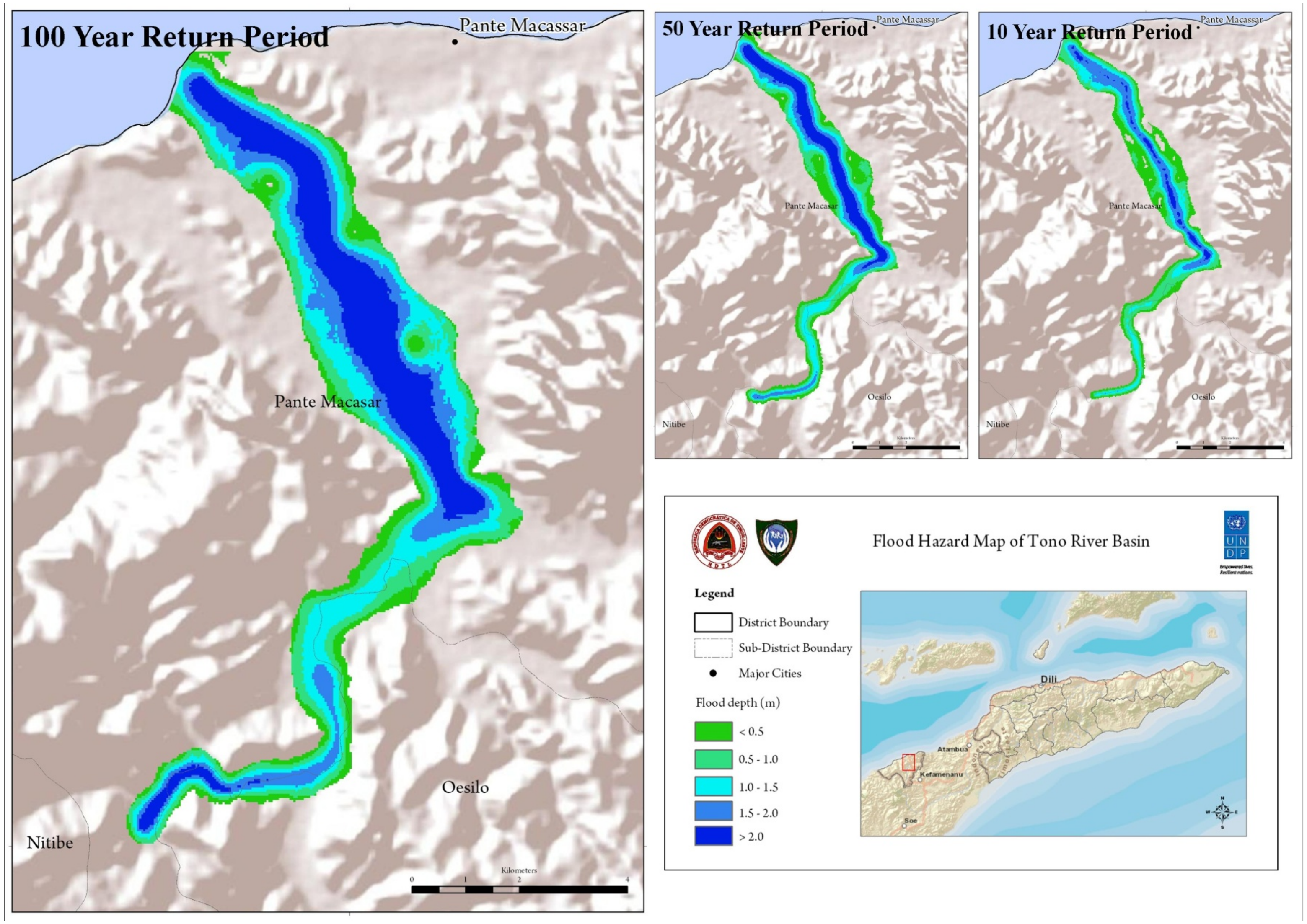

Figure 3.6: Flood hazard map of Tono river basin

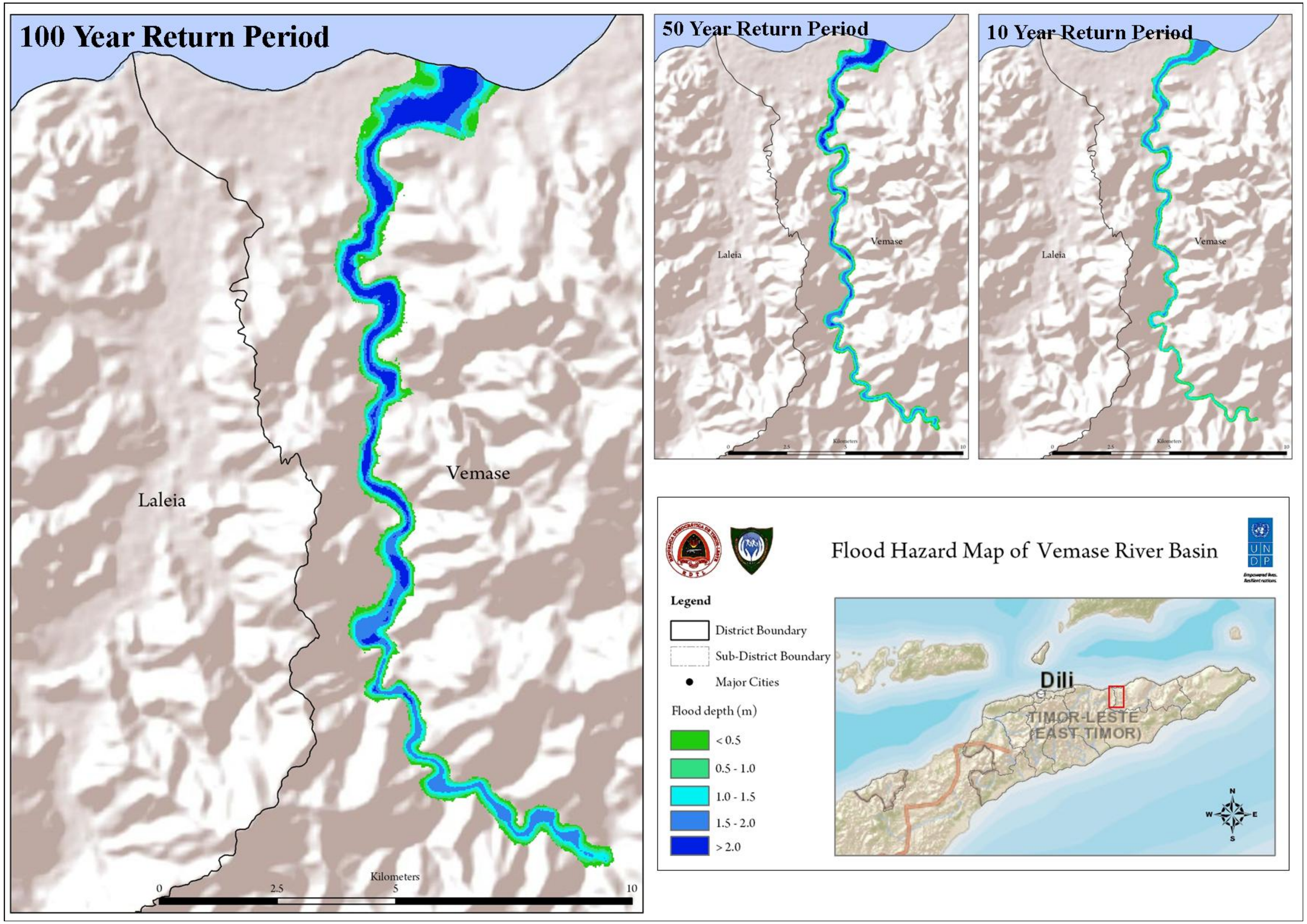

Figure 3.7:Flood hazard map of Vemase river basin

3.1.3 Analysis of Hazard Map

The flood hazard maps depict areas of inundation and flood depth in the river basins. The flood hazard map analysis was carried out by overlaying the flood hazard maps over district boundaries in the selected river basins. Throughout the 7 selected river basins, the inundated areas were calculated at different flood depth ranges in each district, starting from less than 0.5 m, 0.5 m – 1.0m, 1.0 m – 1.5 m and so on. The percentage of inundated areas at different flood depths at the return period of 100 years were summarized in Table 3.1

Table 3.1: Percentage of flood inundation area in different depths for 100 year return period based on 7 selected river basins.

District	Percentage of flood inundation area for each depth (m)					Area of District (sq.km)
	< 0.5	0.5-1.0	1.0-1.5	1.5-2.0	> 2.0	
Aileu	0.15%	0.20%	0.22%	0.12%	0.05%	676
Ainaro	1.10%	0.65%	0.63%	0.53%	0.02%	870
Baucau	0.08%	0.11%	0.14%	0.10%	0.00%	1,508
Bobonaro	0.13%	0.25%	0.25%	0.26%	1.53%	1,381
Covalima	0.15%	0.08%	0.14%	0.26%	0.00%	1,207
Dili	0.28%	0.40%	0.49%	0.00%	0.00%	368
Ermera	0.24%	0.31%	0.17%	0.15%	1.32%	771
Lautem	0.02%	0.04%	0.05%	0.02%	0.00%	1,813
Liquiçá	0.27%	0.42%	0.23%	0.15%	2.60%	551
Manatuto	0.25%	0.52%	0.36%	0.32%	0.43%	1,786
Manufahi	0.01%	0.01%	0.01%	0.00%	0.00%	1,327
Oecusse	0.56%	0.47%	0.35%	0.36%	0.08%	817

It can be seen from Table 3.1 that of the 12 districts in the 7 selected river basins, Liquiçá district has the highest percentage (2.6%) of flood inundation areas with flood depth over 2 meters. The inundated areas with flood depth greater than 2 m in Liquiçá district make up 14.3 km^2 of the area of the district. In Ainaro district, the inundation areas with flood depths less than 0.5 m account for 95.7 km^2 (or 1.1%) of the total 870 km^2.

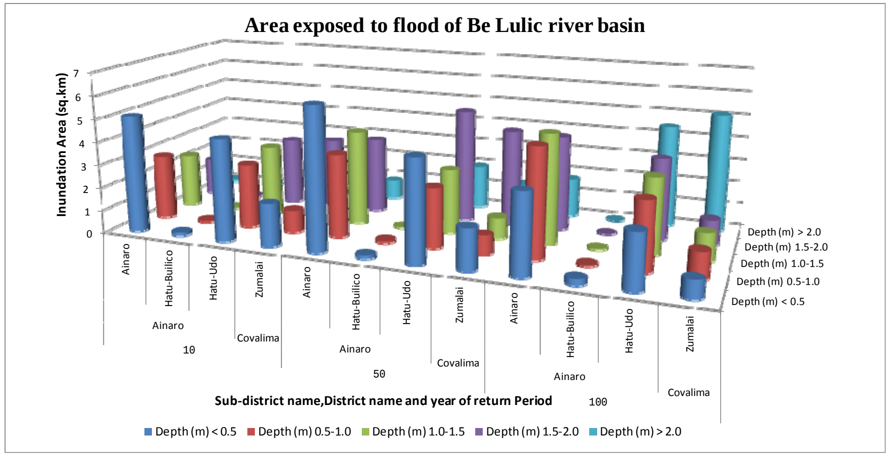

Figure 3.8: Area exposed to flood of Be Lulic river basin in different return period

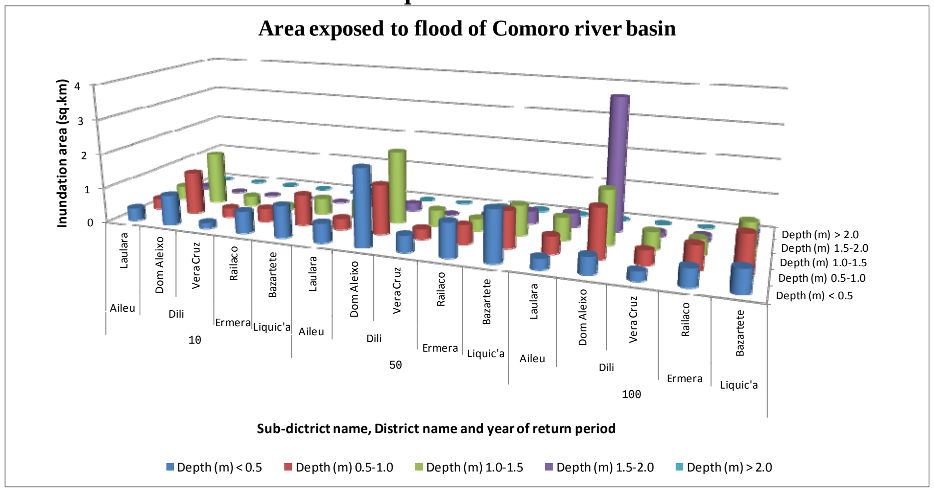

Figure 3.9: Area exposed to flood of Comoro river basin in different return period

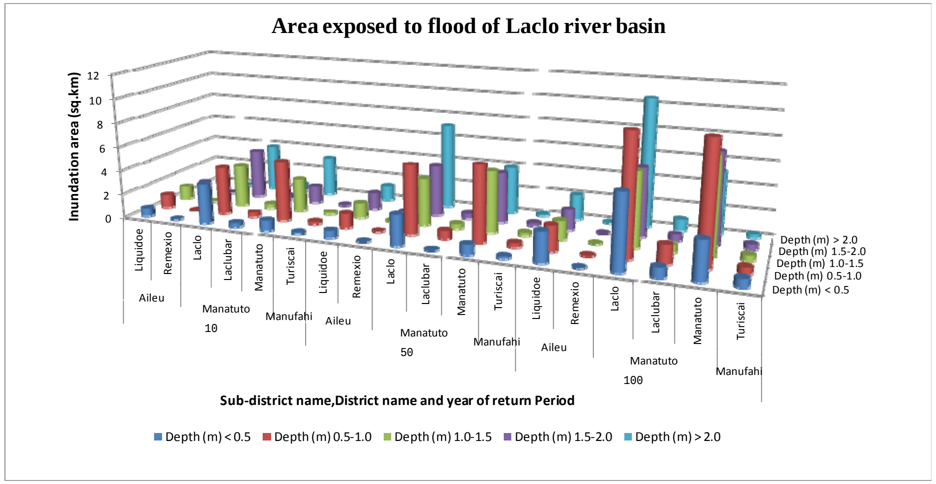

Figure 3.10: Area exposed to flood of Laclo river basin in different return period

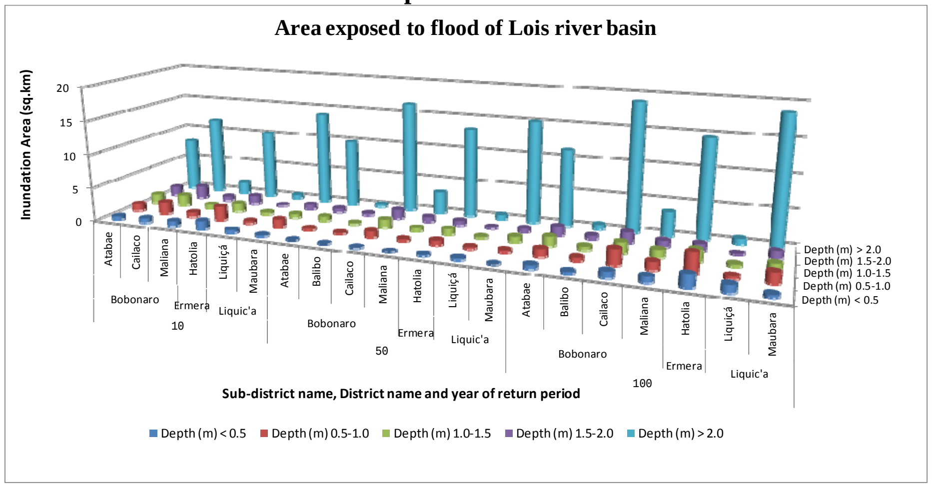

Figure 3.11: Area exposed to flood of Lois river basin in different return period

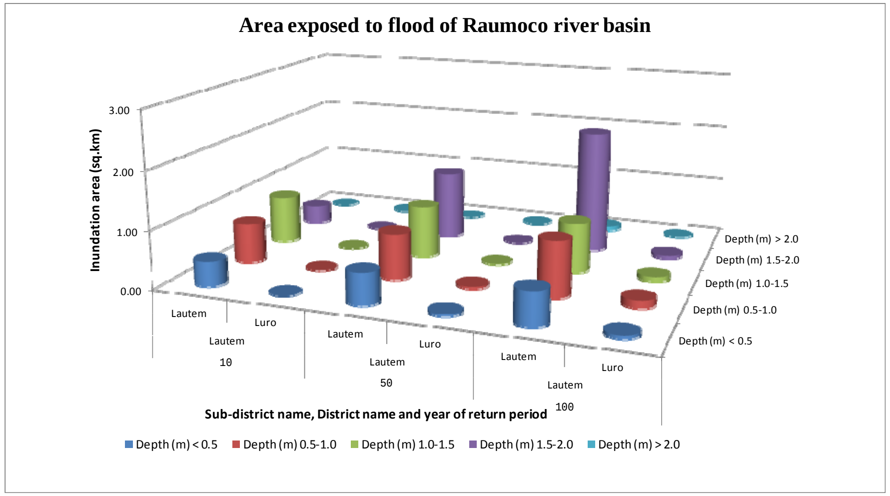

Figure 3.12: Area exposed to flood of Raumoco river basin in different return period

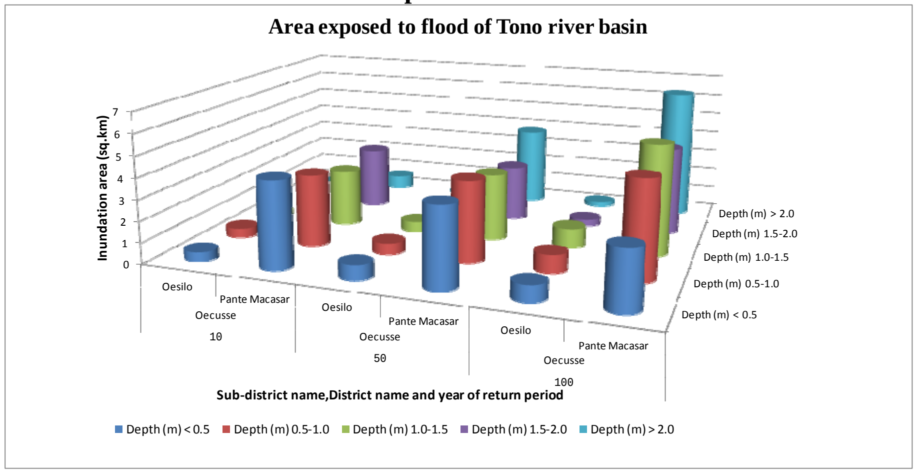

Figure 3.13: Area exposed to flood of Tono river basin in different return period

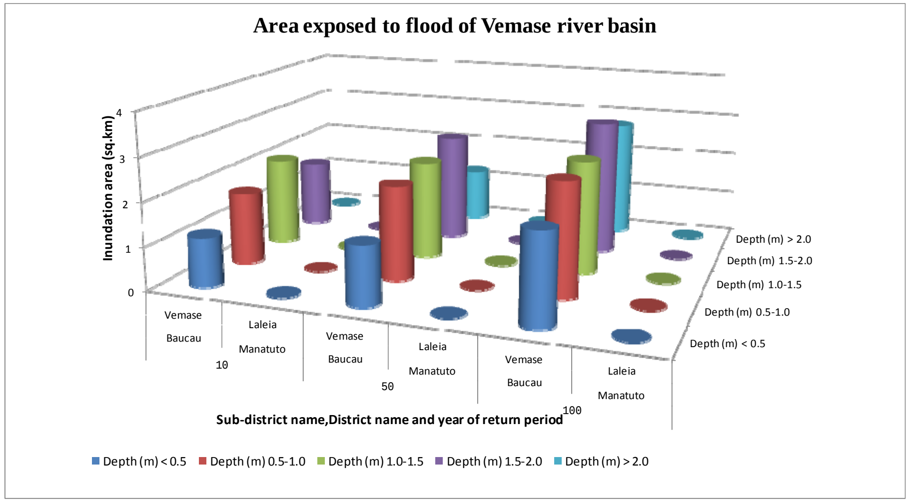

Figure 3.14: Area exposed to flood of Vemase river basin in different return period

3.1.4 Application of Hazard Maps

The flood hazard maps were developed for the following purposes:

- The flood hazard maps can be used by policy makers, decision makers and planners as a basis for future master plans and safe development. Authorities can take necessary actions to reduce the impacts on various economic sectors such as agriculture, housing, tourism, industry and production.
- The flood hazard maps will help the government of Timor-Leste and local authorities to understand the severity of flood hazards in the depicted areas and develop necessary mitigation and preparedness plans.
- The flood hazard maps can help policy makers, decision makers, planners and other parties to plan and implement an effective system of the flood management in Timor-Leste.
- The flood hazard maps will help international and national relief agencies and humanitarian organizations prioritize hazard disaster preparedness and mitigation interventions.
- The Ministry of Agriculture may use these maps to change crop patterns and develop other non-structural measures for reducing the negative impacts flooding has on agriculture.

3.1.5 Recommendations

- Flood hazard assessments for Timor-Leste have been done at the national level for seven priority river basins. Due to the limited access to detailed data and field visits, the results of the flood hazard assessment are limited to the national level. It is recommended that site-specific flood hazard mapping is carried out for local level analysis and more detailed planning.
- Since Timor-Leste is frequently affected by flooding, the national level inundation maps of Timor-Leste should be used for developing more detailed flood inundation maps for the country. The detailed inundation maps will help policy makers, planners, decision makers and related actors to better plan and implement an effective flood management system.
- The current flood hazard maps have been developed for 7 of the most important river basins in Timor-Leste. These river basins are frequently reported to have flooding that affects residents and property.

3.1.6 Special Remarks

- The current flood hazard maps show a broad picture of the area affected by flood inundation at the national level. Whenever possible, it is recommended that site-specific flood hazard mapping using more precise and detailed data is carried out for local level analysis and more detailed planning.

3.2 Landslide

3.2.1 Background

Landslides induced by flooding are reported to be one of the most common disasters in RDTL. The country experienced large-scale landslides in many mountainous areas, especially in Liquiçá district, due to heavy rains brought by La Niña weather patterns from December 2007 to April 2008. A recent landslide in Bobometo village of Oekusi destroyed at least 2 hectares of local farmland and forced the evacuation of 15 families living around the affected area. In Timor-Leste, high occasional rainfall, steep slopes, high weathering rates and slope material with low shear resistance or high clay content are the main preconditions for landslides. A recent analysis of the landslide risk (NDMD, 2010) revealed that the eastern half of the country is highly prone to landslides. Apart from their potential to cause casualties and damage to communities in RDTL, landslides can also cause major disruption to the fragile road network, isolating communities for long durations. Deforestation, vegetation destruction by fire or other sources and inappropriate agricultural activities in RDTL have contributed to creating conditions that make areas prone to landslides.

3.2.2 Map Contents

The landslide hazard maps show spatial distribution of susceptibility zones. The range of zones are negligible, low, medium, high, and very high. Country, district and sub-district boundaries are marked as overlay layers for more detailed spatial distribution. The graph below illustrates the colors that are used to indicate the different susceptibility zones.

Landslide Susceptibility
Very Low
Low
Medium
High
Very High

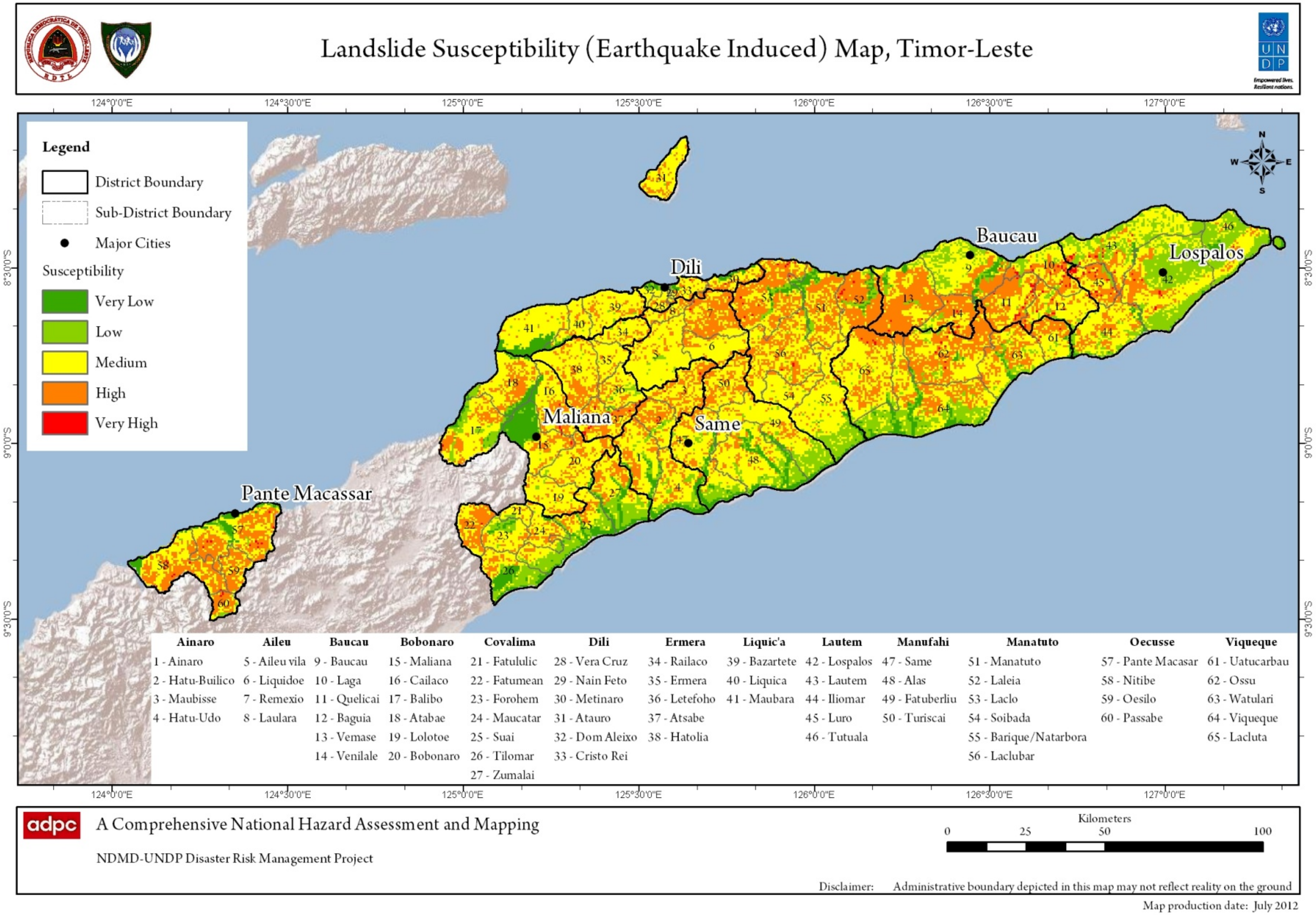

Figure 3.15: Landslide susceptibility (earthquake induced) map of Timor-Leste

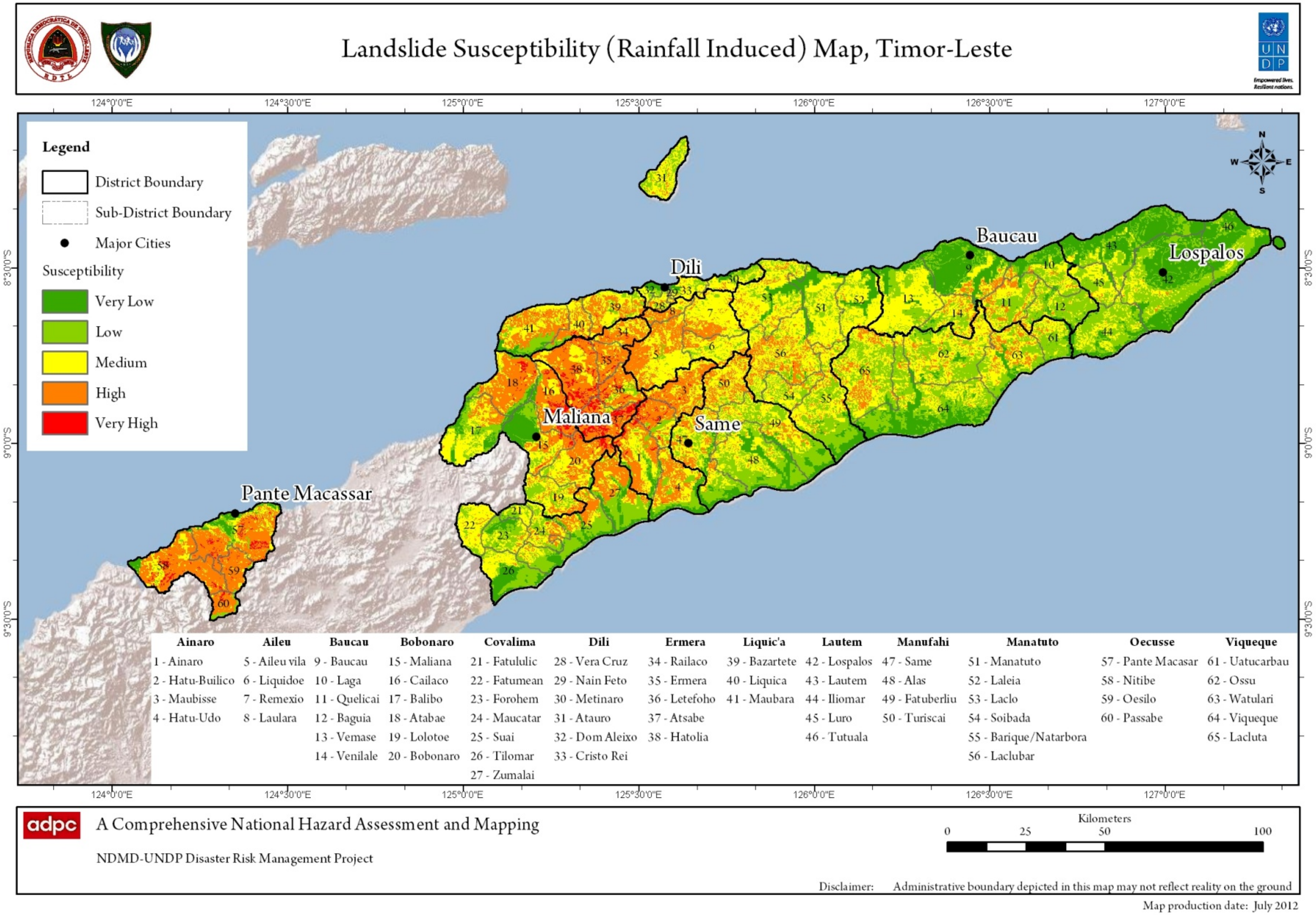

Figure 3.16: Landslide susceptibility (rainfall induced) map of Timor-Leste

3.2.3 Analysis of Hazard Map

Earthquake induced landslide susceptibility map

Earthquake induced landslide susceptibility in Timor-Leste is classified into five zones including very low (negligible), low, medium, high and very high. The study results show that approximately 50 percent of the country falls within medium landslide susceptibility zones, 1 percent falls within very high zones and 29 percent falls within high zones. These very high and high susceptibility zones are located along the eastern and northern coast.

The distribution of landslide susceptibility zones (earthquake induced) in Timor-Leste is presented in Table 3.2

Table 3.2: Percentage of area exposed to landslide (earthquake induced)

District Name	Percentage of area exposed to landslide					Area of District (sq.km)
	Very Low	Low	Medium	High	Very High	
Aileu	0.0%	1.3%	68.9%	29.5%	0.2%	676
Ainaro	7.8%	8.6%	52.9%	30.6%	0.1%	870
Baucau	2.6%	12.5%	40.3%	42.6%	1.9%	1,508
Bobonaro	12.3%	6.2%	56.0%	25.3%	0.3%	1,381
Covalima	13.3%	22.6%	41.9%	22.2%	0.0%	1,207
Dili	7.0%	4.3%	65.9%	22.4%	0.4%	368
Ermera	0.7%	2.3%	65.9%	30.3%	0.7%	771
Lautem	3.5%	37.2%	42.0%	16.0%	1.3%	1,813
Liquiçá	11.1%	3.1%	75.5%	10.3%	0.0%	551
Manatuto	4.3%	9.4%	48.2%	37.7%	0.5%	1,786
Manufahi	8.9%	16.0%	57.8%	17.3%	0.0%	1,327
Oecusse	6.5%	2.8%	39.2%	50.4%	1.1%	817
Viqueque	5.3%	14.5%	45.1%	34.7%	0.4%	1,880

Rainfall induced landslide susceptibility map

Rainfall induced landslide susceptibility in Timor-Leste is classified into five zones, ranging from very low (negligible), low, medium, high and very high. Approximately 33 percent of the country falls within medium landslide susceptibility zones which are spatially distributed evenly across the country. Low and very low zones are located in the lowland area, mostly in the eastern part of Timor-Leste. However, it is important to note that the landslide zone can vary even in the low and very low zones, especially in the rocky area along the coast.

Identification of very high and high susceptibility zones are priority areas for landslide hazard risk assessments. This study reveals that about 2 percent and 23 percent of Timor-Leste is prone to very high and high landslide respectively. These areas are typically located in mountainous regions with relatively soft rock masses that surround harder fragments (hills). High and very high susceptibility zones are prevalent in the western part of Timor-Leste, such as in Bobonaro, Ermera, and Ainaro districts. The distribution of landslide susceptibility zones (induced by rainfall) in the country are presented in Table 3.3

Table 3.3: Percentage of area exposed to landslide (rainfall induced)

District Name	Percentage of area exposed to landslide					Area of District (sq.km)
	Very Low	Low	Medium	High	Very High	
Aileu	0.0%	6.6%	56.7%	36.6%	0.1%	676
Ainaro	7.1%	12.3%	30.4%	46.7%	3.5%	870
Baucau	24.6%	33.2%	34.4%	7.7%	0.0%	1,508
Bobonaro	11.4%	15.6%	31.0%	37.7%	4.2%	1,381
Covalima	15.4%	37.8%	30.2%	16.5%	0.1%	1,207
Dili	9.5%	30.5%	52.7%	7.4%	0.0%	368
Ermera	0.3%	2.5%	19.3%	63.8%	14.1%	771
Lautem	47.7%	38.1%	13.7%	0.5%	0.0%	1,813
Liquiçá	4.8%	15.1%	38.5%	41.0%	0.6%	551
Manatuto	10.2%	25.5%	53.1%	11.3%	0.0%	1,786
Manufahi	12.4%	37.2%	35.4%	14.9%	0.1%	1,327
Oecusse	6.0%	6.5%	15.5%	67.1%	4.8%	817
Viqueque	14.5%	40.6%	34.9%	10.0%	0.0%	1,880

3.2.4 Application of Hazard Maps

- The maps will help planning and development agencies when carrying out physical and social development in hazard prone areas.
- The maps will help the department to focus on landslide disaster-prone areas and seek cooperation with various other response agencies and departments for better disaster preparedness.
- The maps will help to identify the sites for structural and non-structural mitigation projects. The maps will help in prioritizing site-specific studies and mitigation interventions.

3.2.5 Recommendations

- Analysis of parameters related to landslide susceptibility is necessary to create a rating system (either qualitative or quantitative) by Timor-Leste landslide experts. This rating system could be used to analyze susceptibility for the whole of Timor-Leste.
- More detailed analyses on high and very high susceptibility zones are recommended in the context of transportation infrastructure.
- In relation to precipitation and flood, a dynamic model for landslides should be developed for Timor-Leste. Due to landslide occurrence that is closely related with specific rainfall periods, the threshold of a precipitation-triggered landslide can be a vital help in disaster risk management.

3.2.6 Special Remarks

Landslide susceptibility assessment involves a high level of uncertainty due to data limitations. A landslide inventory database for Timor-Leste does not exist for the whole country. A specific rating system for landslide susceptibility in Timor-Leste also has not been developed. For these reasons, this landslide susceptibility assessment used a semi-quantitative rating system.

3.3 Coastal Erosion

3.3.1 Background

The coastal zone is the dynamically active interface between land and water. At this interface, the energy of waves, tidal currents and the wind interact with the geo-morphological structure and beach sediments through processes of erosion, transport and deposition. Coastal erosion in particular, if excessive, could result in significant economical losses, social problems and ecological damage. However, estimation of coastal sediment transport rates is quite complex since many effects have to be integrated such as the co-existing wave-current environment, variations in the mean water level (tide, set-up and set-down), cross-shore and alongshore components, breaking wave effects (turbulence and undertow), bathymetric influence (mean slope and bed forms) as well as other geomorphic influences. The total length of the coastline of Timor-Leste is about 780 km, of which about 300 km belongs to the south coast and the remainder is mostly in the north. The coastal areas experience two monsoonal wind wave climates with predominantly southwest to northwest winds during October-March and northeast to southeast during April-September, besides the persistent swell.

3.3.2 Map Contents

The hazard map depicting the relative susceptibility of the coastline of Timor-Leste to erosion is shown in Figure 3.17. The relative susceptibility to beach erosion is classified on this map as low, moderate and high using three color bands for easy reference and contrast.

Table 3.4: The classification of RES (Relative Erosion Susceptibility) Index.

RES Index	Relative Classification	Color code	Length of coast (km)
≤ 3	Low		187
> 3 to ≤ 7	Moderate		362
> 7 to 10	High		231

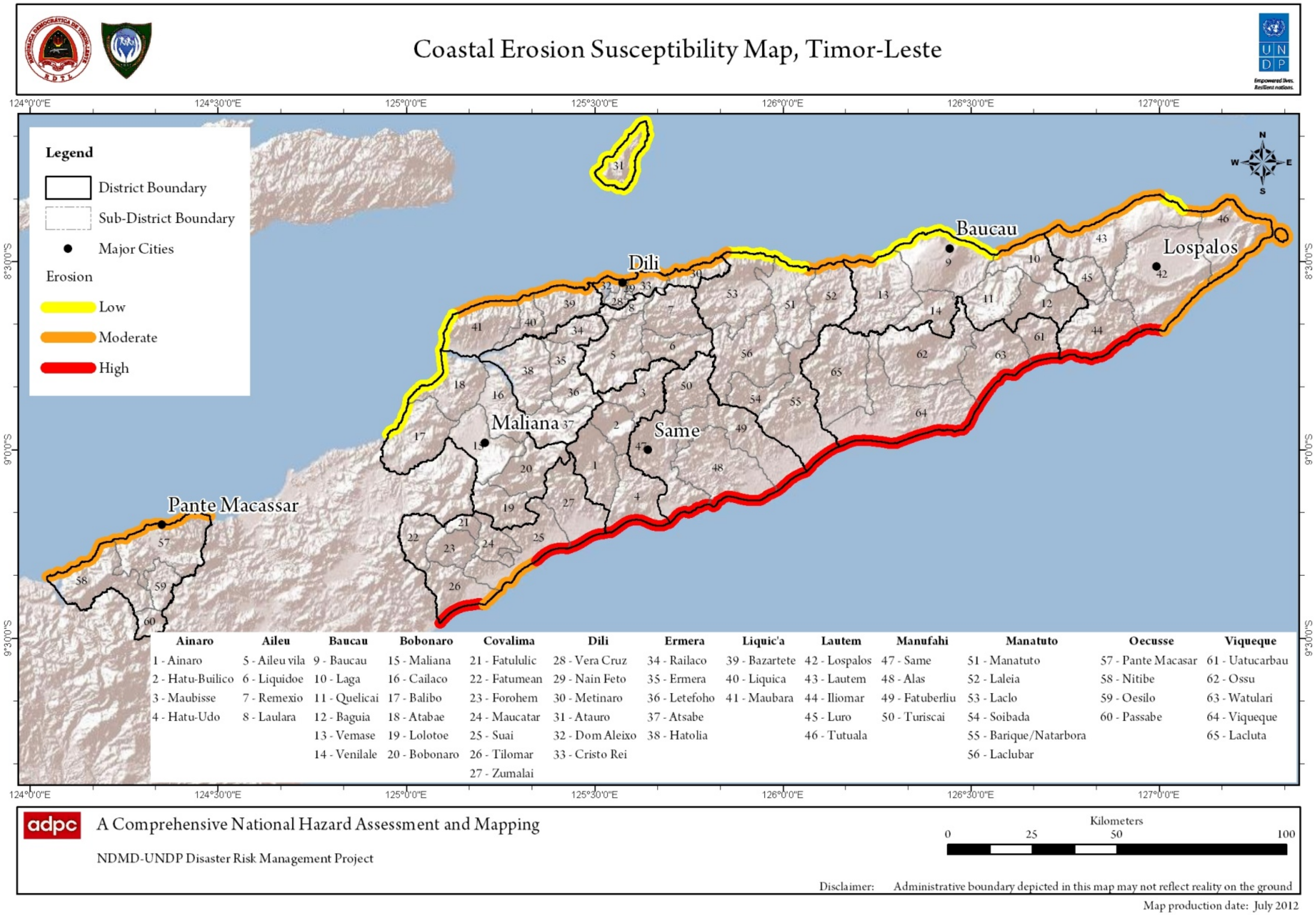

Figure 3.17: Coastal erosion susceptibility map for Timor-Leste

3.3.3 Analysis of Hazard Map

The present analysis provides a broad picture and a general understanding of the relative susceptibility of Timor-Leste's coastline to beach erosion. The stretches of the coast with the highest erosion hazard ranking (i.e., high) is concentrated mostly along the south coast which is exposed to higher waves compared to the north coast. Comparatively, the north coast is comprised of stretches belonging to both low and moderate levels of erosion hazard.

This hazard map provides an indication of the potential susceptibility of the coastline to erosion in a relative and spatially-averaged sense, and therefore, the current erosion rates at some stretches may not necessarily be the same as those indicated here. Furthermore, this study provides erosion susceptibility at the national level considering the average conditions for each coastal sector, however, there can be inner-cell variations at a more local scale. Accordingly, the classification given in the present assessment provides a means for identifying coastal reaches with the most potential for high erosion susceptibility; however, this will not be a substitute for site-specific field studies and monitoring programmes.

Figure 3.17 describes the stretches of the coast of Timor-Leste with different levels (low, moderate and high) of susceptibility to coastal erosion. Table 3.5 shows the percentages of the coastline in each district by susceptibility to coastal erosion, where 100% of the coastlines in Aileu,Manufahi and Viqueque District fall within the high zone.

Table 3.5: Percentage of shoreline length exposed to coastal erosion

District Name	Percentage of length of shoreline exposed to coastal erosion			Total length (km)
	Low	Moderate	High	
Aileu	0.0%	0.0%	100.0%	21
Baucau	62.1%	37.9%	0.0%	67
Bobonaro	100.0%	0.0%	0.0%	33
Covalima	0.0%	36.3%	63.7%	58
Dili	55.1%	44.9%	0.0%	102
Lautem	5.1%	74.7%	20.2%	172
Liquiçá	19.9%	80.1%	0.0%	58
Manatuto	47.6%	29.3%	23.1%	52
Manufahi	0.0%	0.0%	100.0%	46
Oecusse	0.0%	100.0%	0.0%	55
Viqueque	0.0%	0.0%	100.0%	75

3.3.4 Application of Hazard Maps

This erosion hazard map can be used as a tool at the national level to assist in coastal development planning, to prioritize the allocation of resources for coastal erosion mitigation, as well as to educate the general public about beach erosion and associated impacts. This map, and the information presented therein, is not a legal document and should not be used for any regulatory purposes.

3.3.5 Recommendations

There are a number of uncertainties in the estimation of coastal areas susceptible to erosion, such as those involving potential short-term erosion associated with decadal coastal fluctuations, long-term erosion trends associated with changes in coastal processes and the potential impact of sea level rise on coastal erosion. Moreover, availability of necessary data for Timor-Leste is rather sparse at present, and therefore, this assessment should be refined using more detailed data as well as through field validation. It is also necessary to study and delineate erosion trends and transport rates based on historical coastal morphological evolution, for example, by using high resolution, multi-temporal satellite imagery and other remote sensing data and tools.

3.3.6 Special Remarks

One of the key limitations of this study was a lack of sufficiently high resolution data for factors influencing coastal erosion and the unavailability of GIS layers for coastal landforms in regard to Timor-Leste. Therefore, the available data with regard to each factor and corresponding attributes had to be utilized..

3.4 Strong Wind

3.4.1 Background

A storm is any disturbed state of an astronomical body's atmosphere, especially affecting its surface and strongly implying severe weather (en.wikipedia.org/wiki/Storm). According to the World Meteorological Organization (WMO), storms are categorized according to wind speed. For example, tropical depressions range from 0-62 km/hr while category 3 storms range from 178-209 km/hr. According to this international standard of storm classification, the storms that affect Timor-Leste are tropical storm. The storm tracks of past events from 2000 to 2012 are shown in Figure 3.18.

Timor-Leste is situated in a cyclone belt where increased storm activities can be expected. Besides cyclones, Timor-Leste is affected annually by tropical storms. These tropical storms can be as devastating as a cyclonic activity as they can deposit extremely high amounts of rainfall in a short time period. Tropical cyclones can affect Timor-Leste between November and April; however their effect tends to be weak. In the 41-year period between 1969 and 2010, 31 tropical cyclones passed within 400 km of Dili, an average of less than one cyclone per season (PCCSP, 2011).

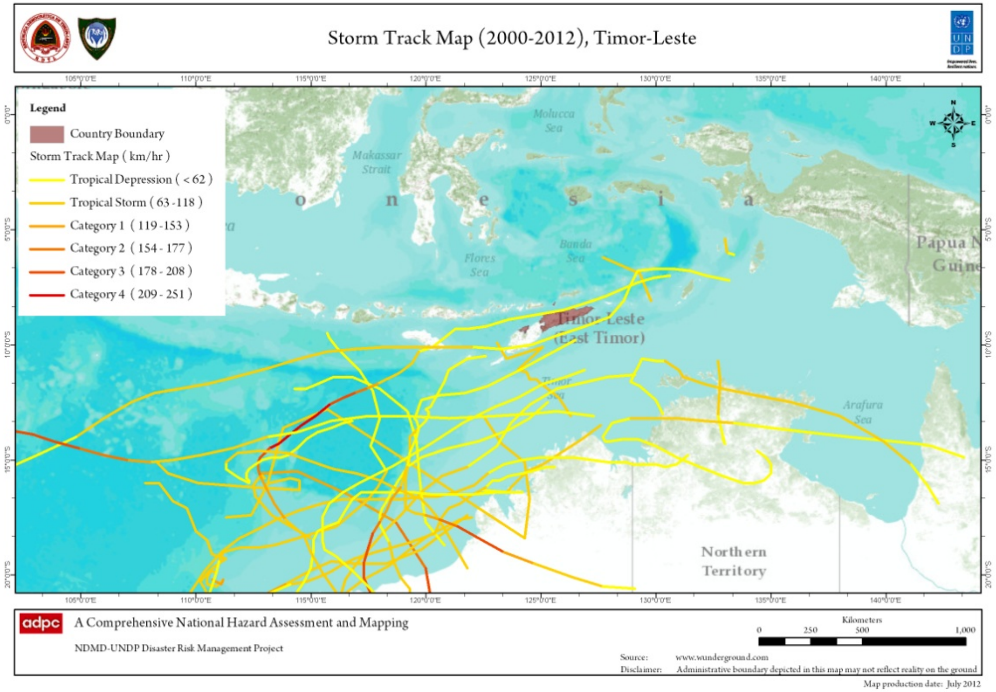

Figure 3.18: Storm track of past events from year 2000 to 2012

Category	Wind speed mph (km/h)	Storm surge ft (m)
Five	≥ 156 (≥ 250)	> 18 (> 5.5)
Four	131-155 (210-249)	13-18 (4.0-5.5)
Three	111-130 (178-209)	9-12 (2.7-3.7)
Two	96-110 (154-177)	6-8 (1.8-2.4)
One	74-95 (119-153)	4-5 (1.2-1.5)
Additional classifications		
Tropical storm	39-73 (36-117)	0-3 (0-0.9)
Tropical depression	0-38 (0-62)	0 (0)

Figure 3.19: WMO Scale adopted from Saffir-Simson

3.4.2 Map Contents

The current storm track and expected return period maps were developed based on data available from a storm/typhoon-related international agency called the NCEP FNL. The map shows the distribution of intensity throughout the country. The maps were prepared for 10, 50 and 100 year return period.

The strong wind hazard maps were developed with 10, 50, and 100 year return period. Country, district and sub-district boundaries were demarcated for detailed susceptibility in specific regions. The colors designated for the specific wind speed ranges are shown below.

Color Code	Wind speed (km/hr)
	Less than 62 km/hr
	62 – 65 km/hr
	65 – 75 km/hr
	75 – 85 km/hr

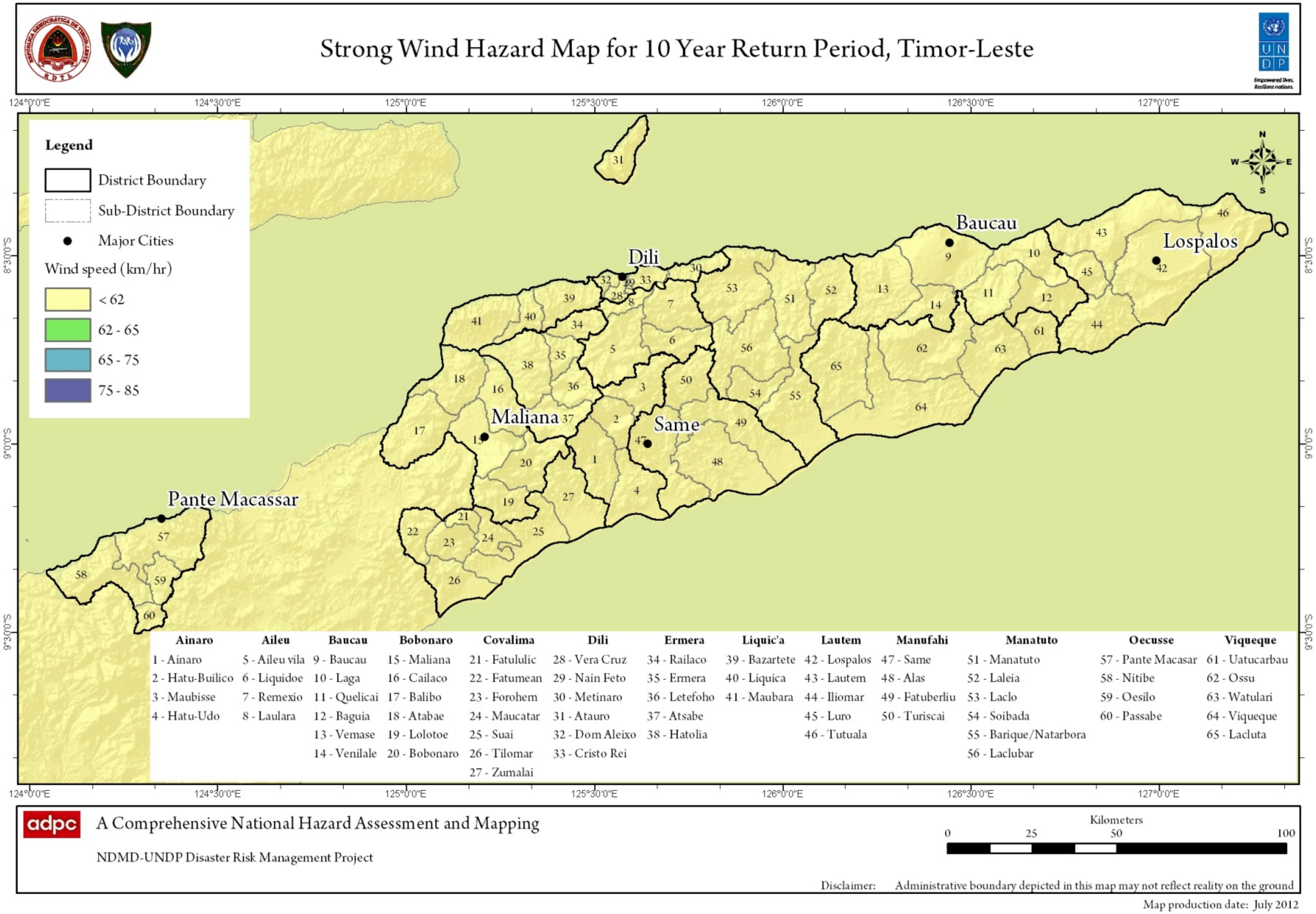

Figure 3.20: Strong wind hazard map for 10 year return period for Timor-Leste

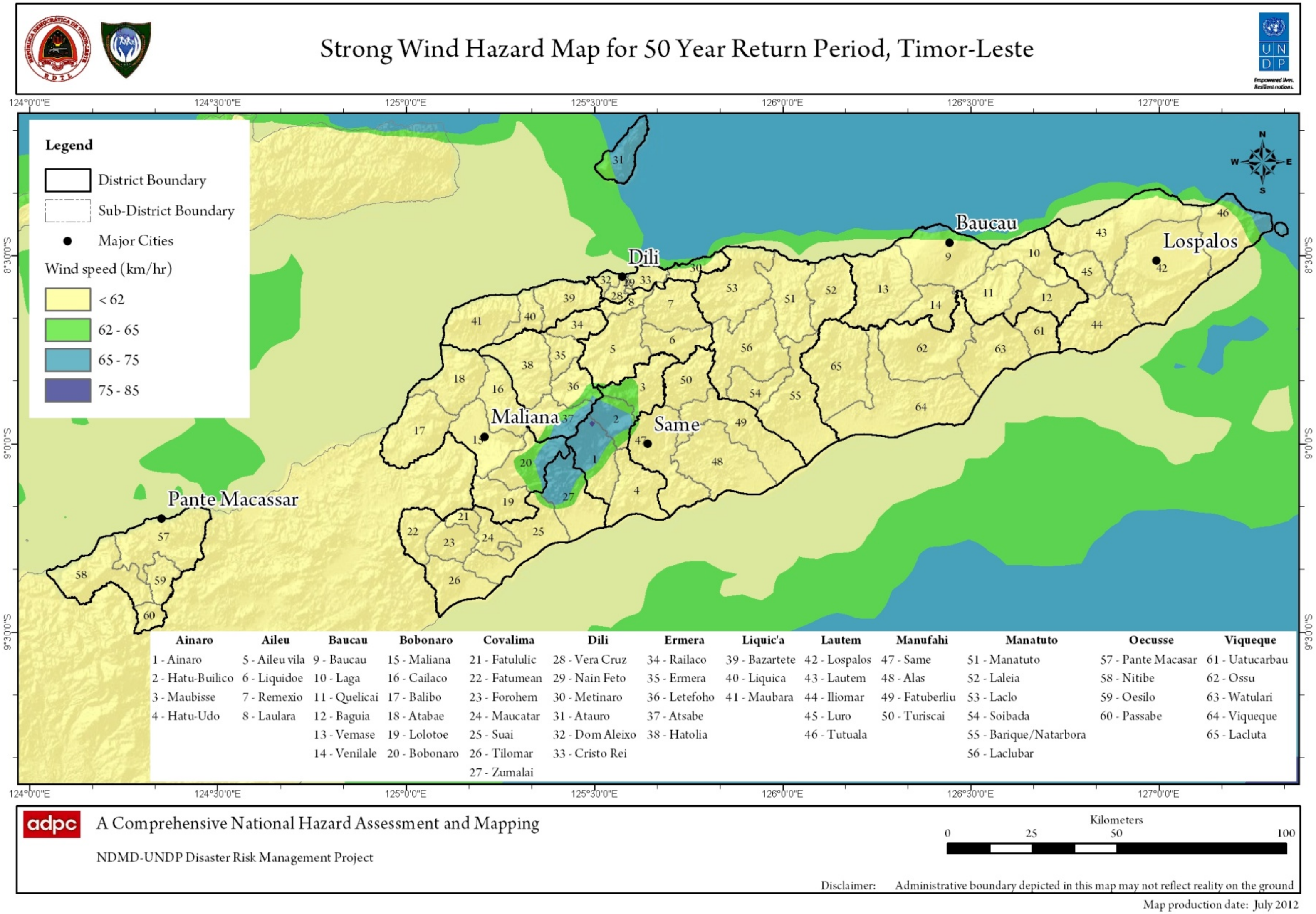

Figure 3.21: Strong wind hazard map for 50 year return period for Timor-Leste

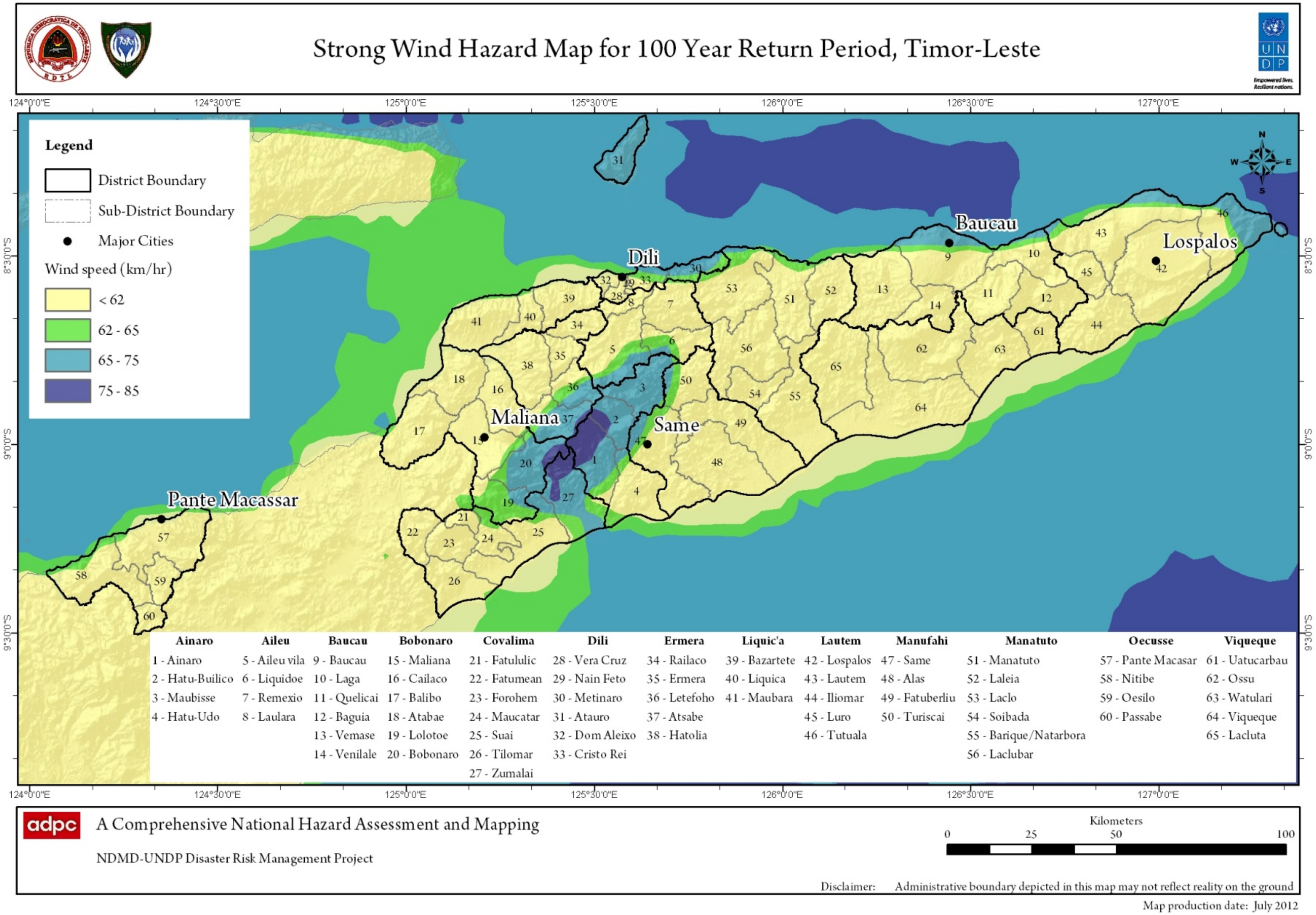

Figure 3.22: Strong wind hazard map for 100 year return period for Timor-Leste

3.4.3 Analysis of Hazard Map

The strong wind hazard maps depict the areas of possible maximum ground wind speeds over the country. The analysis of strong wind hazard maps were carried out by organizing the wind speeds into four categories (i.e. <62, 62-65, 65-75 and 75-85). The district boundaries were also added to the maps. The strong wind hazard maps were prepared for 10 year, 50 year and 100 year return periods. The table below summarizes the percentage of area exposed to strong winds for the 100 year return period for different districts.

Table 3.6: Percentage of area exposed to strong wind for 100 year return period

District Name	Percentage of area exposed to each wind speed (km/hr)				Area of District (sq.km)
	< 62	62-65	65-75	75-85	
Aileu	83.2%	13.2%	12.6%	0.0%	676
Ainaro	22.2%	10.6%	45.4%	14.1%	870
Baucau	91.3%	0.0%	8.5%	0.1%	1,508
Bobonaro	72.5%	10.6%	15.1%	1.3%	1,381
Covalima	72.3%	8.9%	10.5%	8.0%	1,207
Dili	25.0%	19.9%	54.8%	0.0%	368
Ermera	69.3%	11.4%	18.2%	0.7%	771
Lautem	84.2%	3.2%	11.8%	0.8%	1,813
Liquiçá	94.1%	5.5%	0.0%	0.0%	551
Manatuto	95.5%	4.0%	0.3%	0.0%	1,786
Manufahi	90.0%	4.8%	4.9%	0.0%	1,327
Oecusse	92.4%	5.3%	1.8%	0.0%	817
Viqueque	99.5%	0.4%	0.0%	0.0%	1,880

3.4.4 Application of Hazard Maps

Storm maps were developed on a national scale for Timor-Leste. Storm-prone areas were delineated at the district and sub-district levels based on the return period of past events. The storm maps were developed for several purposes: (should add one sentence in combining hazard, vulnerability and risk assessment)

- Storm maps will be helpful when making decisions about physical and infrastructural development in the country. The map will help policy makers and decision makers understand the severity of potential storms and take necessary action to sustain the development through the introduction of necessary programs and measures.
- All the map results will be useful for the planning and design department to make decisions. These maps could provide a basis for the government to predict storms and estimate storm-related disaster damage.
- Education, health, housing, lifelines and transportation sectors need special attention for storm safety. The storm zones will provide understanding about expected performance of structures during storms and necessary measures to protect these structures.
- The zones will further help the local urban government to introduce and enforce building bylaws and building codes to protect urban infrastructure.
- The map will help national and international NGOs prioritize DRR strategies.

3.4.5 Recommendations

- The cyclone hazard maps could be improved by increasing the number of storm events used in the probabilistic analysis. More storm events (at least 40-50 events) should be included in the analysis to represent the population of the storm. Finer spatial resolution of WRF model outputs reflecting the local topographic and orographic effects, such as a 5 km or 3 km grid size, could improve the accuracy of the cyclone hazard map. For instance, coarse spatial scale cannot take the impacts of mountain or mountain ranges into account but the finer spatial scale will resolve this problem. In addition, it is important to validate the WRF simulated wind speed with the observed wind speed to check how good the numerical simulated outputs are. It is also important to utilize higher number of observe data to validate the results. Once the discrepancy is estimated then the bias correction can be carried out to improve the simulated wind speed.

- Whenever more detailed data is available in Timor-Leste, it is recommended that detailed studies and mapping of specific locations where storms are most likely to take place are carried out based on the results and methodology mentioned above.

3.4.6 Special Remarks

- These storm hazard maps for Timor-Leste are intended for use in disaster risk mitigation planning, evacuation planning and in public education and awareness activities only. These maps, and the information presented therein, are not legal documents and should not be used for any regulatory purpose.