United Nation Development Program
Papua New Guinea

Developing a Comprehensive Hazard Profile for East Sepik, Madang, Morobe, New Ireland and Northern Provinces in Papua New Guinea

Inception Report

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Abbreviations

Abbreviation	Expanded Form
UNDP	United Nations Development Programme
OCCD	Office of Climate Change and Development
PNG	Papua New Guinea
DRM	Disaster Risk Management
GIS	Geographical Information System
HEC-RAS	Hydrologic Engineering Centre's River Analysis System
NRIS	National Risk Information System
FEMA	Federal Emergency Management Agency
SRTM	Shuttle Radar Topography Mission
LULC	Land Use Land Cover
PSHA	Probabilistic Seismic Hazard Analysis
VRG	Variable Grid Resolution
URG	Uniform Resolution Grid

Executive Summary

Papua New Guinea, a South Pacific island country, is prone to multiple natural disasters including earthquakes, river and coastal flooding, coastal erosion, volcanic eruptions, tsunamis, cyclones, landslides, droughts and frost. According to a study, PNG ranks as one of the most disaster prone countries in the region comprising 26 Asia-Pacific countries.

These natural disasters have consistently affected key sectors of the national economy such as agriculture, infrastructure and community livelihoods. The social and economic consequences are multiplied due to the high levels of vulnerability of people due to lack of infrastructure, low human development indicators, and a high population growth rate. A major factor in increasing the population's vulnerability is the extreme isolation of large parts of the country. The capital city is still not connected by road to most of the country and the range of communication, including radio, is extremely limited[1].

The main objective of this assignment is to assist the Project Management Unit develop a comprehensive hazard profile that covers all major hazards prevailing in East Sepik, Madang, Morobe, New Ireland and Northern Provinces with a focus on coastal and inland flooding which are likely to exacerbate due to climate change. The hazard profile would specially take note of coastal and inland flooding in the provincial capitals of Wewak (East Sepik), Madang (Madang), Lae (Morobe), and Kimbe (West New Britain). The five pilot provinces have been identified as most vulnerable to climate change-related coastal and inland flooding (OCCD, 2010). Hazard maps developed as part of this study will help identify the risks from coastal and inland flooding in these provinces, particularly to verify the level of vulnerability of the communities or regions.

To accomplish this objective, the OCCD and UNDP commissioned RMSI to undertake this study to assist the Government of PNG in determining the comprehensive hazard assessment arising from natural hazards, specifically coastal flood, inland flood, and earthquake, and integrating the hazard data, models and maps into the most appropriate National Hazard Risk Information System. In addition, the study aims to enhance national capabilities for risk assessment/data integration and dynamic mapping by engaging key planners, policy and decision makers, as well as the national technical institutions and professionals throughout the project implementation and beyond.

The present 'Inception Report' is the first deliverable of this assignment and elaborates the approach and methodology finalized for the study, the key deliverables and the timelines based on the interactions and as agreed during the discussions and consultations at Inception workshop with all the relevant organizations and other stakeholders.

Hazard assessment and mapping will emphasize on the severity, frequency and geographical extent of inland and coastal flood hazards. Our approach for hazard mapping and assessment is based on the application of international best practices of probabilistic hazard assessment and adapting them to local conditions in consultation with engagement of key stakeholders in project activities. Information dissemination and capacity building through training and workshops is also a key component of the project activity.

Methodology for Inland Flooding: Floods are, in general, caused due to excess or intense rainfall over a region. The RMSI team shall consider the impacts of such rainfall episodes on the major river basins at each of the five provinces together with the presence of various storage structures and considering the existing flood mitigation approaches in assessing the riverine (inland) flood hazards. Flood hazard assessment shall identify and demarcate areas,

[1] http://www.undp.org.pg/docs/publications/DM%20Country%20Report.pdf
http://gfdrr.org/ctrydrmnotes/PapuaNewGuinea%20.pdf

which are currently exposed to floods. The relevant information on the extent and depth of flooding throughout flood prone areas for a range of flood magnitudes would be inferred and presented. The team will use the Hydrologic Engineering Centre's River Analysis System (HEC-RAS), which has the capacity to model flood extent, flood depths and flood velocity, using 1D hydraulic modeling through the river system for historical as well as potential return period events.

Methodology for Coastal floods: Coastal flood hazard assessment shall identify and demarcate areas, which are currently exposed to high tides along the coastlines. It will provide information on the extent and depth of flooding throughout flood prone areas for a range of flood magnitudes. Based on high tidal amplitudes for a particular coastal stretch, RMSI team will identify the particular timeframe when the maximum tide occurs. Analysis would also be carried out to assess the plausible changes in these magnitudes in a warmer atmosphere for the future. These extreme tidal levels will be mapped on coast to understand the spatial extent and temporal distribution of frequency and intensity of extreme tidal waves. The total surface water levels and the inundation extent will be computed as a linear addition of extreme tidal amplitudes. The flood extent maps will be generated for various ranges of tidal amplitude varying from low and moderate to high as one of final product under the assignment.

Exposure Data Collation: RMSI project team will collate all available data on exposure elements such as buildings, infrastructure, critical facilities, demographics, and livelihood collected from various government departments with the support of OCCD and UNDP. As exposure data development is not part of the scope of the present study, the team will rely on the existing exposure maps/GIS data available for the study area. RMSI, with the support of OCCD and UNDP, will interact with the provincial administrations to collect required data on exposure elements. The acquired data and its integration into maps generated in GIS format will be further reviewed for their integration in exposure data development and overlaid with the hazard data developed for the provinces under study.

Data Validation and Consultations: RMSI project team will present the findings of the hazard profiling and assessment before the key stakeholders in the workshop for validation and consultations. Prior to presenting the results to key stakeholders, these will be shared with selected technical team from stakeholder organizations and the products developed by RMSI would be carefully reviewed for their utility and integration in their ongoing and future activities.

Capacity Building and Information Dissemination: The capacity assessment of stakeholders will consider both government institutions and social organizations. The information dissemination will be through province level consultation, training and workshops. Outcomes of study shall be appropriately disseminated through workshops to all the stakeholders. During the training sessions, RMSI will deliberate and illustrate to the key stakeholders (who shall take up the identified hazard modeling investigations as part of their ongoing responsibility in respective organizations) the approaches followed for model development and applied for the hazard assessment.

1 Introduction

1.1 Study Background and Area of Interest

Papua New Guinea (PNG) is a South Pacific island country. It is bound by the Gulf of Guinea and the Coral Sea to the south, Indonesia to the west, the Solomon Sea to the east, and the Bismarck Sea to the northeast. PNG comprises the eastern half of New Guinea Island, four additional islands (Manus, New Ireland, New Britain, and Bougainville) and about 600 smaller islets and atolls to the north and east. The country lies between latitudes 0° and 12°S, and longitudes 140° and 160°E. Being close to the equator, the country falls within the equatorial humid tropical region. Rainfall varies across the country and is at its heaviest in the highlands to the west where the mean annual precipitation is around 9,000 mm, while it is less than 1,000 mm in Port Moresby, the capital and largest city of PNG.

The country is prone to multiple natural disasters including earthquakes and volcanic eruptions, tsunamis, riverine and coastal flooding, landslides, droughts, coastal erosion, cyclones and frost. According to a study, PNG ranks as one of the most disaster prone countries in the region comprising 26 Asia-Pacific countries. Section 1.3 discusses the hazards considered under this study and the ensuing vulnerabilities in more detail.

These natural disasters have consistently affected key sectors of the economy such as agriculture, infrastructure and community livelihoods. The social and economic consequences are multiplied due to the high levels of vulnerability of people due to lack of infrastructure, low human development indicators, and a high population growth rate. A major factor in increasing the population's vulnerability is the extreme isolation of large parts of the country[2].

PNG has limited capacities and has followed separate strategies to respond to these disasters. In this regard, there is a need to develop a proactive approach by integrating disaster mitigation into development planning. Besides this, it is also important that policy making and development plans need to take account of both physical measures to reduce adverse impacts (such as construction of dykes and other preventive measures against inundation for protecting infrastructures and life) as well as comprehensive disaster preparedness plans, for identified provinces which are at risk of consequences of climate change, to reduce vulnerability to community livelihood.

The joint initiative of United Nations Development Programme (UNDP) and the Office of Climate Change and Development (OCCD) as part of the project on 'Enhancing Adaptive Capacity of Communities to Climate Change-related Floods in the North Coast and the Islands Regions of PNG' aims at addressing these problems. The project aims at conducting an initial hazard analysis for five selected pilot provinces mentioned below. The study involves the creation of hazard maps in proper GIS formats, which can be readily integrated into a National Risk Information System.

The study area includes the five pilot provinces of PNG, namely, East Sepik, Madang, Morobe, New Ireland and Northern Province, that are located along the North Coast and the Island Regions of PNG (Figure 1-1), and which are mainly vulnerable to the flood (inland and coastal) hazards.

[2] http://www.undp.org.pg/docs/publications/DM%20Country%20Report.pdf
http://gfdrr.org/ctrydrmnotes/PapuaNewGuinea%20.pdf

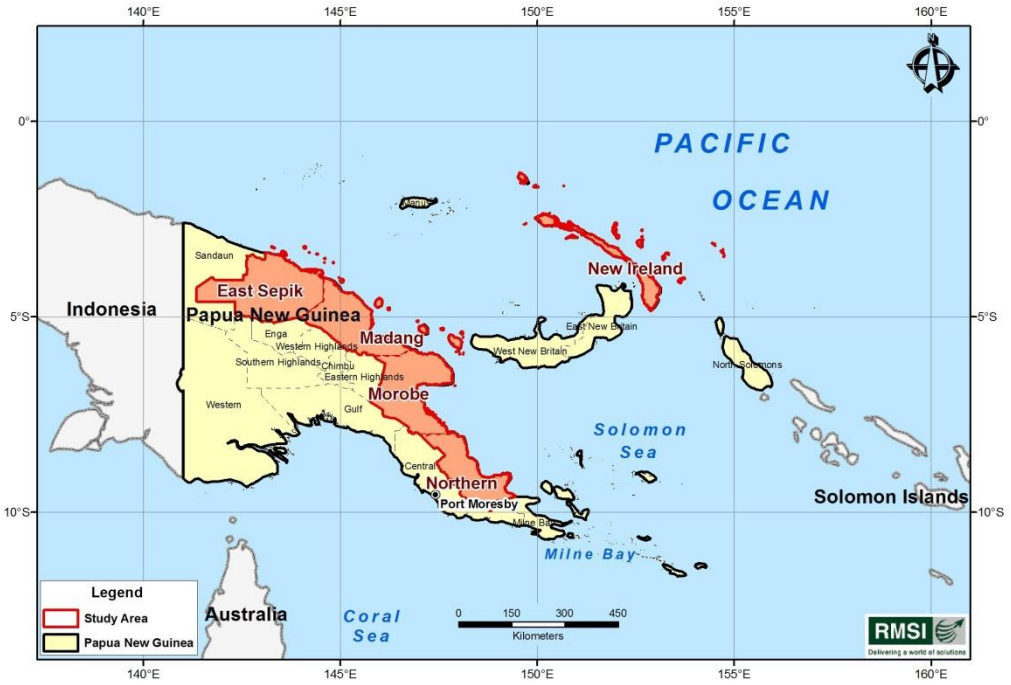

Figure 1-1: Study area showing the five pilot provinces of Papua New Guinea

1.2 Objectives of the Study

OCCD and UNDP has commissioned RMSI to undertake this study with the objective of assisting the Government of PNG in carrying out a comprehensive hazard assessment arising from coastal and inland floods and other hazards which have a potential to exacerbate due to climate change for the five identified provinces, and in development of hazard data, models and maps for its integration into a suitable National Hazard/Risk Information System. The hazard maps will help analyze the levels of vulnerability of the communities or regions identified in the project. These hazard maps are intended to serve as inputs to the detailed risk assessment followed by mitigation planning exercises in these provinces with the view of enhancing national capabilities.

1.3 Current Situation in the Pilot Provinces

As already stated above, PNG is highly prone to a host of natural hazards putting PNG's economic development and social well-being at risk. This is an increasingly accepted view now that climate variability and change has the potential to exacerbate the intensity and frequency of some of the weather related hazards (in addition to the earthquake hazard historically prevalent in East Sepik, Madang, Morobe, and New Ireland). The impacts of climate extremes and climate change can already be seen in PNG especially on coastal flooding due to very high tides and the resulting coastal erosion/sedimentation, inland flooding, increased prevalence of epidemics, degradation of coastal ecosystems (damage to coral reefs), and affecting community livelihoods by forcing them to migrate to urban areas.

Inland and Coastal Flooding: Every year floods cause heavy financial national losses due to damage to buildings and critical infrastructure, and agricultural crops in PNG. Floods also disrupt businesses and often lead to outbreaks of epidemics. Flood is the second most severe hazard in terms of the population affected. It affects about 22 % population on an average annual basis. The country has experienced about 12 flood events in the past 33 years, some of the notable events being in 1983, 1992, 1993, 1999, 2004, 2005, 2006, 2012, and 2013. This translates in a return frequency of once in three years. Damages from floods are reported to be around USD 57 million on an average annual basis.

Extreme tides associated with stronger wave actions and sea level rise are resulting in expansion of inundation in low-lying coastal areas. Consequently, saltwater intrusion is also affecting the groundwater particularly in the coastal areas where it negatively affects agriculture and drinking water supplies. This leads to agricultural losses and erosion of shorelines along the coastal regions of PNG, particularly the provincial capitals of East Sepik (Wewak), Madang (Madang), Morobe (Lae), and West New Britain (Kimbe).

Flooding is most common on low-lying flood plains near rivers. Inundation due to prolonged and intense spells of rainfall during the wet season often causes severe impacts in low-lying areas where they damage crops, road crossings, culverts, bridges and urban drainage infrastructure. The analysis of the hazard's occurrences in PNG indicates that inland and coastal floods are the major hazard in the five provinces, namely, East Sepik, Madang, Morobe, New Ireland and Northern Provinces.

Earthquakes: The provinces of East Sepik, Madang, Morobe, and New Ireland in PNG are being affected historically with regular and yet unpredictable occurrences of earthquakes because of high seismicity in this region. Over the past 25 years, PNG has had more than 500 earthquake-related fatalities. The Mw 7.1 earthquake of July 17, 1998 struck the north coast region near Aitape triggering a large undersea landslide that caused a devastating tsunami with almost 2,200 deaths. The April 1, 2007 Mw 8.1 earthquake created about one meter uplift due to tectonic movement. Figure 1-2 shows the epicentral distribution of historical earthquakes (Mw greater than or equal to 5.0) in and around Papua New Guinea. A review of historical earthquakes reveals that strong to severe earthquakes have occurred in and off the coast of the country causing great losses to human life, buildings, and infrastructure.

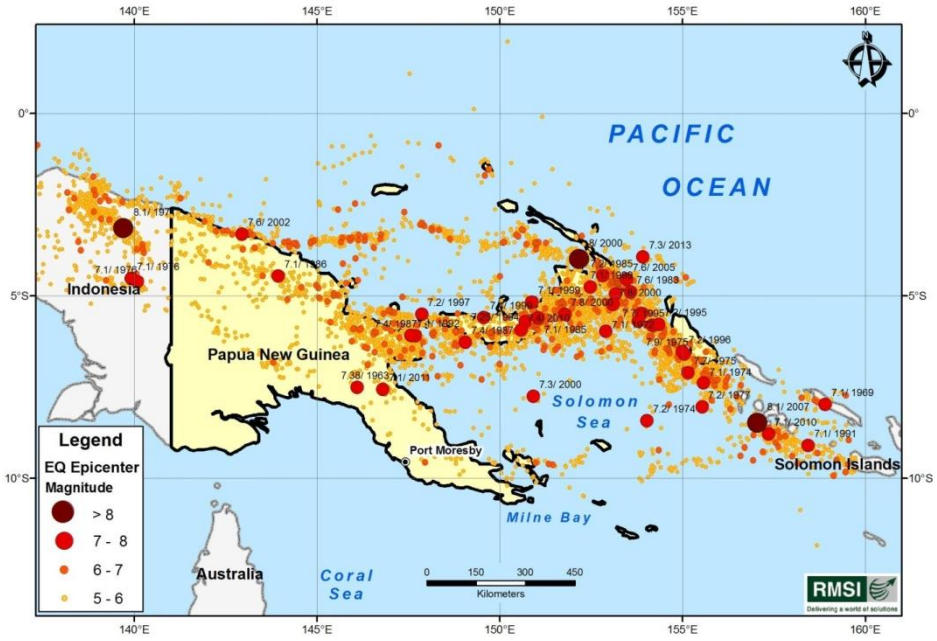

Figure 1-2: Major historical earthquakes in and around Papua New Guinea

1.4 Scope of Work

The scope of the assignment includes:

1. Development of a comprehensive hazard profile for the five provinces under consideration for the major hazards currently prevailing in the identified provinces and likely to be exacerbated by the enhanced climate variability and climate change
2. Enhancement of national capabilities for risk assessment and dynamic mapping by engaging national institutions and professionals in this exercises

3. Preparation and provision of hazard data, model and maps for their potential integration into the National Hazard/Risk Information System

The above scope of work will be achieved by undertaking the following key activities:

1. Define a conceptual model with evaluation methodology for hazard specific assessment for hazard mapping
2. Collate multi-sectoral exposures encompassing buildings, infrastructure and demographics for showing the exposure to various hazard zones
3. Delineate and characterize hazard-prone areas for the major hazards identified:
    - Analyze environmental background in the context of hazard origin, in terms of global warming and environmental degradation
    - Prepare a catalog of historical hazard events that should include the physical characteristics of hazards, sources of threats, magnitude, duration, frequency, probability, trends analysis, extent and intensity field for each identified hazard-prone areas
    - Prepare historical hazard scenarios and associated hazard intensity maps for the major hazards identified
    - Delineate and characterize the hazard-prone areas including hazard zoning based on identified conceptual model
    - Document each provinces' hazard maps on multi-sectoral exposures to identify the elements at risk
    - Characterize hazards in terms of their frequency, probability of occurrence and seasonality of their occurrence
4. Prepare probabilistic hazard scenarios and associated hazard intensity maps for the major hazards identified
    - Identify most plausible event scenarios in consultation with key national authorities
    - Simulate hazard scenarios making use of selected models and tools
    - Develop comprehensive probabilistic hazard intensity maps based on agreed conceptual/mathematical model for key return periods (2, 5, 10, 25, 50 and 100 years)
    - Prepare all hazards maps taking into account the national cartography parameters and compliance with the official projection system
    - Prepare the set of digital hazard datasets in proper GIS formats, which can be readily integrated in a National Hazard/Risk Information System.
5. Validation and Consultation
    - Validation of hazard scenarios and hazard intensity maps through consultations with stakeholders and key agencies in the five provinces
6. Develop hazard data, models and maps for its potential integration into the National Hazard/Risk Information System.
7. Training Workshops
    - Conduct training sessions of technical resources on the complete hazard mapping process
    - Conduct a national workshop to present the findings of the study.

1.5 Project Schedules

The Comprehensive Hazard Assessment and Mapping assignment will be undertaken according to the following timelines.

Table 1-1: Schedules for major deliverables

Deliverable	Expected Submission Date*	Expected date of Client Feedback
Inception Report	20th March, 2014	29th March, 2014
Submission of hazard intensity maps for peer review	11th April, 2014	18th April, 2014
Submission of report on the Comprehensive Hazard Profiles for five pilot provinces for peer review	25th April, 2014	2nd May, 2014
Delivery of the sets of digital hazard datasets	12th May, 2014	---
Delivery of Users training	13th - 14th May, 2014	---
National stakeholders workshop to present all the outputs such as the synthesis report on hazard profile, improved national risk information system	15th May, 2014	---

1.6 Organization of the Report

The present Inception Report is the first deliverable in the *'Development of a Comprehensive Hazard Profile for East Sepik, Madang, Morobe, New Ireland and Northern Provinces in Papua New Guinea'* Project.

The report consists of five chapters. Chapter 1 serves as an introduction to the study area, the general hazard perspective, the need for the study, and the objectives, scope and schedules of the study. Chapter 2 provides the methodology that will be followed for developing comprehensive and provincial hazard profiles, the data collection activity for the purpose and its digitization for analysis of hazards, delivery of digital hazard datasets and capacity building. Chapter 3 details the progress of the study during the 'Inception Workshop and Data Collection Mission' carried out during January and February 2014. It also lists the data collected and data gaps for hydro meteorological, GIS, and exposure data. Chapter 4 is devoted to Project Management aspects related to Managing the Study, i.e. team organization, detailed work plan, main deliverables etc. Chapter 5 provides details of RMSI's plans to undertake the training at the end of this study. The details are provided based on the present perceptions and may marginally deviate based on the overall objectives of the project and the data availability constraints as the project progresses.

2 Methodology

2.1 Overall Approach

RMSI's project approach emphasizes on engaging national stakeholders throughout the project cycle with the key objective that this exercise will help enhance the national capabilities of DRR activities in PNG and help them mainstream DRR and climate change in the country's development activities. The inclusive and participatory approach, starting with stakeholder consultation, has been emphasized right from the first mission.

Hazard mapping and assessment is being carried out following the international best practices of probabilistic hazard assessment and adapting them to local conditions. Taking into consideration the duration of the project, RMSI will work in close collaboration with various stakeholders and local experts of PNG at various stages of the project during the hazard assessment phase.

The major steps in our approach to the objectives of the project and involvements of various stakeholders in the project activity are illustrated in Figure 2.1.

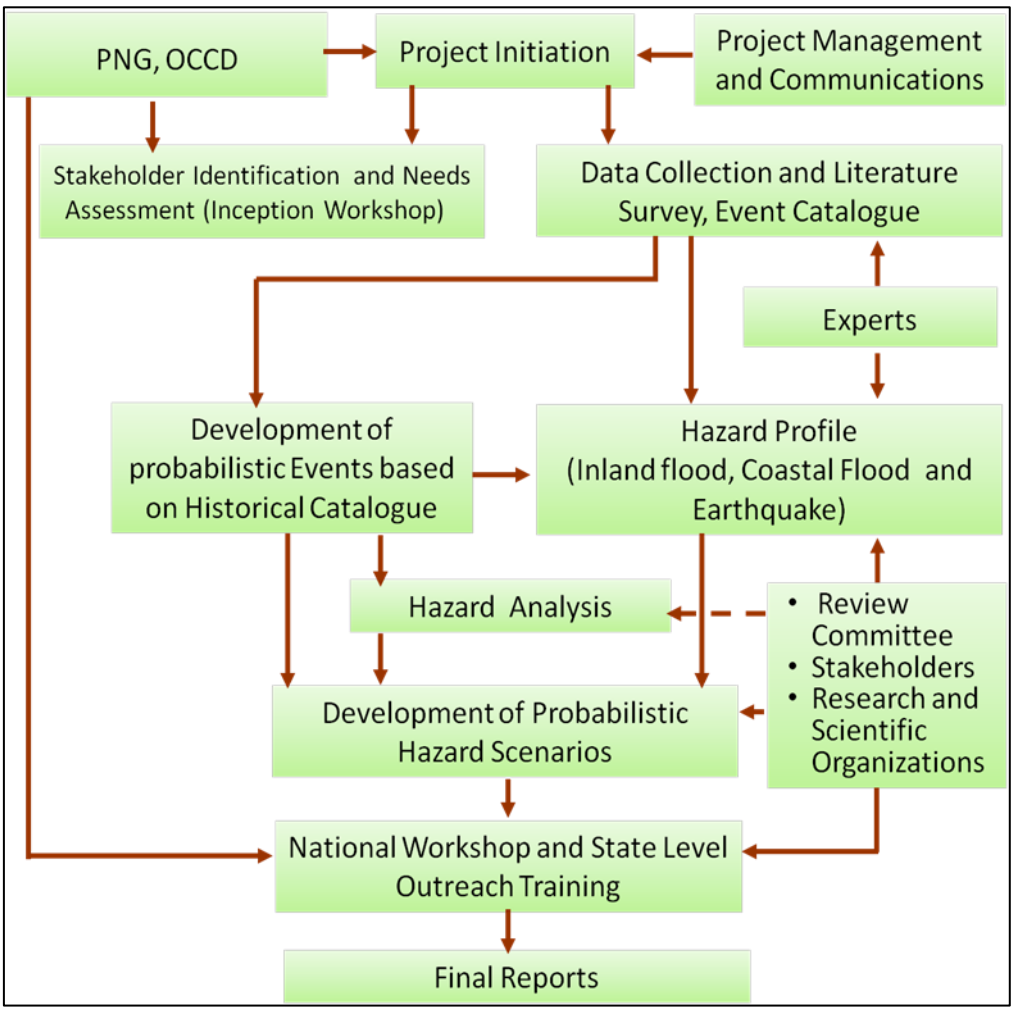

Figure 2-1: Flowchart showing approach and involvement of local agencies

2.2 Inception Workshop and Data Collection Mission

The RMSI team, in close coordination with UNDP, undertook the Inception Workshop as part of the agreed upon project management and communication activities. The workshop facilitated the formal introduction of members of the project team to the OCCD, Government of PNG, key organizations engaged in similar or allied assignments and the local UNDP office bearers. The Workshop also assisted in the project team to engage with the key stakeholders and obtain the primary data sources required to carry out the study. Following the Inception Workshop, one of the team members further interacted with the identified stakeholders to collect relevant datasets with the active support of OCCD and UNDP.

The meeting also paved the way to identify national research and scientific groups, which are working on various hazards in the country. The team is presently undertaking a desk research in consultation with these identified research and scientific groups to identify past and ongoing hazards modeling and assessment studies. Such studies are being reviewed to understand the methodology and data used. During this mission, the RMSI team also explored the availability of the existing National Hazard/Risk Information System, if any. This is essential in short listing a platform where the outputs of this study may be integrated.

During the stakeholder consultations, an initial understanding has been developed regarding how various stakeholders' agencies can contribute to the study by sharing necessary data as well as individual technical experts who will be closely involved throughout the project. UNDP assistance was commendable in arranging the necessary requests for the datasets from the identified organizations. The RMSI team member visited the identified stakeholders, discussed data requirements, and developed an initial understanding of the data and associated attributes - each of them would be providing within the agreed timelines. Further details of the workshop and data collection mission are given in Section 3.

2.3 Development of Comprehensive Hazard Profile

In hazard analysis, the severity and geographical extent of the critical perils, which have the potential to exacerbate as a consequence of climate change as identified during the inception mission will be assessed. The proposed overall methodology to be followed for hazard analyses is defined in this section. This can be varied in accordance with the needs of the stakeholders to be assessed immediately after project initiation. In general, the following steps are involved in hazard analysis (Figure 2-2).

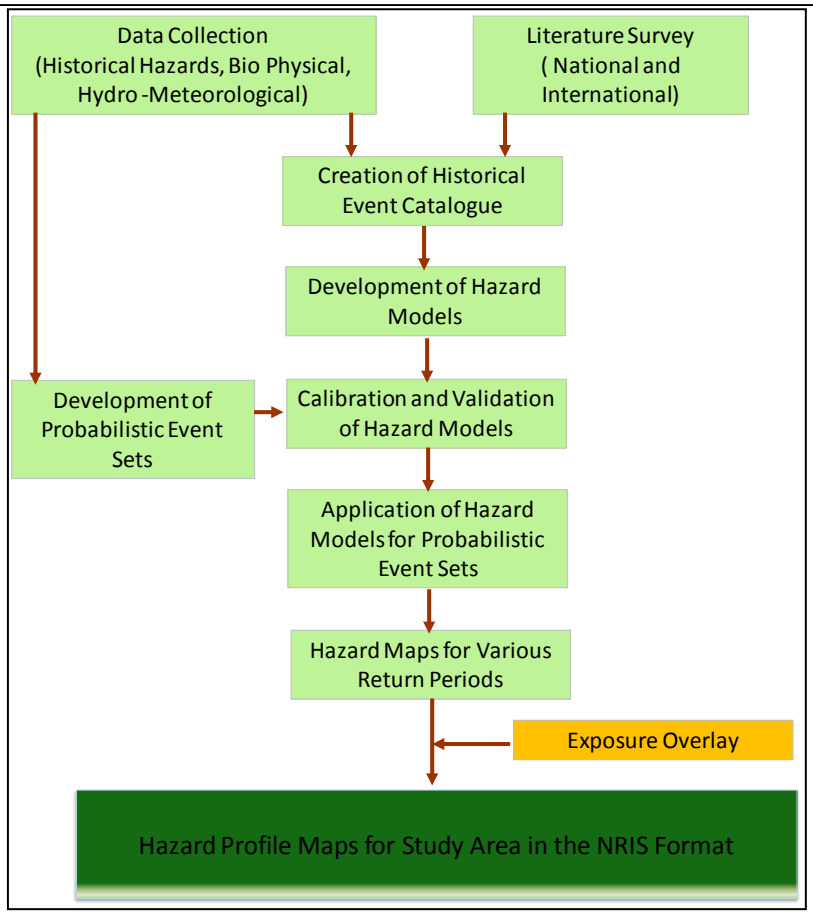

Figure 2-2: Steps involved in hazard assessment methodology

In addition to the data developed for national level studies, the team will also collect and review the information of historical events from global / international / regional sources to prepare historical event catalogues. The focus will be on identifying the sudden onset hazards based on past and current hazard information, that have the potential to be major disasters in coming decades and beyond. This will draw upon all existing and accessible data, reports, and collated information, including sources like National Disaster Centre of PNG, government agencies, EM-DAT, Dartmouth Flood Observatory, Relief web, UNDP / ADB / World Bank publications and reports, and province level information obtained from respective government agencies such as Planning Agencies, Economic Development / Statistics / Revenue.

RMSI team will employ internationally accepted models and tools for this study, which can be extended to other parts of the country or updated in the future. The team shall work in close coordination with research and scientific organizations from PNG at various stages of the hazard assessment. The hazard models represent the computerized simulation of the physical behavior of the hazard. For example, for slow onset hazards it simulates how the hazard develops, propagates, disseminates, and degrades. The primary output from the model is the assessment of the intensity of the hazard at various locations across the modeled area. For different hazards, the measure of the intensity is different. For example, in case of floods it is flow and depth, for earthquake it is peak ground acceleration or spectral acceleration, etc.

These hazard models will be used to analyze the intensity of historical events and the event related information will be collated to validate and calibrate the model. At the end of this process, the model uncertainty will also be estimated. The objective of this step is to ensure

that the model is able to emulate any future hazard events with a known degree of uncertainty.

A series of probabilistic events will be generated ranging from events that are more frequent to rare. The probabilistic events will be generated from the characteristics of historical events using simulation techniques. For example, in case of flood, the characteristics that will be considered are flood depth and extent.

The validated and calibrated model will be used to assess the intensity of every probabilistic event at various locations across the five pilot provinces. The locations could be centroids of administrative boundaries, variable resolution grid, or the specific location (longitude, latitude) of an infrastructural element. Once all these have been estimated, probabilistic hazard maps of various return periods will be created. Every such map indicates the hazard intensity at any location that has a chance of happening within "N" number of years. For example, a 50-year return period map shows the hazard intensity that has a chance of happening once in 50 years at various locations.

The methodology for individual hazard mapping and assessment exercises are provided in Section 2.4. These can vary in accordance with the needs of the study and data availability to be accessed immediately after project initiation.

2.4 Development of Provincial Hazard Profiles

Details of hazard assessment methodologies for the selected hazards are given in the subsections below.

2.4.1 Inland Flood Hazard Assessment

Floods due to excess rainfall are major cause of the flooding in the study area. The RMSI Team shall consider detailed basin impact and the presence of various storage structures and flood mitigation in assessing this riverine (inland) flood hazard. Flood hazard assessment shall identify and demarcate areas, which are exposed to floods. It will provide information on the extent and depth of flooding throughout flood prone areas for a range of flood magnitudes. The flood hazard assessment framework to be adopted for this study is given in Figure 2-3, which comprises of the following:

- Identification, acquisition, compilation and review of all relevant hydro meteorological and biophysical data. These data include terrain, soil, land use land cover (LULC), runoff/river discharge and flood protection measures to form the input for the model.
- Probabilistic analysis of runoff to simulate various return period events (2, 5, 10, 25, 50 and 100 years) for various flow gauge stations.
- Hydraulic modeling to estimate flood levels throughout the flood basins for various flows generated from key return period events.
- Flood hazard mapping to show flood extent and flood depth for a range of events, which is the result of hazard assessment.

Probabilistic Simulation of Flood Hazard: This comprises of probabilistic simulation of flood flows and derivation of flood inundation maps. Probabilistic simulation is necessary due to non- availability of historical observations for long periods. Generally, historical observations are available for a relatively short period (say 20 to 50 years). Probabilistic simulation helps in generating events to capture extremes that might not have present in the available historical data sets. From the data collection and inception mission, it is learnt that historical observed flow data is not readily available in the country.

Understanding an unavailability of observed flow data, team proposes a return period wise runoff estimation using river basin area, topography and rainfall in the basins by applying methods of un-gauged flow estimations. The Papua New Guinea Flood Estimation Manual prepared by SMEC Australia has comprehensively documented the river basin specific

approaches for runoff estimation from un-gauged basins in the country. These approaches along with the collected rainfall data shall be adopted probabilistic runoff analysis.

The probabilistic simulation for annual maximum rainfall for duration equal to the time of concentration of the basin(s) will be carried out after identifying the appropriate probability distribution. The linear moment (L Moment) technique (Hosking, 1990) will be used to determine the most appropriate distribution. Various L moment parameters (ratios) will be estimated using the annual maximum rainfall data. Various rainfall magnitudes will be simulated using all the appropriate distribution for the long term to capture extremes. By using the probabilistic rainfall magnitudes, probabilistic runoff at key return periods (2, 5, 10, 25, 50, 100 years) shall be estimated for various flow gauge stations/basins. These sets of probabilistic event flows will be given as inputs to the hydraulic model for determining flood extents for each probabilistic event.

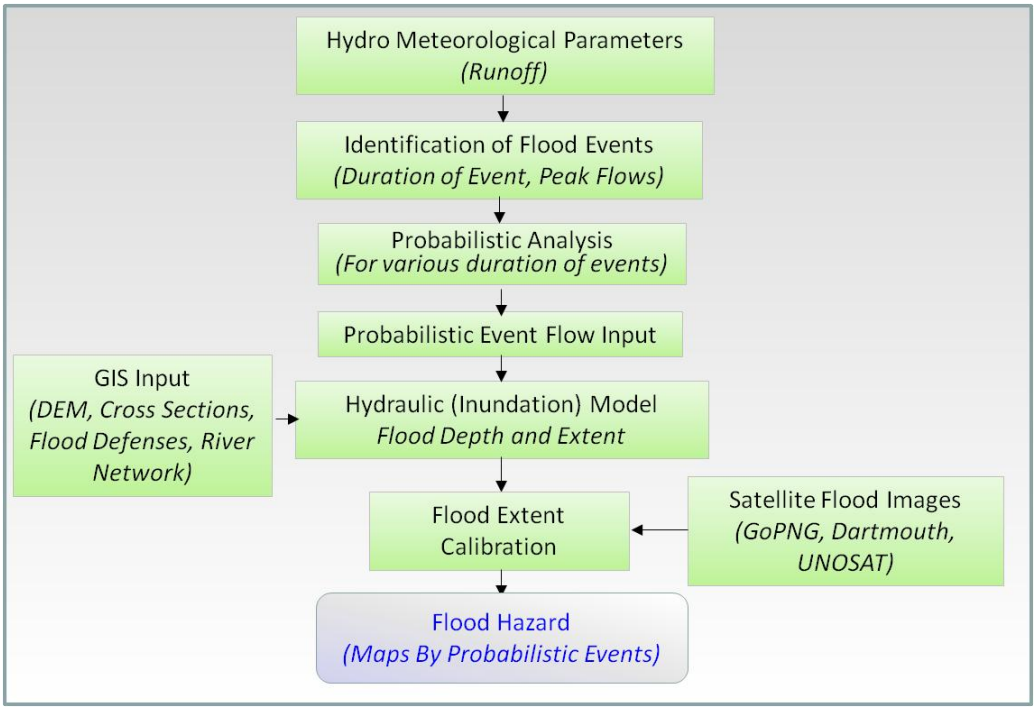

Figure 2-3: Flood hazard assessment framework

Flood Hazard Maps: Based on the flow values for various return periods, RMSI team will determine the boundaries of the flood plains by using one-dimensional hydraulic model HEC-RAS. Details of HEC-RAS model are given in Appendix 1. A flood extent maps will be prepared by integrating model results with GIS data to produce a map with varying flood depths depicted in different colors. The corresponding flood extent maps will be generated for all return period events (2, 5, 10, 25, 50, 100 years) for further integration in the National Risk Information System.

Flood inundation maps for past events: Maps or remote-sensing images of major historical flood events for validating and calibrating the modeled flood inundation extent and depth available with agencies like Dartmouth Flood Observatory, and PNG government agencies will be used if available.

2.4.2 COASTAL FLOOD HAZARD ASSESSMENT

Coastal flood hazard assessment shall identify and demarcate areas, which are exposed to high tidal waves. It shall provide information on the extent and depth of flooding throughout flood prone areas for a range of flood magnitudes. The coastal flood hazard assessment framework to be adopted for this study is depicted in Figure 2-4.

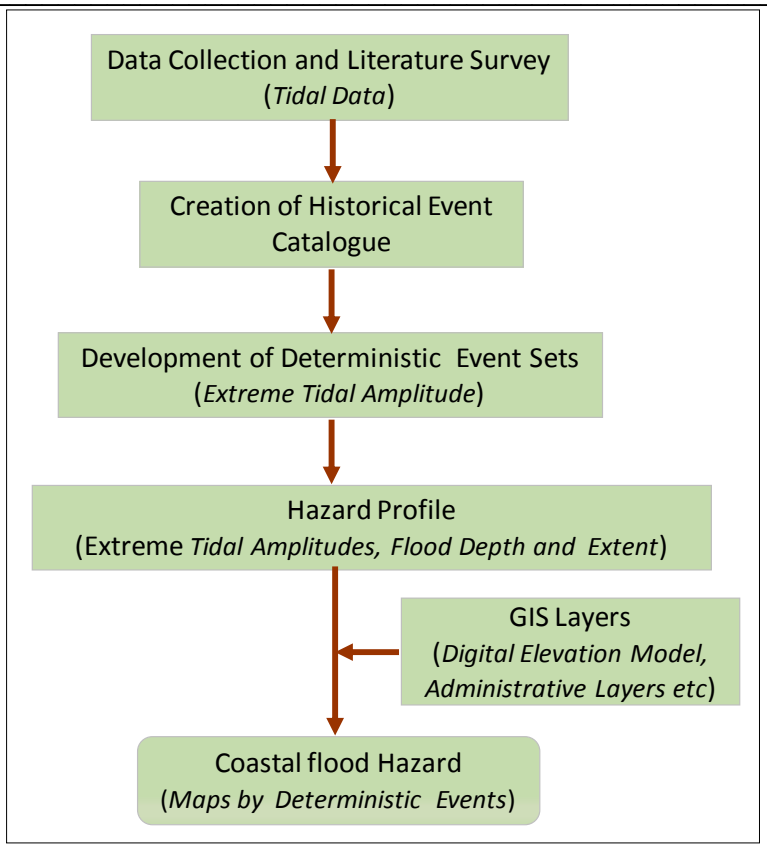

Figure 2-4: Coastal flood hazard assessment framework

To accomplish this task, RMSI team has initially identified locations in the five provinces that are affected due to the adverse impacts of high tidal waves. The team tried to collect the 30-year historical daily / hourly tidal values at each location for coastal flood hazard mapping during the data collection mission. However, due to non-availability of tidal data for 30-years with national agencies of PNG, the team has planned to use the daily hourly tidal amplitudes available at nearby stations to five identified provinces for coastal flood hazard mapping[3]. While using the tidal amplitude of nearby stations, geographical features will be studied before applying them over the identified provinces. Based on high tidal amplitude values for a particular coastal stretch, the team will identify the months in a year during which the maximum tide occurs. Accordingly, tidal data for those particular months will be considered for the available period. Finally, tidal amplitude will be interpolated at each coastal stretch of about 5 km interval. The vintage of daily / hourly tidal amplitude/sea levels available at nearby stations, which will be used for coastal hazard assessment, are explained in Appendix 2.The interpolated extreme tidal values and resulting water levels along the coast will be mapped to understand the spatial and temporal distribution, including frequency and intensity, of extreme tidal wave events. Finally, coastal flood hazard maps over the region will be prepared. The team will also consider Standard Tide Tables available with national nodal agencies of PNG while preparing tidal hazard maps. These tidal hazard maps would serve as a useful input in defining coastal structures and in assessing the vulnerability of the various coastal zones.

GIS Mapping of Tidal Flood Hazard Maps: The coastal inland extent of flooding that could be generated by high tidal waves at any coastal stretch will be prepared by integrating

[3]https://www.bodc.ac.uk/data/online_delivery/international_sea_level/south_pacific/#Rabaul and https://www.bodc.ac.uk/data/online_delivery/international_sea_level/south_pacific/#Lombrum http://ilikai.soest.hawaii.edu/uhslc/rqds.html

extreme tidal amplitude with coastal high resolution onshore topography data to demarcate the inland extent of inundation using GIS techniques. As the tidal amplitudes are projected onto the coast from the mean sea level, the associated flood depths will be inferred by subtracting local topography from the extreme tidal amplitudes. The tidal flood extent maps will be generated for various ranges of tidal amplitudes ranging from low and moderate to high amplitudes. Finally, the coastal flood hazard maps of extreme tidal values will be generated into proper ESRI GIS shape file format. No on-site training activity for coastal inland flooding hazard assessment approach has proposed at the project submission stage.

2.4.3 EARTHQUAKE HAZARD ASSESSMENT

RMSI's methodology of hazard mapping and modeling of the earthquake hazard was planned to follow internationally recognized standards for probabilistic seismic hazard analysis (PSHA). The earthquake catalogues, reports and earthquake hazard model outputs on PSHA maps for different probabilities of exceedance (return period) from these and other published studies were to be considered as key inputs for the proposed study. Major earthquake events were proposed be investigated to identify and list their source parameters, intensity of ground shaking, damage patterns etc. With identified seismic sources, RMSI team was to provide two to three key return period probabilistic hazard maps.

The seismic source zones and conceptual earthquake hazard model used in PSHA studies is proposed to be reviewed. The stochastic sets of earthquake events, if made available, shall be used to generate PSHA maps for different probabilities of exceedance at Variable Grid Resolution (VRG) level. In case, stochastic event set of earthquake hazard model is not available and only hazard maps for peak ground acceleration (PGA) are available at rock level, then as a fallback option, RMSI team can estimate local soil amplification for different probabilities of exceedance by classifying the available geology/geomorphology layers into different classes on a finer grid cell using NEHRP (2007)/HAZUS-MH soil classification scheme. By convoluting the PGA gridded maps for different return periods (base rock ground motion maps) with soil amplification factor layers; the earthquake hazard maps for different return-periods (including soil amplification) can be computed at Uniform Resolution Grids (URG) for the study area. The hazard intensity maps thus inferred need to be validated through consultations with stakeholders and key agencies. The above can facilitate in developing a comprehensive earthquake hazard profile for the five provinces of PNG. In addition, this would facilitate characterization of the hazard in terms of earthquake ground motion for different probabilities of exceedance for the study area and thus render their utility in future earthquake risk assessment studies.

It may be noted here that we have received a letter dated 11th February 2014 from Dr. Varigini Badira, the Executive Director, OCCD pointing the concerns of Port Moresby Geophysical Observatory. The said letter states that inclusion of Earthquake Hazard Assessment within the scope of this study could be "a duplication of effort" and our focus for this study should be primarily targeted on inland and coastal flooding. The letter further states that, should we decide to include the Earthquake Hazard Assessment in this study, we need to provide adequate justification for the connection between geological events and climate change. RMSI has sought further clarification on the issue from OCCD and UNDP and a final decision on inclusion of Earthquake Hazard Assessment as part of this study would be taken only on their confirmation and our own homework on establishing a linkage between Earthquake and climate change.

2.5 Delivery of Digital Hazard Datasets

The RMSI representative had discussions with Ms. Gwen Maru, Environment Analyst, UNDP and Ms. Maureen Ewai, Project Manager, UNDP along with the entire team from OCCD and UNDP working on this project during debrief meeting on 12th Feb 2014. It was decided that RMSI will deliver all final datasets in ESRI shape file format (as key project deliverable) for easy integration with the envisaged risk information system to be put in place in the future.

2.6 Collation of Province Wise Exposure Data

RMSI project team will collate available data on exposure elements such as buildings, infrastructure, critical facilities, demographics, and livelihood from various government departments with the support of UNDP. As exposure data development is not part of the scope of the present study, the team will rely on the existing exposure maps/GIS data available for the study area. RMSI, with support of UNDP, will work with the Province administration to collect required data on exposure elements. The acquired data and maps in GIS format will be further reviewed for their use in exposure data development and overlaid with the hazard data developed for the study area. If data is not available at locational level (point/line/polygon), the team will aggregate the exposure information provided by Provinces for the study area. For details of the exposure data collected for the five provinces of PNG, please refer to Annexure of this report.

2.7 Enhancing of National Capabilities for Risk Assessment

The salient findings of our study and the conclusions arrived at shall be disseminated in the stakeholder workshop involving UNDP and government agencies, research and scientific organizations, and other stakeholders. The workshop shall cover all aspects of methodology and approaches followed, data used and sources, key findings, and assumptions/limitations, if any, in the datasets used or models and tools adopted.

As part of the national capability-building task, RMSI will carry out the following activities:

1. Identification of key stakeholders: The Inception Workshop held at the OCCD in Port Moresby (detailed activity is contained in Section 3) has facilitated RMSI to identify the key national stakeholders and the current activities of their organizations in PNG. RMSI has an preparing an initial list of organizations (shall include provincial level organizations and their representatives as well in due course) from which representatives at working level on the subject matter could be involved at various stages in the project activity throughout the project cycle. RMSI intends involving individuals in the domains as enumerated in Table 2-1 in specific aspects of the present study.

Table 2-1: Stakeholder Engagement

	Domain	Aspects of Involvement
a)	Hydrologist, Meteorologists, Physicists, Mathematicians	Modeling of the physical characteristics of the flood hazard
b)	Mathematicians, Statisticians	Frequency and intensity analysis of historical events and development of probabilistic scenarios
c)*	Geologists, Seismologists	Modeling of the physical characteristics of the earthquake hazard
d)	Geographers, Remote Sensing and GIS professionals	Effective risk mapping, multi-sectoral spatial exposure data development and integration with National Hazard/Risk Information System

** In case earthquakes are included within the scope of this study*

2. Data validation and consultation: RMSI project team will present the findings of the hazard profiling and assessment before the key stakeholders in the final workshop for validation as indicated in Section 5. Prior to presenting the results to key stakeholders these will be discussed with selected technical team from stakeholder organizations and any variations will be resolved. In addition, RMSI team will elaborate the approach and

data sources used for developing the hazard maps. The views and observations of the key stakeholders on the hazard profiles and assessments will be collected and documented. The hazard profile and assessment report will be modified based on the inputs collected in this workshop.

3. National hazard assessment workshop: A national level workshop will be conducted with the support of OCCD and UNDP to present the final findings of the study to the stakeholders. The details of the workshops are provided in Section 5.

3 Inception Meeting and Data Collection Mission, January-February 2014

3.1 Inception Meeting: 26-29 January 2014

RMSI initiated the project activities with the first field visit and Inception Meeting to introduce the project and the team, plan and firm up the major project activities, discuss the previous studies related to the subject matter of the study, identify data needs and its availability with stakeholder organizations, and identify expected support from various national and provincial agencies. This meeting facilitated an initial understanding of the data/information available, which could be utilized for this study.

The meeting also helped identify various national research and scientific groups, which are working on multiple aspects of various hazards in the country in various stakeholder institutions. Individuals from these groups are now being identified for continuous involvement in the project activities at various levels.

The team also identified the custodian for the required data and gained access to some of this data with the coordinated support from OCCD and UNDP. The data collected during the mission is detailed in section 3.3 below. During this process, the visiting RMSI team also explored the existence of a National Hazard/Risk Information System at OCCD. The visiting RMSI members also collected valuable insights and information by engaging in discussions with stakeholder organizations. All information gathered till date has been documented and presented in this report under section 3.3.

Table 3-1: Details of Inception Workshop activities

26 January 2014		Dr. Murari Lal, Team Leader, Arrival at Port Moresby
27 January, 2014		12.00 Noon – 15.30 PM
	Institution/Venue	UNDP Office, Port Moresby
	Contacts	Project Manager, Adaptation Project Office, 14 Floor, Deloitte Tower
	Key Discussions	The purpose of this meeting was to discuss on the objectives of the project and plan for inception meeting and subsequent data collection activities and site visits during this mission. The points touched up include:
		1. RMSI-India will be responsible for implementing the current project entitled “Development of a comprehensive hazard profile for East Sepik, Madang, Morobe, New Ireland and Northern Province in Papua New Guinea”.
		2. The detailed list of stakeholders for the hazard assessment inception meeting who have been invited were discussed in terms of their importance in providing the data for the project. It was agreed that a few more would be invited based on our discussions.
		3. The meeting would be held at OCCD Conference Hall on 29th January from 9 AM.

		4. The total number of participants for the inception meeting was estimated to be around 30.
		5. It was appropriate to visit and discuss with the officials at the Office of the Climate Change Department (OCCD), the nodal institution for the project in PNG. A request was made to UNDP, which welcomed this initiative.
		6. A meeting with Office of the National Weather Service and National Disaster Centre based in Port Moresby was also requested.
		7. A compulsory UN security briefing has been arranged by UNDP for tomorrow morning, which would be attended by Lal and Pratul.
	Actions	Ms. Maureen will follow up to arrange the meetings with officials at the Office of the Climate Change Department (OCCD), Office of the National Weather Service and National Disaster Centre for tomorrow.
	Participants	• Ms. Gwen Maru, EE Project Analyst, UNDP • Ms. Maureen Ewai, Project Manager, Adaptation Fund, UNDP • Lal Murari (RMSI, TTL)
28 January, 2014		09.00 AM – 15.30 PM
	Institution/Venue	UNDP Office and Hotel Hodava
	Key Issues	1. Pratul Srivastava arrived at Port Moresby 2. UNDP Security Briefing could not be arranged today and has been differed for Thursday - Pratul to attend. 3. The Director, National Weather Service and Climate Manager are travelling outside Port Moresby and would be back on Thursday only. The meeting would be re-scheduled on Friday. 4. The meeting request to National Disaster Office was not responded to UNDP and hence no meeting could be arranged. 5. UNDP conveyed its regret that RMSI was not able to get its local consultants to join the crucial Inception Meeting/Workshop. 6. The length of Pratul's stay and visit to provinces as part of the mission was taken up by UNDP. Pratul agreed that he would be visiting Morobe and Madang provinces. 7. Ms. Maureen suggested that she will also join Pratul for the visit to these two provinces, connect him to local authorities for briefing them on the project, and discuss on data availability. 10. UNDP advised that RMSI team should not engage private taxis for moving within the city due to security reasons. UNDP or OCCD vehicles

		would be arranged for our business meetings / engagements.
	Participants	• Lal Murari (RMSI) • Ms. Maureen Ewai, Project Manager • Pratul Srivastava (RMSI, at Hotel Hodava)
29 January, 2014		08.30 AM – 15.00 PM
	Institution/Venue	Conference Room, OCCD, Port Moresby
	Key Activities	1. RMSI team reached the venue at 8.45 AM as planned. 2. OCCD staffs were very cooperating in elegantly arranging for the projection facility and in extending hospitality to UNDP, RMSI team and Invitees. 3. The Director, Adaptation Division of OCCD welcomed the guests and fellow colleagues from multiple organizations for coming to the workshop in his welcome speech. 4. A brief introduction to the project was given by Ms. Gwen Maru on behalf of UNDP. 5. Ms. Maureen Ewai requested all the workshop participants to state their affiliation and organization they come from to get introduced to the gathering. 6. The participants were also shared with a questionnaire to fill in their contact details and the data that their organization may have and willing to share them for this project. 7. After a brief tea break, RMSI team was asked to make a presentation on the objectives of the project and the approach and methodology being adopted by them for the purpose and also indicate the milestones during the next two months (the project is to be completed by March end). 8. RMSI Team led by Pratul presented a brief introduction of RMSI followed by the scope, objectives and the approach to be followed for the project. 9. This was followed by a lengthy discussion on the selection of hazards (in particular the earthquakes together with floods in relation to climate change). All these queries were aptly answered by RMSI team (Lal) to the satisfaction of stakeholders. 10. A request was made by RMSI team to the participants of the workshop that the priority exchange of required data is essential for successful completion of the project within the given time line. 11. The matter of field visit to the identified

		provinces in the project was also raised and UNDP and RMSI team conveyed that a visit to Morobe and Madang provinces has been finalized for the purpose. 12. The Director, Adaptation Division, OCCD also requested RMSI to present the project details with Provincial stakeholders during the field visit and seek their support and cooperation in locally held data and information. 13. Mr. Philemon, Senior coordinator from Department of Provincial & Local government affairs proposed that RMSI team could visit his office today afternoon itself to exchange data/information on the project. Mr. Pratul has visited their office this afternoon. 14. Mr. Goodwill Amos, Manager, Forest Policy Directorate has invited RMSI team to visit his office tomorrow morning for exchange of information and data. 15. Pratul is also scheduled to visit National Weather Service on Friday for meeting the Director, NWS and obtain rainfall data from all the stations in selected provinces. 16. The UNDP will request OCCD Office to formally write an introduction letter for RMSI to visit other nodal organizations in Port Moresby in coming days prior to his visit to Morobe and Madang. 17. Pratul will also be attending security briefing tomorrow at UNDP Office. 18. Ms. Maureen will arrange for vehicle from OCCD / UNDP for RMSI team to attend the upcoming business meetings / engagements in Port Moresby.
	Participants	• Lal Murari (RMSI) • Ms. Maureen Ewai, Project Manager, UNDP • Ms. Gwen Maru, UNDP • Other stakeholders (a complete list of all the participants is attached as Annexure)

3.2 Data Collection Activities: 30 January – 12 February 2014

Table 3-2: Details of Data Collection during the first Mission

30th Jan 2014		9:30 am to 1 pm
	Institution/Venue	Conference room, Forest Authority (FA)
	Key Activities	1. Ms. Maureen, UNDP and Mr. Pratul Shrivastava first met with Mr. Goodwill Amos, Manager REDD and Climate change.

		2. Mr. Goodwill introduced Ms Maureen and Mr. Pratul to the team working for the project - Landuse and Landcover for entire PNG and Mr. Masamichi Haraguchi, Consultant from Kokusai Kogyo Co. Ltd., Japan 3. Mr. Pratul provided an overview of the present project and its data requirements to the FA team members. 4. FA team informed that they were in the final stage of the Land use / Land cover development but they have to check with Managing Director, to share this data with OCCD. They requested Ms. Maureen to send a formal request and have promised to get back to her.
	Participants	Ms. Maureen Ewai, Project Manager, UNDP Mr. Goodwill Amos, Manager REDD and Climate Change, PNG Forest Authority Mr. Masamichi Haraguchi, Engineer, Kokusai Kogyo Co., Ltd. Team members from PNG FA team working on the Land use / Land cover development Project. Mr. Pratul Shrivastava, RMSI, India
31st Jan 2014		9:00 AM to 2:00 PM
	Institution/Venue	University of PNG (UPNG)
	Key Activities	1. Prof. Augustine J. Mungkaje, UPNG organized a meeting with departments holding key data at UPNG, which could be of use in the study 2. The first meeting was with Ms. Regina Kiele (Lecturer in GIS) from 9.30 am. Ms, Regina was very supportive and ran through all the GIS data she is using as part of her teaching curriculum like Geobook. She also mentioned that the complete datasets and rights to share these data are with Dr. Phil Sherman, UPNG Remote Sensing Centre. 3. We met with Dr. Phil Sherman, UPNG Remote Sensing Center. Pratul provided an overview of the project and the data requirements for this project. Dr. Sherman informed that the development of these data involved huge investment and there are proprietary issues associated with these data. It would be difficult for him to share these data with OCCD. 4. Later, we visited Mr. Simon Kawagle (UPNG Earth Sciences Discipline), and provided an overview of the project. He told us that he does not have these datasets. He told us that he can help us if we have any technical queries in this regard. 5. We tried to meet Professor Chalapan, for tidal data but he was busy with some meeting.

	Participants	1. Dr. Phil Shearman (UPNG Remote Sensing Centre) 2. Mr. Simon Kawagle (UPNG Earth Sciences Discipline) 3. Ms. Regina Kiele (Lecturer in GIS) 4. Assoc. Professor Augustine J. Mungkaje Director, Motupore Island Research Centre, School of Natural and Physical Sciences, University of Papua New Guinea 5. Ms. Maureen Ewai, Project Manager, UNDP 6. Mr. Pratul Shrivastava, RMSI Pvt. Ltd.
3rd Feb 2014		9:30 AM to 4:00 PM
	Institution/Venue	GeoHazard, National Mapping Bureau
	Key Activities	1.Visited GeoHazard office and provided an overview of the project and data requirements. Mr. Chris showed some of old reports and told that he needed a box of photocopy paper so that he can give photocopy of these report. We promised him to give him the box by the next day. 2. We visited National Mapping Bureau and met with Mr. Elenki regarding administrative boundaries and other related datasets. He asked us to send a letter addressed to his director on the OCCD letterhead. 3. We visited UNDP office for security briefing. Around 2:30 pm
	Participants	1. Mr. Chris Mckee, Assistant Director, Geohzards Division, Dept. Mineral Policy and Geohazards Manangement 2. Mr. Elenki, National Mapping Bureau, PNG 3. Ms. Maureen Ewai, Project Manager, UNDP 4. Mr. Pratul Shrivastava, RMSI Pvt. Ltd.
4th Feb 2014		9:30 AM to 5:00 PM
	Institution/Venue	National Weather Service, OCCD, Geohazards
	Key Activities	1. Visited National Weather Service office and met with Mr. Kashis and Mr. Robert regarding weather data. They asked for a formal letter from the OCCD Director. 2. Mr. Robert has showed all the facilities available with the National Weather Services, PNG 3. Photocopy paper box was handed over to Mr. Chris
	Participants	1. Mr. Kashis , National Weather Service 2. Mr. Robert , National Weather Service

		3. Ms. Maureen Ewai, Project Manager, UNDP 4. Mr. Pratul Shrivastava, RMSI Pvt. Ltd
5th Feb 2014		9:30 AM to 5:00 PM
	Institution/Venue	OCCD
	Key Activities	1. Collected all the GIS data (Geobook, Inundation map from Ms. Rose, GIS Division OCCD 2. Follow ups with all the agencies over phone for data. 3. Letters prepared for all the agencies for data collection work
	Participants	1. Ms. Maureen Ewai, Project Manager, UNDP 2. Ms. Rose, GIS Division, OCCD 3. Ms. Luanne Losi , OCCD 4. Ms. Manau Renagi, OCCD 5. Ms. Joycelyn Nagai, UNDP 6. Ms. Grace Jackson, OCCD 7. Mr. Pratul Shrivastava, RMSI Pvt. Ltd
6th Feb 2014		9:30 am to 5 pm
	Institution/Venue	National Statistical Organization, OCCD, DEC
	Key Activities	1. Visited NSO to see data availability and their price. 2. Letters finalized and sent to respective agencies 3. Meeting with Mr. Mario, DEC, for SMEC report and hydrological data
	Participants	1. Ms. Maureen Ewai, Project Manager, UNDP 2. Ms. Rose, GIS Division, OCCD 3. .Ms. Luanne Losi , OCCD 4. Ms. Manau Renagi, OCCD 5. Ms. Joycelyn Nagai, UNDP 6. Ms. Grace Jackson, OCCD 7. Mr. Pratul Shrivastava, RMSI Pvt. Ltd
7th Feb 2014		11 am to 5 pm
	Institution/Venue	University of Technology, (UNITECH), LAE
	Key Activities	1. Meeting with Prof. Kobal and Dr. Shailesh Samanta 2. Gave a presentation in the Dept. of Civil Engineering before Prof. Kobal and Dr. Samanta 3. Collected data from Dr. Samanta

	Participants	1. Prof. Christopher Andrew Kobal, PNG University of Technology, Private Mail ; Bag, Lae, Morobe 2. Dr. Sailesh Samanta, Department of Surveying & Land Studies, PNG University of Technology 3. Mr. Pratul Shrivastava, RMSI Pvt. Ltd
10th Feb 2014		9:30 am to 5 pm
	Institution/Venue	OCCD, NSO and NMB
	Key Activities	1. Organized all the data collected so far from different departments 2. Followed up with Mr. Rober regarding weather data 3. Followed up with Mr. Mario regarding SMEC report. 4. Visited National Statistical Organization (NSO) along with Ms. Luanne to meet the Director for NSO data. 5. Visited National Mapping Bureau (NMB) for boundary layers.
	Participants	1. Ms. Luanne Losi , OCCD 2. Mr. Pratul Shrivastava, RMSI Pvt. Ltd
11th Feb 2014		900 AM to 4:00 PM
	Institution/Venue	OCCD, DEC
	Key Activities	1. Collected SMEC report for DEC office 2. Collected some of the statistical data available with OCCD office
	Participants	1. Mr. Mario, DEC 2. Ms. Maureen Ewai, Project Manager, UNDP 3. Ms. Rose, GIS Division, OCCD 4. Ms. Luanne Losi , OCCD 5. Ms. Joycelyn Nagai, UNDP 6. Mr. Pratul Shrivastava, RMSI Pvt. Ltd.
12th Feb 2014		9:30 AM to 11:00 AM
	Institution/Venue	OCCD
	Key Activities	1. Debrief meeting 2. Presentation by Pratul regarding status of data collected till date 3. Identified key departments where further follow-ups were required
	Participants	1. Ms Gwen Maru, Environment Analyst, UNDP

		2. Ms. Maureen Ewai, Project Manager, UNDP 2. Ms. Rose, GIS Division, OCCD 3. Ms. Luanne Losi , OCCD 4. Ms. Manau Renagi, OCCD 5. Ms. Joycelyn Nagai, UNDP 6. Ms. Grace Jackson, OCCD 7. Mr. Pratul Shrivastava, RMSI Pvt. Ltd.

3.2.1 AGENCIES CONTACTED

During the Inception Meeting and Data Collection mission, many of the nodal agencies (see the list in Table 3-3) who are custodians of various data required for the hazard analysis, were visited. The data collected from these agencies and other sources as of this date are being reviewed so that the identification of gaps, if any, could be done keeping in view the overall needs of stakeholders and clients with respect to the knowledge base and data on assessment of climate change impacts on various hazards.

The Institutional Expert along with RMSI team and local expert will understand, review and analyze the existing institutional set up. This will be focused to the theme of the project and the team will also capture the allied activities of the stakeholders in the region and its interrelationships. For this task, RMSI shall work closely with UNDP and OCCD. OCCD would facilitate the team by providing the necessary inputs on legal and policy aspects.

Table 3-3: List of Nodal agencies

S. No.	Data	Contact Person/Agency
1	Coastlines (Lat, Long) data for selected provinces, namely, East Sepik, Madang, Morobe, New Ireland and Northern Province in Papua New Guinea	National mapping , Department of Justice and Attorney General – National Delineation – PM Masio Nidung (National Fisheries Authority/ PNG Forest Authority), OCCD – LIDAR data – GIS office
2	High resolution coastal bathymetry	NMSA (National Maritime Safety Authority), PNG Ports
3	Tidal amplitude at coastal stations for provinces under study	NMSA (National Maritime Safety Authority)
4	Wind driven wave height	NMSA (National Maritime Safety Authority)
5	Daily maximum stream flows at all gauge stations for last 30 years	National Weather Service, DEC
6	Daily rainfall data measured at rain gage stations in the catchments for last 30 yrs	National Weather Service,
7	River geometry and Profile for major rivers, if available	Dept of Environment, PNG Water
8	Reservoir capacities and storages, Reservoir inflows/ outflows, Elevation-storage-outflows/Elevation-area-outflows	PNG Water, DEC
9	Flood inundation maps and Satellite Images for past significant flood events	National Disaster Center, Water Resources Section DEC, MRA

S. No.	Data	Contact Person/Agency
10	Information on flood defenses – embankment, levee, bridge/ culvert, abutment etc.	Department of Transport and works, Provincial works office for 5 provinces, PNG Ports
11	Soil Type, Land Use and Land Cover Maps for Provinces Under Study	DAL – Dept of Agriculture and Land, NARI, PNG Forest Authority, DEC
12	Digital Terrain Model/ Elevation Maps for Provinces Under Study	UPNG GIS Center, National Mapping Bureau, PNG FA
13	Information on Past Studies related to river basins, floods and water resources including The PNG Flood Estimation Manuals (SMEC 1973 & 1990)	SMEC, DEC, PNG Water, PNG Power
14	Existing latest Earthquake Catalogue for PNG and surrounding areas	Geo-science Australia , PMGO , UPNG Geology Department,
15	Reports on significant Past Earthquake events	PMGO, National Disaster Center, UPNG Geology Department, MRA
16	Geology (including faults and lineaments), Geomorphology and Soil maps in digital format (preferable in .shp, .tab, .grd)	PMGO, National Disaster Center, UPNG Geology Department, MRA
17	High resolution DEMs (10 m or, better spatial resolution.) for entire PNG	UPNG GIS Center, National Mapping Bureau, PNG FA
18	PGA (rock) data from existing EQ Model for different Return Periods developed by SOPAC and PMGO in GIS format	Geo-science Australia , PMGO , UPNG Geology Department,
19	Administrative Boundaries (Country boundary, Province boundary)	National Mapping Bureau, Electoral Commission and lands department, MRA, PNG FA
20	Urban land use (building cluster footprints) at 1: 10,000/ 1:25,000 scale. With details of building structure (RBC, RCC) and functionality (residential, commercial, industrial, public)	Departments of land and physical planning, UPNG Geography department, DAL, Office of Urbanization, Provincial town planning office or provincial works offices, DPLGA
21	Details on Infrastructure data (roads, bridges, airports, wharves, dams, telecommunication network, power supply, seaports and inland water transport)	Departments of land and physical planning, UPNG Geography department, DAL, Office of Urbanization, Provincial town planning office or provincial works offices, DPLGA, PNG Power, PNG Ports, PNG Telecom,
22	Details on Healthcare facilities (attribute like number of beds, number of doctors, construction types of the hospital buildings, etc)	Department of Health - Health Information System, DPLGA, Provincial Health Advisor
23	Details of educational institutes (location, number of rooms, no of storey, number of staff, contact number, address, construction types, etc)	Department of Education , DPLGA
24	Census population by administrative units including necessary attributes like, male/female, age group, poverty etc.	National Statistical Office
25	Population and household information, Building Types etc.	National Statistical Office, SOPAC, Provincial Planning Offices

S. No.	Data	Contact Person/Agency
26	Livelihoods, i.e. livestock, crops, industries details(the number, location and extent of exposure)	DAL, NARI, PNG FA, Provincial DAL Offices, University of Technology, Natural Resource Agency

3.3 Status of Data Inventory

Data collection for the identified provinces under this study is now well advanced. To date we have obtained data from different sources. Some of the data have been collected directly from the offices of the different departments of the Government of PNG whereas some of the data have been downloaded from the websites of these departments and other international agencies.

The RMSI team is evaluating existing reports/outcomes of the ongoing modeling studies for various hazards assessment such as inland flooding, coastal flooding, and earthquakes for the study area. The team is also assessing data gaps, and will be recommending plausible improvements with reference to current national and international best practices. Details of exposure data collected during the Data Collection mission are given in Annexure 4.

Table 3-4: Status of data collected during the first data collection mission

S. No.	Data	Contact Person/ Agency	Status at the end of data collection mission	Action Required	Suggested Alternate Sources	Associated Limitations
	Coastlines (Lat, Long) data for selected provinces, namely, East Sepik, Madang, Morobe, New Ireland and Northern Province in Papua New Guinea **Received Low resolution coastline from UNITECH, LAE**	Mr. Eleki Minalyo, Sr. Cartographer, National Mapping Bureau (NMB), Land Dept, (Mobile : 70019326, Land line: 3257608) National Mapping Bureau	We may get some higher resolution data from NMB. As per Mr. Eleki it will take another one week to organize the data	Follow up with Mr. Eleki	Received Low resolution coastline from UNITECH, LAE	This may have minor deviation on the final results/outputs/products
	High resolution coastal bathymetry	OCCD GIS – Ms Rose	Not received	Follow up with Ms Maureen		
	Tidal amplitude at coastal stations for provinces under study	Dr. Chalapan UPNG	Received sea level data for 6 different stations for selected provinces under study Kavieng And Alotau 10 Years Rabaul 30 Years Wewak 10 years Madang 15 years Lae 14 years	None	The relevant data on website is provided in Annexure 3.	This may have minor deviation on the result/output.
	Daily maximum stream flows at all gauge stations for last	Mr. Maino, Department of	Not Received	As per Mr. Maion, they are in process		

S. No.	Data	Contact Person/ Agency	Status at the end of data collection mission	Action Required	Suggested Alternate Sources	Associated Limitations
	30 years	Environment		of gathering data and estimating cost for these data. Ms Maureen to follow up with Mr. Mario please.		
	Daily rainfall data measured at rain gage stations in the catchments for last 30 yrs	Mr. Kasis, National Weather Service,	Received	No further action is required		
	River geometry and Profile for major rivers, if available	OCCD GIS	Received only centerline (No attributes like name etc.)			
	Reservoir capacities and storages, Reservoir inflows/ outflows, Elevation-storage-outflows/Elevation-area-outflows	Water PNG, DEC	Not available	Ms Maureen to follow up please.		
	Flood inundation maps and Satellite Images for past significant flood events -	OCCD	Not for historical events. No satellite images	Only area marked as inundated or not inundated		
	Information on flood defenses – embankment, levee, abutment etc.	DEC, Provincial works authorities, Morobe City Authority	Data is not available	We have to request Ms Maureen to follow up		
	Soil Type, Land Use and Land Cover Maps for Provinces	Forest Authority	Not received	Latest data is available with FA.		

S. No.	Data	Contact Person/ Agency	Status at the end of data collection mission	Action Required	Suggested Alternate Sources	Associated Limitations
	Under Study Some maps received from OCCD GIS			Ms Maureen to follow up please.		
	Digital Terrain Model/ Elevation Maps for Provinces Under Study	OCCD	Received			
	Information on Past Studies related to river basins, floods and water resources including The PNG Flood Estimation Manuals (SMEC 1973 & 1990)	Mr. Maino, DEC	Received			
	Existing latest Earthquake Catalogue for PNG and surrounding areas	SOPAC, Geo-science Australia , Geology Department UPNG	Not received	There is very little chance to get this data. We have to find data from global sources	USGS and other published literature	
	Reports on significant Past Earthquake events	Geo Hazard, SOPAC, World Bank	World bank (SOPAC report) received.	-	Published literature	
	Geology (including faults and lineaments), Geomorphology and Soil maps in digital format (preferable in .shp, .tab, .grd)	UNITECH	Partially received	Look for other sources for more data if required	Published literature and PNG Govt agencies	-

S. No.	Data	Contact Person/ Agency	Status at the end of data collection mission	Action Required	Suggested Alternate Sources	Associated Limitations
	Soil Maps – Dept. of Agriculture and Live Stock Geology (Faults and Lineaments) – UPNG					
	High resolution DEMs (10 m or, better spatial resolution.) for entire PNG	UPNG GIS Center, National Mapping Bureau, PNG FA	Received for 3 coastal provinces from OCCD GIS			
	PGA (rock) data from existing EQ Model for different Return Periods developed by SOPAC and PMGO in GIS format	Geo-science Australia, PMGO , UPNG Geology Department,	Not received	Very little chance to get this data Look for global source	Published Global data (USGS/GAR)	Information may be available at a coarser grid
	Administrative Boundaries (Country boundary, Province boundary)	National Mapping Bureau, OCCD	Received province boundary from OCCD	Some more data we may get from National Mapping Bureau Follow up with NMB.		
	Urban land use (building cluster footprints) at 1: 10,000/ 1:25,000 scale. With details of building structure (RBC, RCC) and functionality (residential, commercial, industrial, public)	Ms. Rose, OCCD GIS	Received Scale is not known Required attributes are missing	Try to find data from some other sources with required attributes		
	Details on Infrastructure data - wharves (Ports Authority) , dams	DEC, Water PNG	Not available	We have to request Ms Maureen to follow up		

S. No.	Data	Contact Person/ Agency	Status at the end of data collection mission	Action Required	Suggested Alternate Sources	Associated Limitations
	Details on Infrastructure data - Telecommunication network	Department of telecommunication	Not received	We have to request Ms Maureen to follow up		
	Details on Infrastructure data - Power supply	PNG Power	Not received	We have to request Ms Maureen to follow up		
	Details on Infrastructure data (Bridges, airports,)	UNITECH	Received	No further action is required		
	Details on Healthcare facilities (attribute like number of beds, number of doctors, construction types of the hospital buildings, etc)	OCCD GIS	Received based on 2000 Census data.,	Requested NSO for 2011 data We have to request Ms Maureen to follow up		
	Details of educational institutes (location, number of rooms, no of storey, number of staff, contact number, address, construction types, etc)	OCCD GIS	Received based on 2000 Census data, But we may have to collect data based on 2011 census from NSO	Requested NSO for 2011 We have to request Ms Maureen to follow up		
	Census population by administrative units including necessary attributes like, male/female, age group, poverty etc.	OCCD GIS	received	No further action is required		
	Household information,	National Statistical	Not received	Ms Maureen to		

S. No.	Data	Contact Person/ Agency	Status at the end of data collection mission	Action Required	Suggested Alternate Sources	Associated Limitations
	Building Types (National Housing Corporation) etc.	Office		follow up with NSO please.		
	Livelihoods, i.e. livestock, crops, industries details(t he number, location and extent of exposure)	DAL, NARI, PNG FA, Provincial DAL Offices, University of Technology, Natural Resource Agency	Not received	Ms Maureen to follow up with NSO please.		

4 Project Management

4.1 Team Structure

The proposed project team consists of domain experts to handle all the major hazards identified. We have enhanced the team strength with additional experts taking into consideration of the major hazards in the study area. We have included some of our senior staff for this important project. The current team composition is given in Figure 4-1 below.

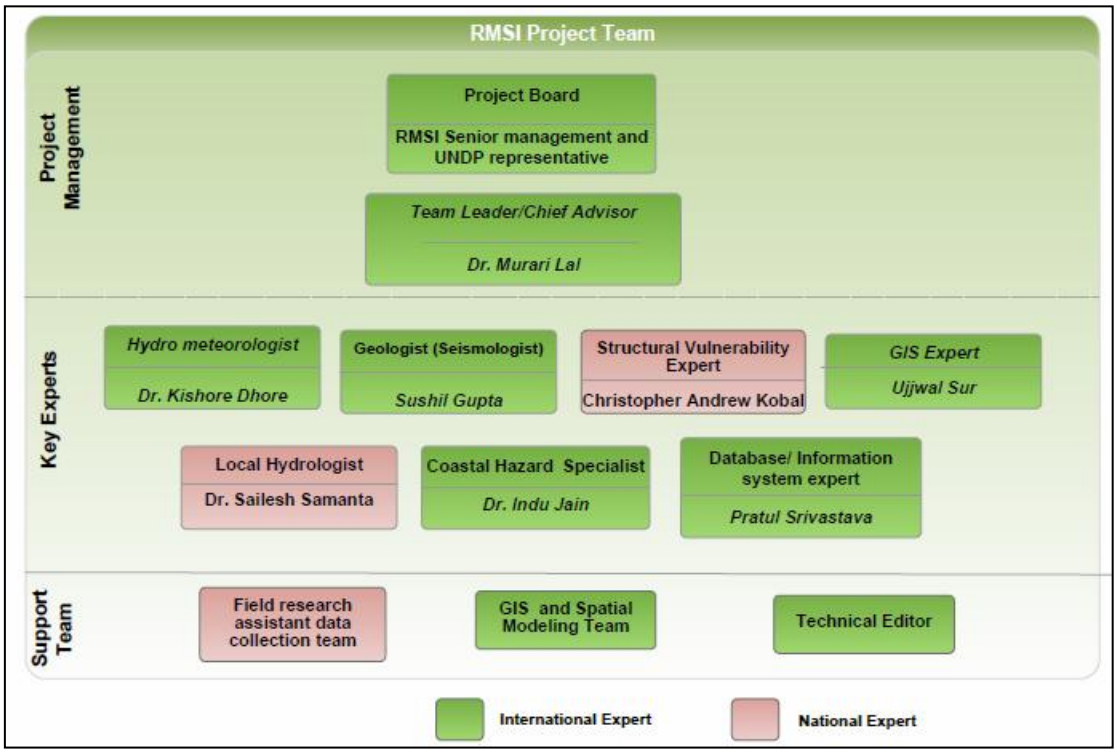

Figure 4-1: Study team structure

4.2 Deliverables

The following outcomes will form the deliverables under the present study:

1. Inland Flood extent maps for various return period events (2, 5, 10, 25, 50 and 100 Years) for all the 5 provinces
2. Coastal inundation extent maps due to coastal flooding for 5 identified provinces impacted from tides.
3. The seismic hazard maps for key return periods (250, 475, 2500 years) for 5 provinces having active seismic activities (unless OCCD and UNDP agrees to drop this to avoid duplication of efforts – we are awaiting response from OCCD/UNDP)
4. The detailed catalog of dataset used to carry for hazard assessments
5. A set of digital hazard dataset, for each hazard with all key return periods, in proper GIS formats, preferable stored in geodatabase, which can be readily integrated on a national risk information system
6. Detailed hazard profiles and report on the comprehensive provincial hazard profiles
7. A well structured documentation of all the methodologies used in the study
8. Technical documentation for technical training for hazard assessment

5 Consultation Workshops

RMSI will carry out two types of workshops – Technical staff training and Final workshop. The agenda for both the workshops will be designed carefully in consultation with OCCD and UNDP. The stakeholders for the participation of the workshop will be identified in consultation with OCCD / UNDP and provincial administration agencies. RMSI assumes that OCCD / UNDP will take care of the required logistics for the participants, venue location and facilities required for the workshop. RMSI will provide the technical handouts, will make presentation and coordinate discussions. The workshop will not only facilitate the dissemination of the findings of the study but will also keep all the stakeholders informed and be at the same level of understanding regarding the process/methodology as a result of which it would pave the way to develop a road map for ongoing Disaster Risk Reduction activities in PNG.

5.1.1 Technical staff's Training

This will be attended by all the selected technical staff from stakeholder organizations that have been identified to be involved with the project activity throughout the development process. The key objective of this training will be reinforce all the concepts, take them step by step through the entire process of the approach and methodology, and train them so they can train others in future. This will be a two-day training process and a tentative schedule of the training is provided in Table 5-1 below.

Table 5-1: Tentative agenda for Technical Staff training

S. No.	Days	Theme	Topics	Duration
1.	Day 1	Fundamentals	Refreshment of fundamental of hazard mapping and exposure development	9:30am – 11am
2.	Day 1	Hazard Assessment	Run-through on the hazard data and hazard model development process step by step using an exercise	11:30am – 1:30pm
3	Day 1	Probabilistic scenario development	Discuss step by step approaching using an exercise to probabilistic scenario creation including criteria identification and weighting determination	2:30pm – 4:30pm
4	Day 1	Exercises	Work through a set of exercises	4:30pm – 5:30pm
5	Day 2	Application of hazard assessment models	Discuss how the hazard model is combined with probabilistic scenario to conduct hazard assessment and its applications	9:30am – 11:30am
6	Day 2	Exercises	Work through a set of exercises	12pm – 1:30pm

S. No.	Days	Theme	Topics	Duration
7	Day 2	Hazard Mapping	Using digital hazard dataset for dynamic mapping	2:30pm – 4:30pm
8	Day 2	Exercises	Work through a set of exercises	4:30pm – 5:30pm
9	Day 2	Feedback and Project closure	Review of Project exercise Review of training and knowledge gained Project closure validation session	Close by 6pm

To conduct this training, detailed training materials will be prepared to cover each and every topic that is going to be discussed. The stress will be on demonstration of concept through solved examples followed by exercises that will be solved by the participants live during the training under the guidance of the trainer. The complete training material will be provided to the participants as digital training manuals along with all exercises properly solved.

5.1.2 NATIONAL STAKEHOLDERS WORKSHOP

The attendees of this back-to-back workshop mostly will be policy makers and selected representatives from stakeholder organizations in five provinces, relevant government organizations including OCCD and the UNDP. The key objective of the final workshop will be to share an overview of the methodology used for the assessment of various hazards, disseminating the key findings, the assumptions, the datasets used, the models adopted and explaining the implications to stakeholders. Tentative agenda for final national workshop is given in Table 5-2.

Table 5-2: Tentative agenda for final national workshop

S. No.	Days	Theme	Topics	Duration
1.	Day 1	Introductions and Fundamentals	Introduction to the Project, team and participants. Refreshment of fundamental of hazard mapping	9:30am – 10:30am
2.	Day 1	Hazard Profile	Overview on the data development and hazard assessment methodologies and result	10:45am – 12pm
3	Day 1	Thematic maps of Hazard Profile	Run-through the probabilistic hazard maps	12pm – 1pm
4	Day 1	Case scenarios with reference to a particular province	Demonstration of probabilistic hazard scenario and their implications for various provinces	2pm – 3:00pm

S. No.	Days	Theme	Topics	Duration
5	Day 1	Hazard Mapping Applications	Discussion on how these maps could be applied for development planning	3:00pm – 4:00pm
Tea Break				
6	Day 1	Feedback and Project closure (Special session as Validation workshop)	Review of Project exercise Review of training and knowledge gained Project closure validation session	4:30pm – 6pm

5.1.3 VALIDATION WORKSHOP

The workshop would be organized as a last session of the final national workshop wherein the highlights on outcome of the project undertaken by RMSI for five provinces would be discussed with OCCD and UNDP together with the concept of data sharing, viewing and extensive use of the integrated hazard maps. for various DRM activities. RMSI will also facilitate the introduction of data sharing approaches such as PostGRES/PostGIS open source relational Geodatabase and technical recommendations for ensuring continuing/dynamic hazard assessments for future activities with OCCD and UNDP.

References

BWR, 1990, Papua New Guinea Flood Estimation Manual, Papua New Guinea Department of Environment and Conservation, Prepared by Snowy Mountains Engineering Corporation Limited, Cooma, NSW, Australia, September 1990.

Annexure 1: Participant list for Hazard Assessment Inception Meeting, Wednesday, 29 January 2014, OCCD Conference room

Name	Designation	Organization	Email Address	Telephone #
Mr. George Kauli	Senior Research Officer	Department of Mineral Policy of Geohazards	george_kauli@mineral.gov.pg	(675) 321 4410 (Ext: 690), (675) 7607 3586
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Miss. Angeline Sawshi	Planning Coordinator	Department of Lands and Physical Planning		
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Mr. Akame Tunama	Director	PL & SMA		
Ms. Lyn Pokam	Acting Senior Coordinator	Department of Provincial Local Level and Government Affairs		72978024/301 1058
Mr. Wesley Welli	Aid Coordinator (ADB) Programme	Department of National Planning & Monitoring		
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Dr. Pratul Srivastava	Database/ Information System Specialist, Hazard	RMSI	Pratul.Srivastava@rmsi.com	

	Assessment Project			
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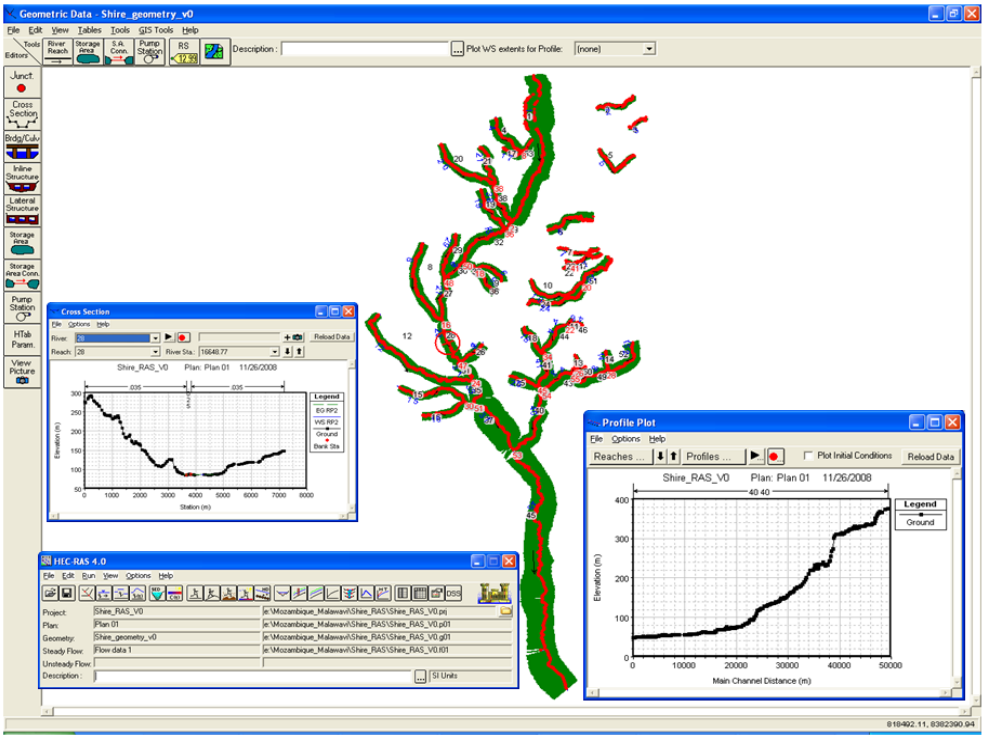
Annexure 2: HEC-RAS model

HEC-RAS model: Flood flows estimated in the probabilistic analysis will be provided as an input to the hydraulic modeling. The hydraulic modeling calculates flood elevations along streams and rivers for flood flows of various return periods ranging from the most frequent to rare events. Flood elevations are then used to delineate the aerial extent of flooding adjacent to the streams and rivers. This technical effort serves to identify areas of flood inundation within the floodplain that are at risk and subject to flood damage. Detailed hydraulic modeling requires an inventory of drainage conveyance structures, surveyed cross-sections of streams and rivers, and elevation information. In addition, site and aerial photographs, historical high water marks from past floods, and anecdotal flood observations all serve to guide a detailed hydraulic modeling. It is proposed to make use of high resolution DEM, if available. In the absence of high resolution DEM, the SRTM (Shuttle Radar Topography Mission) elevation data will be used to generate the most complete high-resolution digital topographic database of the earth. Its resolution is approximately 90 m. Some areas in the study area may not have adequate survey and topographic mapping to warrant detailed hydraulic modeling to predict flood elevations. In these instances, alternative approximate methods will be applied. The RMSI team has experience in applying U.S. Federal Emergency Management Agency (FEMA) approved approximate methods on many floodplain-mapping studies.

The team has applied hydraulic models on numerous flood hazard investigations. Many of these hydraulic investigations have been carried out for calculating flood elevations to standards established by FEMA. Derivation of flood extent, flood depths and flood velocity will be determined using 1D hydraulic modeling through the river system for all historical and return period events.1D model using Hydrologic Engineering Centre's River Analysis System (HEC-RAS) will be applied. In many applications of river flood modeling, a one-dimensional full hydrodynamic modeling system is used. In the areas, water surface profiles for reaches will be determined using one-dimensional steady flow analysis using HEC-RAS software. HEC-RAS is an integrated system that contains one-dimensional hydraulic analysis components for steady and unsteady flow simulation for a full network of natural and constructed channels. The basic computational procedure is based on the solution of the one-dimensional energy equation. Energy losses are evaluated by friction (Manning's equation) as also expansion and contraction losses. The momentum equation is utilized in situations where the water surface profile is rapidly varied. The situations include a mixed flow regime (USACE 2010). Basin geometric data consist of the river system connecting all segments, cross-section data, reach lengths, energy loss coefficients, and stream junction information. The river system schematic defines how the various river reaches are connected, as well as establishes the naming conventions for referencing all the other data. The connecting river reaches are important for the model to understand how the computations should proceed from one reach to the next. The river system schematic will be determined using HEC-Geo-RAS (an arc view extension for pre and post processing of RAS) in GIS environment using ESRI's Arcview. Estimated runoff will be routed through the river system using one-dimensional hydraulic analysis to delineate flood extents and depth. The Figure below shows the sample HEC-RAS geometry, cross section and water surface profile for a river network.



HEC-RAS geometry data

Annexure 3: Tidal Data Vintage

S.No	Station	Data available From (yyyy-MM-DD)	Data available To (yyyy-MM-DD)
https://www.bodc.ac.uk/data/online_delivery/international_sea_level/south_pacific			
1	Rabaul	1966-04-06 1971-12-31 1974-12-11 1975-01-01	1971-12-31 1971-12-31 1974-12-31 1997-12-31
2	Lombrum	1994-09-29 1995-01-01 1996-03-06 1997-01-01	1994-12-31 1995-12-31 1996-12-31 1998-12-31
http://ilikai.soest.hawaii.edu/uhslc/rqds.html			
3	Lae	1984-08-31	1997-12-01
4	Kavieng	1984-09-10	1994-12-31
5	Anewa Bay	1968-08-05	1977-12-31
6	Lombrum Manus Is.	1994-09-29	2012-12-31
7	Wewak	1984-08-29	1994-10-30
8	Madang	1984-08-22	1998-12-31
9	Port Moresby	1984-08-10	1993-12-31
10	Manus Island	1984-09-04	1994-12-31
11	Alotau	1984-09-21	1995-02-24
12	Rabaul	1966-04-06	1997-12-31

Annexure 4: Available Exposure Data and Identified Gaps

The project team has collected the following exposure data from various line ministries of PNG. The following tables show details of the data collected during the RMSI First Mission and the identified gaps.

Sl. No.	Data Types	File Name	Feature Types	Description
1	Administrative	ALL_PNG	Polygon	Country and province boundary
		final_ESK_boundary	Polygon	East Sepik boundary with Census information
		ESK_village	Point	East Sepik village names, codes and population
		MAD_boundary	Polygon	Madang boundary with census information
		MAD_village	Point	Madang village names, codes and population
		MOR_boundary	Polygon	Morobe boundary with census information
		MOR_village	Point	Morobe village names, codes and population
		NIR_boundary	Polygon	New Ireland boundary with census information
		NIR_village	Point	New Ireland village names, codes and population
		ORO_boundary	Polygon	Northern province boundary with census information
		ORO_village	Point	Northern province village name, code and population
2	Population & Household	ESK	Polygon	East Sepik district name with population and household information
		MAD	Polygon	Madang district name with population and household information

Sl. No.	Data Types	File Name	Feature Types	Description
		MOR	Polygon	Morobe district name with population and household information
		NIR	Polygon	New Ireland district name with population and household information
		ORO	Polygon	Northern province district name with population and household information
3	Infrastructure	ESP_AIRSTRIPS_point	Point	Names, types, classes, diameters, slopes, surfaces and authority in East Sepik
		MAD_Airports and Airstrips amg55_5_point	Point	Names, types, classes, diameters, slopes, surfaces and authority in Madang
		nir_Airports and Airstrips amg56_4_point	Point	Names, types, classes, diameters, slopes, surfaces and authority in New Ireland
		oro-Airports and Airstrips amg55_9_point	Point	Names, types, classes, diameters, slopes, surfaces and authority in Northern province
		MOROBE_AIRSTRIPS_point	Point	Names, types, classes, diameters, slopes, surfaces and authority in Morobe
		Mdg_Brg_amg55TAB_font_point	Point	Types, lanes and spans of bridges in Madang
		Morobe Bridge_font_point	Point	Types, lanes and spans of bridges in Morobe
		ESP_Brg_amg54TAB_font_point	Point	Types, lanes and spans of bridges in East Sepic

Sl. No.	Data Types	File Name	Feature Types	Description
		New Ireland Bridges amg56_font_point	Point	Types, lanes and spans of bridges in New Ireland
		nir_Airports and Airstrips amg56_4_point	Point	Airstrip length in New Ireland
		Oro_Brg_amg55_font_point	Point	Types, lanes and spans of bridges in Northern province
		ESepik Boat_polyline	Polyline	Boat route length in km in East Sepic
		Madang_all_boat_polyline	Polyline	Boat route length in km in Madang
		Morobe_Boat_Routes_polyline	Polyline	Boat route length in km in Morobe
		New Ireland Boat Routes_polyline	Polyline	Boat route length in km in New Ireland
		Oro Boat Routes_polyline	Polyline	Boat route length in km in Northern province
		MOROBE_ROADS_polyline	Polyline	Names, types, surface materials, conditions and length etc. information for roads in Morobe
		MOROBE_ROADS_polyline_ss	Polyline	Names, types, surface materials, conditions and length etc. information for roads in Morobe
		NIP Roads_polyline	Polyline	Names, types, surface materials, conditions and length etc. information for roads in New Ireland
		Oro Roads 270509_polyline	Polyline	Names, types, surface materials, conditions and length etc. information for roads in Northern province
		Madang_all_tracks_polyline	Polyline	Madang province all tracks length in km

Sl. No.	Data Types	File Name	Feature Types	Description
		ESP_Road_Cost_Final_edited_polyline_ss	Polyline	Names, types, surface materials, conditions and length etc. information for roads in East Sepic
		Madang Roads Cost Final 190209_Edited_polyline	Polyline	Names, types, surface materials, conditions and length etc. information for roads in Madang
		Morobe_Walk Routes_polyline	Polyline	Length (km) of walk routes in Morobe
		NIP Walk_polyline	Polyline	Length (km) of walk routes in New Ireland
		Oro_Walk Routes_polyline	Polyline	Length (km) of walk routes in Northern province
		ESepik Track_polyline	Polyline	Track length in km for East Sepic
4	Essential Facilities (Education, Health)	ESP_HEALTH_CENTRES_point	Point	East Sepic health centre information such as name, types, agencies and status etc.
		MAD_HEALTH CENTERS_point	Point	Madang health centre information such as name, types, agencies and status etc.
		MOROBE_HEALTH CENTER_point	Point	Morobe health centre information such as name, types, agencies and status etc.
		NIP_HEALTH_CENTRES_point	Point	New Ireland health centre information such as name, types, agencies and status etc.
		ORO_HEALTH_CENTRES_point	Point	Northern province health centre information such as name, types, agencies and status
		ESP_HIGH_SEC_SCHOOLS_point	Point	East Sepic higher secondary schools information such as name, codes,

Sl. No.	Data Types	File Name	Feature Types	Description
				districts, agencies, types and status
		ESP_PRIMARY_SCHOOLS_point	Point	East Sepic primary schools information such as name, codes, districts, agencies, types and status
		ESP_VOCATIONAL_SCHOOLS_point	Point	East Sepic vocational schools information such as name, codes, districts, agencies, types and status
		MADANG_HIGH SEC SCHLS_point	Point	Madang higher secondary schools information such as name, codes, districts, agencies, types and status
		MADANG_PRIM COMM SCHLS_point	Point	Madang primary schools information such as name, codes, districts, agencies, types and status
		MADANG_VOCATIONAL SCHLS_point	Point	Madang vocational schools information such as name, codes, districts, agencies, types and status
		MOROBE_HIGH SEC SCHLS_point	Point	Morobe higher secondary schools information such as name, codes, districts, agencies, types and status
		MOROBE_PRIM COMM SCHLS_point	Point	Morobe primary schools information such as name, codes, districts, agencies, types and status
		MOROBE_VOCATIONAL SCHLS_point	Point	Morobe vocational schools information such as name, codes, districts, agencies, types and status

Sl. No.	Data Types	File Name	Feature Types	Description
		NIP_HIGH_SEC_SCHLS_point	Point	New Ireland higher secondary schools information such as name, codes, districts, agencies, types and status
		NIP_PRIM_COMM_SCHLS_point	Point	New Ireland primary schools information such as name, codes, districts, agencies, types and status
		NIP_VOCATIONAL_SCHLS_point	Point	New Ireland vocational schools information such as name, codes, districts, agencies, types and status
		Oro_HIGH_SEC_SCHLS_point	Point	Northern province higher secondary schools information such as name, codes, districts, agencies, types and status
		ORO_PRIM_COMM_SCHLS_point	Point	Northern province primary schools information such as name, codes, districts, agencies, types and status
		ORO_VOCATIONAL_SCHLS_point	Point	Northern province vocational schools information such as name, codes, districts, agencies, types and status
5	Miscellaneous	GEOLOGY_PNG	Polygon	Geological Units with names, groups, formations, ages and lithology
		Coast	Polygon	Coastal boundary
		roads	Polyline	Road Polyline data with shape and id only
		river	Polyline	River Polyline data with shape and id
		png_towns	Point	Towns of PNG by district and census information

Sl. No.	Data Types	File Name	Feature Types	Description
		capitals	Point	Capital location with id and name

Table indicating gaps in exposure data collected during the first mission

Data Types	Sub-Type	Data Availability	Overall Data Gaps*
Administrative Boundary		✓	No Gaps
Census & Household	Census	✓	No Gaps
	Household	×	Not received
Built-up/Landuse	Residential	×	Not received
	Commercial	×	Not received
	Industrial	×	Not received
Transport Infrastructure	Road	✓	No Gaps
	Bridge	✓	No Gaps
	Airport	✓	No Gaps
	Seaport	Partially received	Only location names are available
Utilities	Electrical	×	Not received
	Communication	×	Not received
	Portable water network	×	Not received
	Waste water network	×	Not received
Essential Facilities	School	Partially received	Capacity, Staff, Structural information not available
	Health	Partially received	Capacity, Staff, Structural information not available
	Safe Shelter	×	Not received
	Fire Station	×	Not received
	Police Station	Partially received	Structural, staff, equipment information not available
Livestock		×	Not received
Agriculture		×	Not received

** The data gaps shown are as on March 06, 2014. The team is presently analyzing the input data received in detail and progressively will update the data inventory table in the course of the project*

END OF INCEPTION REPORT