TURTLE ISLANDS WILDLIFE SANCTUARY CLIMATE RISK AND VULNERABILITY ASSESSMENT

Coastal and Marine Resources Management in the Coral Triangle–Southeast Asia

CORAL TRIANGLE INITIATIVE
ON CORAL REEFS, FISHERIES AND FOOD SECURITY

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Chief Editor: Elvira C. Ablaza
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Copy Editor: Evelyn J. de la Cruz
Author: Dr. Rosa T. Perez
Production Manager: Dana Rose J. Salonoy
Layout: Criselda C. Escalante

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Front Cover: Aman Santos/TA 7813-REG

For more information, please contact:
Asian Development Bank
6 ADB Avenue, Mandaluyong City, 1550 Metro Manila, Philippines
Tel: +63 2 632 4444; Fax: +63 2 636 2444
www.adb.org

ABOUT THE PROJECT

The Global Environment Facility (GEF) and Asian Development Bank (ADB)–funded Regional Technical Assistance Coastal and Marine Resources Management in the Coral Triangle–Southeast Asia (TA 7813-REG) operates in the Sulu-Sulawesi Marine Ecoregion, specifically in Indonesia, Malaysia, and the Philippines (or the CT3).

The project works with communities and local leaders to help them better manage their resources, become better prepared to face climate change effects, and adopt environment-friendly and sustainable livelihood options.

The project also aims to address natural resource degradation, poverty within coastal communities, and weakness in coastal and marine resources management policy implementation.

The project has three main outputs:

- Supporting CT3 governments in establishing an enabling environment for sustainable coastal and marine resources management;
- Addressing constraints to sustainable fisheries management and economic development in the coastal zone, such as illegal, unreported, and unregulated fishing, overfishing, and natural habitat destruction, among others; and
- Establishing a project management system to ensure effective project implementation.

ACRONYMS

ADB	Asian Development Bank
ALOS	Advanced Land Observing Satellite
ARMM	Autonomous Region in Muslim Mindanao
BI	Bureau of Immigration
CDP	Comprehensive Development Plan
CLUP	Comprehensive Land Use Plan
DENR	Department of Environment and Natural Resources
GCM	Global climate model
GHG	Greenhouse gas
GIS	Geographic information system
IPCC	Intergovernmental Panel on Climate Change
JAXA	Japan Aerospace Exploration Agency
LGU	local government unit
MetMalaysia	Malaysian Meteorological Department
MGB	Mines and Geosciences Bureau
NAHRIM	National Hydraulic Research Institute of Malaysia
NIPAS	National Integrated Protected Areas System
NOAA	National Oceanic and Atmospheric Administration
OPASu	Office of the Protected Area Superintendent
PAGASA	Philippine Atmospheric, Geophysical, and Astronomical Services Administration
PAR	Philippine area of responsibility
PEIS	PHIVOLCS Earthquake Intensity Scale
PhilGIS	Philippine GIS Data Clearing house
PHIVOLCS	Philippine Institute of Volcanology and Seismology
PN	Philippine Navy
PSA	Philippine Statistics Authority
RCP	Representative Concentration Pathway
REDAS	Rapid Earthquake Damage Assessment System
RegCM4	Regional Climate Model 4
RETA	Regional Technical Assistance
SLR	sea level rise
SRES	Special Report on Emissions Scenarios
SRTM	Shuttle Radar Topography Mission
SST	sea surface temperature
TIWS	Turtle Islands Wildlife Sanctuary
WMO	World Meteorological Organization

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I. INTRODUCTION

A. Background

The ADB- and GEF-assisted Regional Technical Assistance 7813 for Coastal and Marine Resources Management in the Coral Triangle: Southeast Asia (CTI-SEA) (TA 7813-REG or RETA 7813) was conceived and approved to address issues pertaining to coastal and marine resources degradation, prevalence of poverty among coastal communities, and policy/institutional weaknesses in coastal and marine resources management (CMRM). The RETA is being implemented in the Sulu-Sulawesi Marine Eco-region (SSME) located in the Indo-Western Pacific region, the established center of the Coral Triangle (CT) encompassing Indonesia, Malaysia, and the Philippines.

The RETA is expected to result in the increased resilience of coastal and marine ecosystems and human communities in the Coral Triangle through improved management of coastal and marine resources in the SSME priority seascape. It supports the introduction of more effective management of coastal and marine resources, especially those associated with coral reef ecosystems, to build their resilience in a period of increased threats arising from human-induced and climate change impacts, thereby maintaining ecosystem integrity and productivity and ensuring the improved socioeconomic status of coastal communities.

One of the activities of RETA 7813 is assisting turtle conservation in the Turtle Island Wildlife Sanctuary (TIWS), which is a critical part of the sea turtle migration corridor that includes El Nido in Northern Palawan; Tubattaha Reef, Balabac Island in Southern Palawan; parts of Sabah, Malaysia; and Kalimantan in Indonesia. The RETA is working with the German Development Agency (GIZ) in studying climate change impacts on TIWS, which can provide the basis for socioeconomic planning and sea turtle management, as well as protect and benefit coastal communities. In accordance with an agreement with GIZ in 2013, the RETA is responsible for a climate risk and vulnerability assessment (CRVA) study of the local communities and the preparation of corresponding hazard maps, while GIZ is responsible for the biophysical component of the VA.

B. The CRVA Report

The objectives of the CRVA under this RETA are to: (i) obtain information on the socioeconomic status of coastal communities in the five inhabited islands of TIWS; (ii) extract information on climate-related occurrences in TIWS; and (iii) prepare natural hazard maps, including climate change scenarios, and assess the possible impacts under such scenarios.

This CRVA report deals with the results of the CRVA that was carried out in the islands comprising the TIWS. The report is composed of two parts. The first contains the findings of the purposive socioeconomic survey of respondents through interviews using questionnaires. The second part describes the hazards and presents the results of the exposure mapping using secondary information and ground validation.

II. REVIEW OF CONCEPTS

A. Island Vulnerability

Small islands differ from each other in terms of geography, culture, ecosystem, and population, as well as in their vulnerabilities and capacities. Island vulnerability is often a function of four key stressors: socioeconomic, physical, socioecological, and climate-induced factors. The biophysical characteristics of islands result in differential physical vulnerabilities, like being isolated, far from basic services, and low-lying. Socio-ecological stressors, such as habitat loss and degradation, presence of invasive species, overexploitation, pollution, human encroachment, and diseases, can harm biodiversity and reduce the ability of socio-ecological systems to bounce back after shocks.

To understand the climate risks and vulnerability of islands, it is necessary to assess all of these dimensions of vulnerability. IPCC (2014) has provided information proving that islands faced with multiple stressors can be assumed to be more at risk from climate impacts. However, despite the limited ability of continental scale models to predict climate risks for specific islands, or the limited capacity of island vulnerability indicators, scenario-based damage assessments can be undertaken.

The probability of change in frequency and severity of extreme rainfall events and storm surges in most of the small islands remains poorly understood. Other risks also remain under-researched. These include climate change driven health risks from the spread of infectious diseases, loss of settlements and infrastructure, and decline of ecosystems affecting island economies, livelihoods, and human well-being. Nevertheless, it is possible to consider these risks, along with the threat of rising sea level, and suggest a range of current and future adaptation issues and prospects for small islands.

In general, **risks** are a function of hazards, exposure, vulnerability, and coping or adaptive capacities. **Natural hazards** include geophysical (e.g., earthquakes, volcanic eruptions, earthquake-induced landslides), hydrometeorological (e.g., intense rainfall, intense tropical cyclones, storm surges, floods) and climatological hazards (e.g., long-term average temperature changes, long-term rainfall changes, heat waves, dry spells, and droughts), and sea level rise (SLR). **Exposure** refers to elements that are in the location where hazards are present. **Vulnerabilities** are climate and non-climate sensitivities of the systems being assessed. These refer to the degree to which the system can be affected by various factors, which may be biophysical, ecological, political, cultural, or socioeconomic in nature. In contrast, coping and adaptive capacities are factors that enable the system to cope with or adapt to the impacts and risks of climate change-induced events and other hazards. While the concept of coping capacity is more directly related to an extreme event (e.g., a flood or a typhoon), the concept of adaptive capacity refers to a longer time frame and implies that some learning is happening, either before or after an extreme event. Examples of adaptive capacity are availability and accessibility of resources, technology, institutional support, finances, and education.

B. Climate Change Risks

The IPCC Fifth Assessment Report (AR5) (2014) identified the following current and future climate-related drivers of risk for small islands in the 21st century: SLR, tropical and extra-tropical cyclones, increasing air and sea surface temperature (SST), and changing rainfall patterns. Current impacts associated with these changes include increased erosion and flooding due to SLR in low-lying coastal areas and atoll islands. Future risks associated with these drivers include loss of adaptive capacity and ecosystem services critical to lives and livelihoods in small islands. These could include the loss of turtle habitats and nesting grounds, degradation of available freshwater resources, and increased degradation of coral reefs. Given the dependence of island communities on coral reef ecosystems for a range of services like coastal protection, subsistence fisheries, and tourism, there is a high possibility that coral reef ecosystem degradation will negatively impact island communities and livelihoods. Considering the inherent physical characteristics of small islands, the IPCC AR5 (2014) reconfirms their high level of vulnerability to multiple stressors, both climate and non-climate.

Impacts will not be uniform for all islands. Small islands do not have uniform climate change risk profiles. Rather, their high diversity in both physical and human attributes and their response to climate-related drivers mean that climate change impacts, vulnerability, and adaptation will vary from one island to another. In the past, this diversity in potential response was not always adequately integrated in adaptation planning. Increased trans-island impacts are also recognized. These include the appearance of invasive species and incidences of threats to human health that enhance current threats to biodiversity. For island communities, the risks associated with existing and future invasive species and human health challenges are projected to increase in a changing climate. Box 1 at right provides an overview of future impacts of climate change on island communities. For marine turtles, anthropogenic threats to biodiversity include the destruction of their habitats, illegal fishing methods (e.g., dynamite, cyanide fishing, and trawling), continued poaching by local and foreign fishing vessels, and rampant egg collection. Climate change will exacerbate these conditions.

Box 1: Potential impacts of climate change on small islands (Source: IPCC, 2014)

Freshwater. Climate change is projected, by mid-century, to reduce water resources in many small islands to the point where they become insufficient to meet demand during low-rainfall periods.
Food and income. Deterioration in coastal conditions, like erosion of beaches and coral bleaching, is expected to affect local resources, especially fisheries, and reduce the value of these destinations for tourism.
Geophysical. Small islands have characteristics that make them especially vulnerable to the effects of climate change, sea level rise, and extreme events.
Way of life. Sea level rise is expected to exacerbate inundation, storm surge, erosion, and other coastal hazards, thus threatening vital infrastructure, settlements, and facilities that support the livelihood of island communities.
Agriculture and health. With higher temperatures, increased invasion by non-native species is expected to occur.

III. THE TURTLE ISLANDS WILDLIFE SANCTUARY (TIWS)

A. The Turtle Islands

The Turtle Islands is a group of nine islands located in the Sulu Sea, about 1,000 kilometers (km) southwest of Manila and 40 km north of Sandakan, Sabah. Six of the nine islands are in the Philippines, while the other three lie in Malaysia—all adjacent to the international treaty limit that separates the two countries.

The Philippines' Turtle Islands is actually composed of seven islands in the province of Tawi-Tawi. Six islands, also known as "Turtle Isles," on the Philippine side—Boan, Lihiman, Langaan, Great Bakkungan, Taganak and Baguan—cover around 308 hectares (ha) of land and are clustered as one municipality (fifth class) together with the seventh island, Sibaung. The seven islands, from northwest to southeast, are described below.

- **Taganak** is of volcanic origin and is the largest island of the group, with an area of about 116 ha.
- **Boaan,** also known as Boan, is the second largest island of the group, with an area of 76 ha.
- **Great Bakkungan,** also known as **Bakungaan,** is the third biggest island at 51 ha.
- **Lihiman** is a mud and coralline island of about 29 ha. The island is noted for its explosive mud volcanic extrusions.
- **Baguan** is the easternmost of the islands and is also volcanic in origin. The bell-shaped island has an area of 29.1 ha.
- **Langaan** is a flat coral island of about 7 ha.
- **Sibaung** is the smallest island, with an area of only 0.1 ha.

Taganak has the highest point of land and is approximately 148 meters (m) above sea level. Langaan is relatively flat and nested on an extensive coral reef platform. Except for Langaan, the terrain of the islands is generally undulating to rolling, particularly at the northern end. A unique feature of the islands is the presence of "mud volcanoes," the most prominent of which is in Lihiman, where violent mud extrusions have formed a 20 m crater on the hill at the northeast portion. Mud extrusions or volcanoes are also present in Bakkungan and Boan.

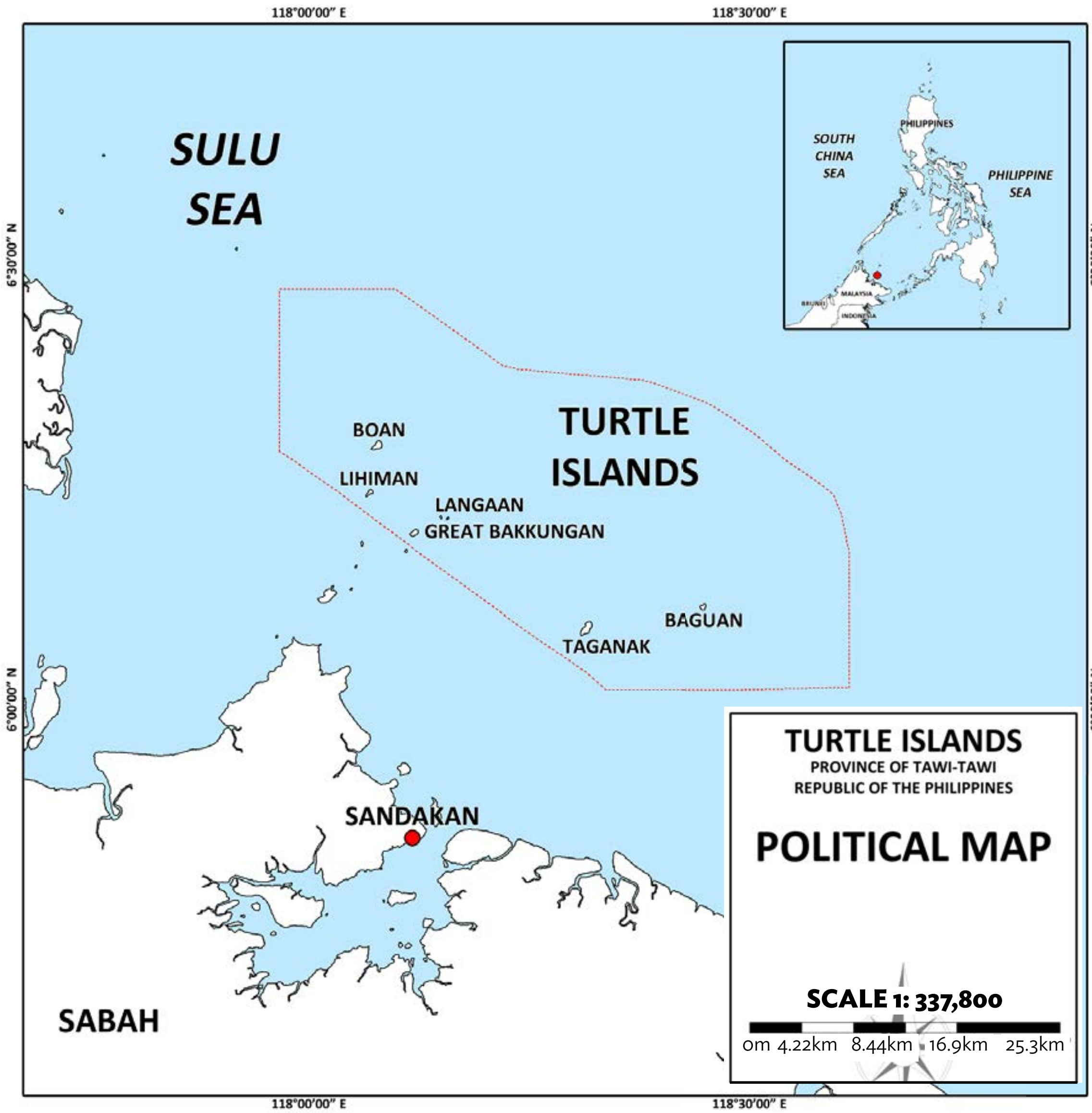
B. The Turtle Islands Wildlife Sanctuary

Along with the three islands of neighboring Malaysia and the surrounding coral waters, the Turtle Islands are one of the world's few remaining major nesting grounds for green sea turtles. In 1996, the governments of the Philippines and Malaysia jointly declared the islands as a Turtle Islands Heritage Protected Area (TIHPA). The declaration was seen as the only way to guarantee the continued existence of the green sea turtles and their nesting sites.

For the six islands, the Philippine Government decided to create special protection zones, where only scientific and conservation activities are allowed. In other zones, certain rules are adopted to prevent negative human impacts on the environment and the turtles. Visiting these zones is only possible with strict guidance and under the supervision of the staff of the government officials.

The Philippines' Turtle Islands were declared a wildlife sanctuary (TIWS) by *Presidential Proclamation No. 171* signed on 26 August 1999. The protected area (PA) is under the administration of the Protected Area Officer (PAO) of the Department of Environment and Natural Resources (DENR) in Region 9.

Figure 1. The Turtle Islands, Tawi-Tawi Province



UNIVERSAL TRANVERSE MERCATOR PROJECTION DATUM: WORLD GEODETIC SYSTEM 1984
Disclaimer: Administrative boundaries are approximate **Date:** July 2016

C. Geographic Location

The TIWS is a municipality composed of six major islands: (from west to east) Boan, Lihiman, Great Bakkungan, Langaan, Taganak, and Baguan, in the province of Tawi-Tawi on the southwestern tip of the Philippines (Figure 1). It is approximately located at the intersection of 6°10' N and 118°10' E. The island group lies within Sulu Sea and is adjacent to the international treaty limits that separate the Philippines and Malaysia. It is situated northeast of Borneo, south of Palawan, and northeast of Tawi-Tawi, and is about 1,000 km southwest of Manila.

D. Baseline Profile

1. Physiographic Features

The Turtle Islands, with a total area of 138,357 ha, is bounded by the Sulu and Mindanao Seas in the north and south and by the Celebes Sea in the east and south.

Rainfall in the Turtle Islands is more or less evenly distributed throughout the year. It falls under Climate Type III based on the Modified Coronas Classification. Average temperature ranges from 27-30°C. The islands' climate is governed by the northeast and southwest monsoons, which prevail from November to March and June to September, respectively. The North Pacific Trades dominate during the transition between the two monsoons.

Nearby weather stations are located in Sabah, Malaysia (Sandakan, 44 km south of Turtle Islands), and Mapun (Cagayan de Tawi-Tawi) in Southern Philippines (96.1 km northeast of Turtle Islands). Rainfall data from Mapun indicates that the wettest period in the southwestern Sulu Sea occurs in October and November, while the least amount of rainfall falls in March and April. Data from Sandakan shows that high rainfall occurs in December and January. Temperature ranges from 26-27.8°C, with January being the coolest month and May, the warmest. Relative humidity ranges between 78-86%.The area is mostly cloudy throughout the year, while wind speed averages at 3 km/sec annually. Meager data from Baguan show a similar rainfall trend in Sandakan, with the highest rainfall recorded in the months of December and January.

2. Hydrological Features

Potable water is sourced from artesian and open wells, which are found in most of the islands. Most of the islands have shallow aquifers. Surface water in the form of rivers, lakes, drainage, and basins is not found in the islands.

3. Geological Features

The Turtle Islands is an aggregation of small islands of diverse geological origin. Their geology ranges from coral-fringed volcanic Island (Baguan and Taganak) to non-volcanogenic sub-aerial mud volcanoes situated above sedimentary and volcanic rock substrate (Great Bakkungan, Lihiman, and Boan).

The Turtle Islands lies on the southwestern edge of the Sulu Sea Basin, a small marginal basin close to the southeast of the North Palawan Block. It is subdivided into two distinct sub-basins by a major bathymetric high—the Cagayan Ridge. The basin and ridge are generally oriented along a NE-SW axis.

[1] Traditionally, geologists have used different abbreviations for ages (time before present) and duration (amount of time elapsing between two different events). Ages are abbreviated from Latin: **Ga (giga-annum)** is a billion years, **Ma (mega-annum)** a million years, **Ka (kilo-annum)** a thousand years. (https://www.thoughtco.com/how-we-talk-about-geologic-time-3974394)

The northwest sub-basin is composed of basement rock that is either volcanic or continental (or both) in nature covered with a thick (6-8 km) sedimentary fill (Murauchiet et al., 1973; Mascle and Biscarrat, 1978). The southeast sub-basin is characterized by an oceanic basement overlain by a thin (1-2 km) cover of sediments (Mascle and Biscarrat, 1978). The oldest known sediments have been dated late Miocene to early Middle Miocene, while volcanic ash appeared at around 6 mega annum 1 (Ma) (Ranginet et al., 1989).The Cagayan Ridge is composed of volcanic material dated 14.7 Ma (Kudrasset et al., 1986, 1990). It corresponds to a volcanic arc that had been active until the end of the early Miocene. The oceanic crust of the southeast Sulu Sea Basin is presently undergoing subduction along the Sulu-Negros Trench.

4. Land Cover and Land Use

The existing land use pattern of the area is generally classified into agricultural/seasonal croplands, wooded areas, open areas with settlements, predominantly coconut plantations, secondary growth forests, grass/scrubland, and beach areas or sandy areas. Nine types of land cover can be observed in the islands and are broadly classified into natural and man-made. Man-made land cover includes the settlement and agricultural areas, while natural land cover types are grasses, brush/shrubs, wooded areas, and bare areas. The details are presented in Table 1.

It is interesting to note that only Baguan has bare areas, which are usually sandy beaches. These areas define the zone for nesting and potential hatchery sites of the green turtles. These also indicate that, in other areas where there are no such sites, the encroachment of human settlements along the coast is apparent. The bare areas are also an indication of the extent of coastal erosion, which may be due to the natural active costal processes or the rise in sea level from time to time.

Table 1. Summary of Types of Land Cover in the Islands of the Turtle Islands, Tawi-Tawi

Island	Land Cover								
	Settlement	Wooded + Agri	Open + Agri	Coconut	Open Grassland	Brush/ Shrubs	Wooded	Mangrove	Bare area
Taganak	X			X	X		X		
Boan	X	X		X	X			X	
Great Bakkungan	X	X		X	X				
Lihiman	X	X	X		X	X	X		
Langaan	X	X				X			
Baguan	X	X		X	X				X

[2] **Subduction** is a geological process that takes place at convergent boundaries of tectonic plates where one plate moves under another and is forced or sinks due to gravity into the mantle. Regions where this process occurs are known as subduction zones. Source: https://support.google.com/webmasters/answer/6229325?hl=en

IV. TIWS SOCIOECONOMIC SURVEY

From the end of August to December, turtles come by the hundreds from the surrounding coastal waters to dig and lay their eggs in the sand. In order to get a firsthand account of the threats of climate and weather-related changes, a purposive survey was conducted with 316 respondents in the populated barangays. In July 2014, a training of enumerators was conducted in Taganak Island to orient them on the use of the survey questionnaire developed by the RETA 7813 team, headed by the project's Climate Change Specialist. The questionnaire was designed to collect basic demographic information, socioeconomic data, observations and perceptions on weather patterns, coastal habitats and resources, as well as coping and adaptive capacity to respond to climate change. A separate questionnaire was designed for fishers to determine their perceptions of the status of habitats and resources in TIWS. The survey was conducted for a period of two months, with enumerators staying in the islands to conduct their interviews. The results of the survey are presented below.

A. Characterization of Respondents

A total of 316 questionnaires were accomplished, with 50% coming from Taganak, the island with the biggest population. The distribution of respondents from the different islands is shown in Figure 2. Of the total number of respondents, 260 (82%) are male, and 56 (18%) are female (Figure 3). Except in Boan, where there was an equal ratio of male and female respondents, majority of respondents in the islands are male.

Figure 2. Total Number of Respondents Per Island

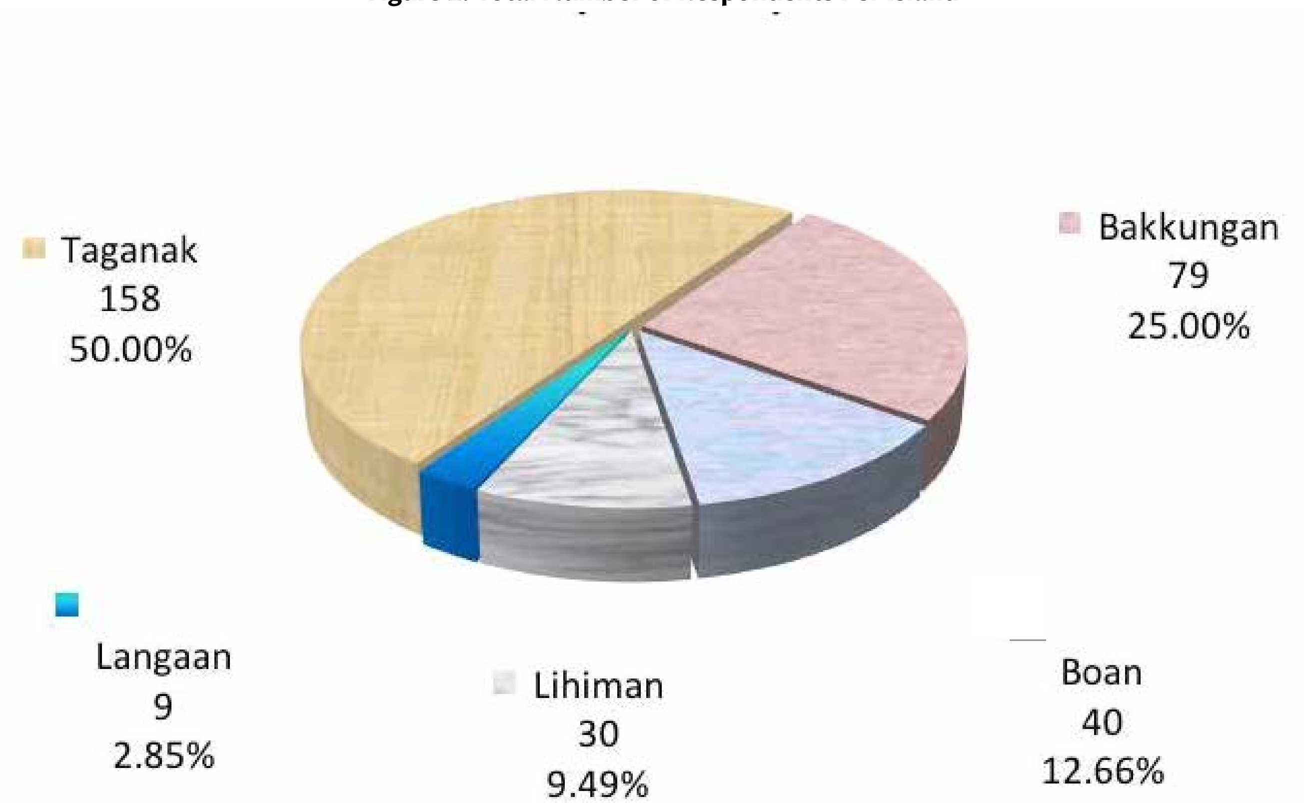
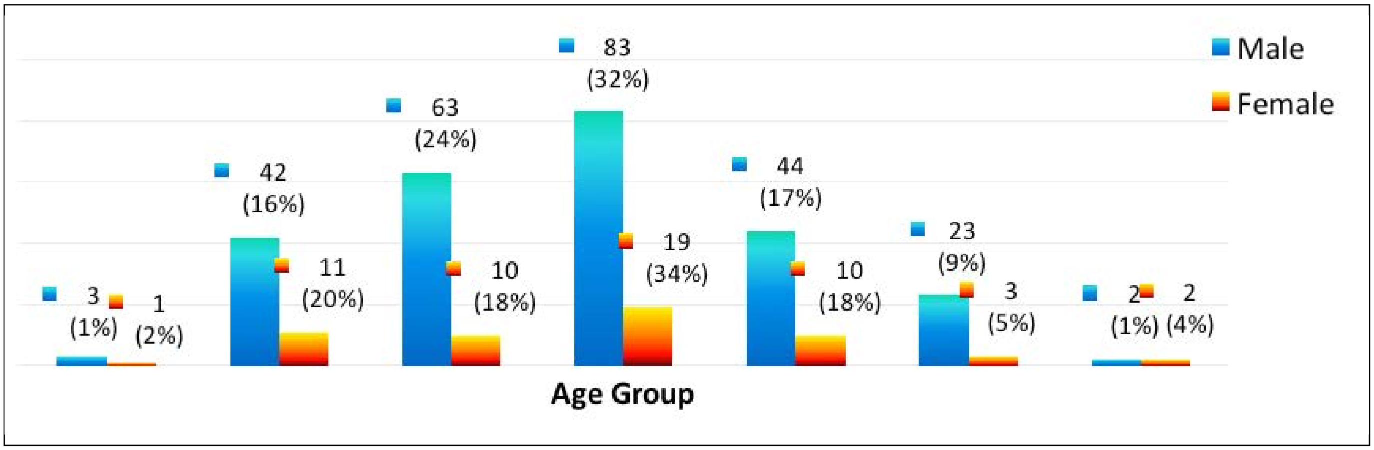


Figure 3. Ages of Male and Female Respondents in Five Islands



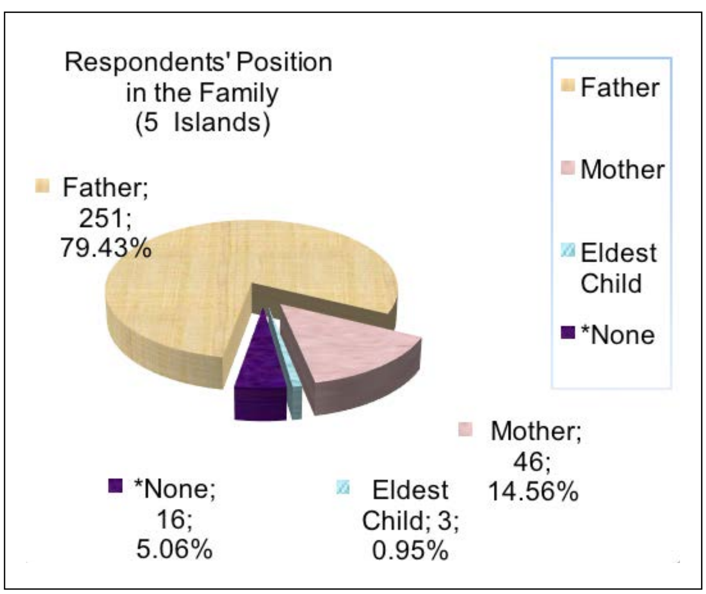
The male respondents were mostly 40-49 years old (32%), followed by those in the 30-39 age group (24%). Those in the 20-29 age bracket and 50-59 age group comprised 16% of respondents. Roughly 23 (9%) respondents were 60 years old and above.

Similarly, majority of the female respondents (34%) were 40-49 years old (34%), followed by those in the 20-29 age range (20%). Those in the 30-39 and 50-59 age ranges had the same percentage of respondents (around 18%).

Respondents from the five islands rely on their natural resources as a source of livelihood to support their families. The main source of income reported was fishing, at 72% (226), followed by farming (around 17%). The rest of the respondents had different occupations (like government employee, store owner, laborer, and boat operator), while a few were unemployed (5%) or did not give a response.

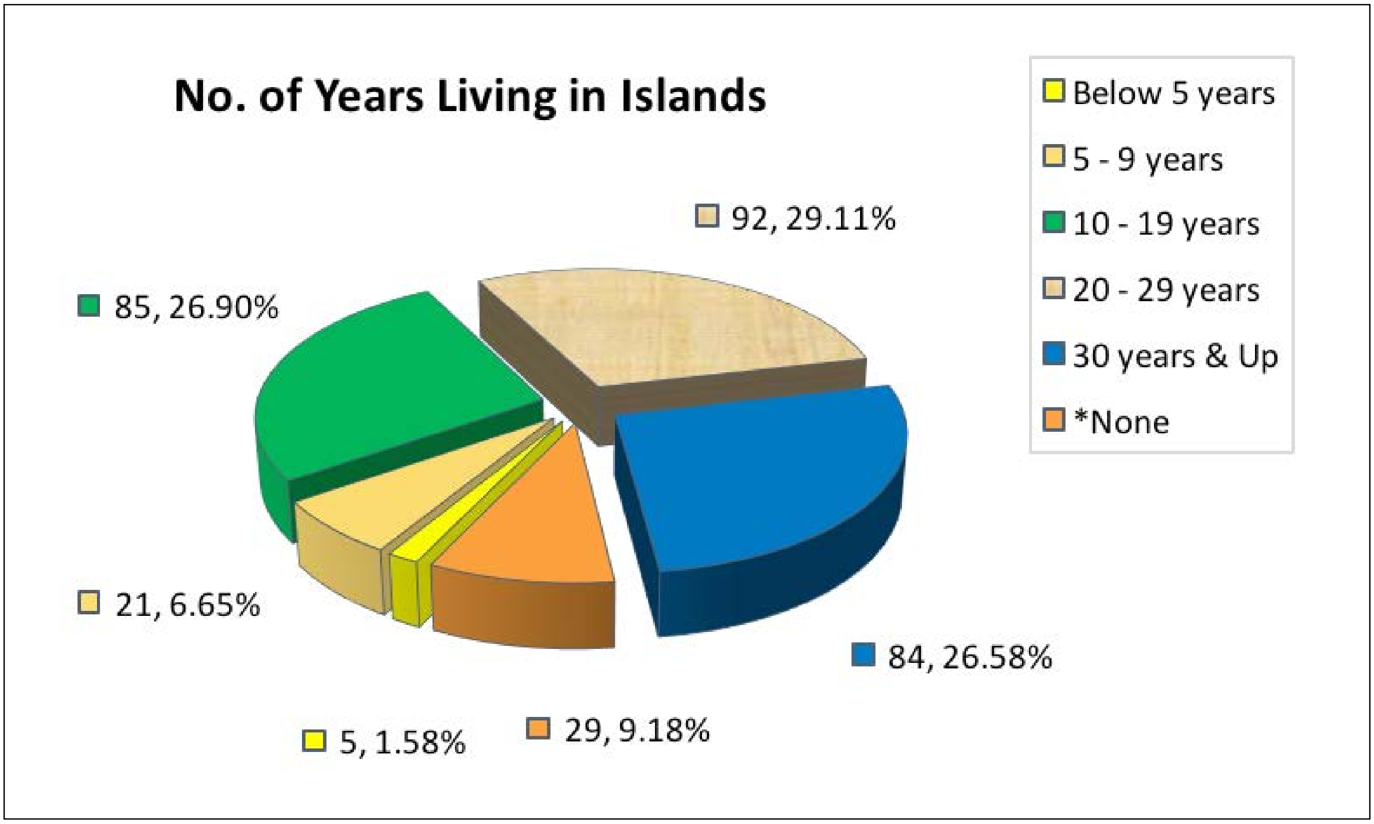
Of the total male respondents, a large majority (79%) were heads of their families while female respondents were mostly mothers (Figure 4).

Figure 4. Respondents' Position in the Family in Five Islands



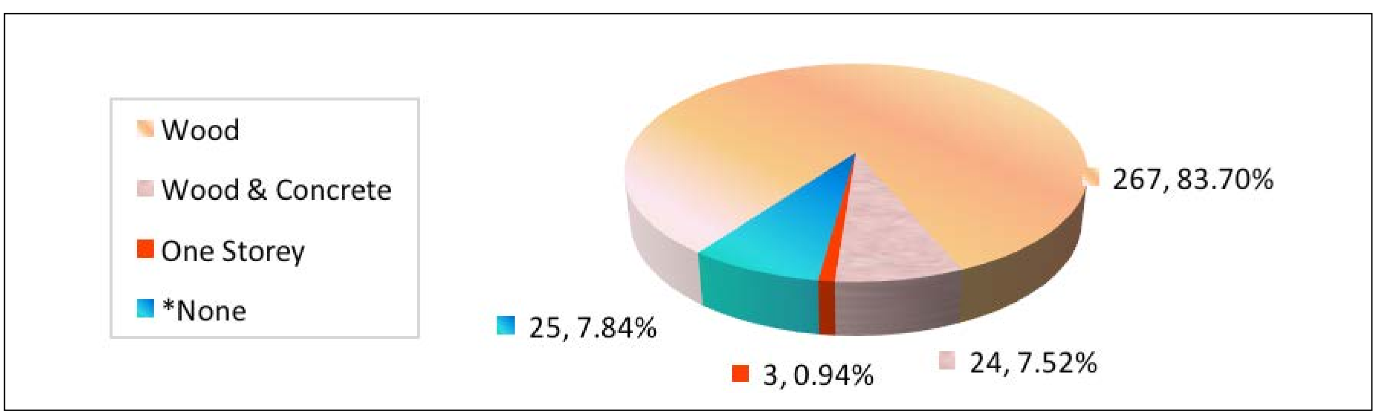
In terms of their length of stay in the Turtle Islands, a combined total of 176 respondents (56%) said that they have been living in their island for at least 20 years. Around 27% (85) have been in their island for 10-19 years; the rest have been in Turtle Islands for nine years or less (Figure 5). With the proximity of Sandakan Island (45 minutes from Taganak by speedboat), many residents of the Turtle Islands take seasonal work in Sandakan or other parts of Sabah, although the number cannot be verified as workers take the "backdoor" route—that is, they do not pass through immigration either through the Philippines or Malaysia.

Figure 5. Number of Years of Residence in the Islands



With the typical island conditions and the absence of tropical cyclones in the Turtle Islands, it is no surprise that 83% (267) of respondents reported that their houses were made entirely of wood, while 24 (7%) said that their houses were a mix of concrete and wood. Around 8% did not give a response (Figure 6).

Figure 6. Type of House of Respondents in Five Islands



B. Socioeconomic Features

1. Number of Communities/Barangays and Population

The Turtle Islands is politically subdivided into two barangays: Barangay Likod or Likud Bakkao and Barangay Dambilah or Taganak Poblacion. Barangay Likud is composed of three sitios situated within Taganak Island: Bakkao, Pallang, and Limao-Limao. Barangay Likud Bakkao comprises the islands of Boan, Lihiman, Langaan, Bakkungan, and Baguan in the southwestern side of Taganak Island, which is called Poblacion. Information on the population of these islands is given in Table 2.

Table 2. Population of Two Barangays

Barangay	Population
Likod (Likud Bakkao)	1,342
Dambilah (Taganak Poblacion)	2,430
	3,772

Source : 2010 census

2. Sources of Livelihood

Most of the inhabitants (63.2%) in the area depend on fishing-related livelihood activities. The most widely used fishing gears are hook and line, fish nets, and fish traps *(bubo)*. Around 11% of the total number of households supplements their living by farming, mostly by growing cassava at a subsistence level.

3. Tourism and Recreation

Tourism is still to be developed in the Philippine side of the Turtle Islands, in stark contrast to the islands under Malaysian jurisdiction. Selingan Island, in particular, has become a top tourist destination where the waiting period for tourists to view nesting turltes and release hatchlings is at least six months. The Philippines' Turtle Islands boast of unique attractions: an active mud volcano (in Lihiman), a dazzling sandspit (Langaan), colorful and rich coral reefs, and the large number of nesting turtles in Baguan Island. However, the distance from the Tawi-Tawi mainland, lack of regular and safe transport, absence of tourism facilities, and growing security concerns, hinder the development of a bustling tourism industry, similar to what can be found in the Malaysian islands. The Philippine government has in fact earmarked 28 million pesos a few years ago to establish pilot tourism infrastructure in Taganak Island, but the delay in developing the tourism masterplan, securing the necessary environmental clearances, and the change in political administration, have been major setbacks in realizing this tourism project for TIWS.

C. Threats and Vulnerabilities

The islands are experiencing the effects of active geo-morphological processes—short-term, seasonal, and long-term movements. These processes have resulted in changes in shoreline configuration and a certain degree of erosion. The effects of SLR on the islands have not been adequately evaluated, although studies indicate they could range widely from minimal to catastrophic.

Today, the population swells when there is open conflict in Mindanao and shrinks when immigration policies allow economic migrants to find greener pastures in Sabah. The people of the Turtle Islands, therefore, are highly vulnerable to changes in the ecosystem since their livelihoods depend directly on the sea.

The islands are visited by more than 2,000 turtle nesters every year, making it a major nesting ground for marine turtles, including green sea turtles and hawksbill turtles. However, like in many areas in the SSME, turtles are hunted for their meat and shell. In response to the decline in the world's population of marine turtles, the International Union for Conservation of Nature (IUCN) has classified all marine turtle species as endangered.

Turtle eggs are culturally and economically valued in Tawi-Tawi and are traditionally eaten by locals. This has resulted in excessive egg collection, especially in Baguan. Threats to the marine turtle population paved the way for the Philippine government to declare the islands as the Turtle Islands Wildlife Sanctuary or TIWS through Republic Act (RA) 7586 in 1999. Baguan has since been declared as a strict protection zone with no human inhabitants allowed, except for wardens who patrol the area and monitor nesting incidences. Although egg collection in the other islands, except Baguan, has been regulated under a 60:40 arrangement between the local government and local collectors, the demand for turtle products is still high in the international market, thus putting sea turtles still at grave risk.

Other social problems present in TIWS, as reported by the ASEAN Biodiversity Information Sharing Service, are: (i) the high incidence of intrusion of foreign vessels in the vicinity of Taganak Island; (ii) illegal fishing, (iii) the use of TIWS as a jump-off point for smuggling; and (iv) its use as a jump-off point for illegal migration to Sabah.

D. Summary of Respondents' Perceptions on the Current Situation

1. Physical Conditions

Temperature. Of the respondents, 96% observed that the dry season now is considerably hotter than in the past; 3% said that there has been no change or difference in the dry season temperature; while 1% said that the temperature is actually lower than in previous years.

Rainfall. About 46% of the respondents said that there are fewer days with rainfall, while 38% said there are fewer rainy months. With respect to rainfall volume, 53% said that rainfall volume has decreased. Interestingly, 24% observed the opposite, saying that the volume of rain has actually increased. Around 15% did not notice any difference.

Severe dry season. Majority reported having experienced a severe dry season, with 5% (15) saying that it happened in 1999, 2001, 2004, 2010, and 2014. About 51% (160) of the respondents did not give the year when they experienced a severe dry season. When asked how often they experience a severe dry season, 29% (93) said it happens every 3 years, while 7% (23) said it occurs every 7 years. Around 29% (93) could not remember the frequency.

Shoreline changes. When the respondents were asked if they had observed any changes in the shoreline, only 49% (154) responded. Of this total, 41% (128) said that the shoreline was getting closer, while 8% (26) claimed that the shoreline was retreating. As to the distance in the change in the shoreline, the average reported was 13 m.

Disasters. The islanders have experienced a number of natural disasters in recent years. Around 78% (247) of the respondents said that powerful storms, which hit the islands, carried strong winds and heavy rains. Others (30%) gave varied answers but most experienced big waves brought by "typhoons"[3] that hit the shoreline.

In Taganak, the respondents experienced disasters in 1997, 1998, 1999, 2000, 2003, 2007, 2010, 2011, 2012, and 2013. These were typhoons that brought huge waves and heavy rains, causing flooding. A

[3] These are the perceptions of the respondents and may not be the same as the actual instrumented observations

tornado was also experienced in Taganak in 2000. Respondents in Bakkungan recalled disasters in 1997, 2000, 2008, and 2010. A tornado hit the island in 1997 and 2008. Lihiman respondents experienced disasters in 2010 (tornado), 2012 (tornado), 2013 (tornado with lightning), and 2014 (lightning that hit houses and trees). In Boan and Langaan, disasters encountered were caused by very strong winds and rains, which toppled houses and destroyed or damaged boats.

General observations[4] on present weather patterns. In the last few years, changes in present weather patterns have been observed. In previous years, the dry season (summer) began in April and ended in September, with some cloudy days experienced in the summer months. At present, the dry season starts in March and ends in October, but summer is getting much hotter than usual (with no clouds). April to September can be especially hot. In the past, it rained from October to February; at present, the rainy season starts in November and ends in February. Heavy rains and stronger winds with big waves are experienced in December and January.

Changing weather patterns have adverse effects on human health, livelihood, and the environment. On **human health,** majority (87%) of the respondents said that temperature and rainfall changes have caused them to suffer from frequent coughs and cold, while 20% (64) said that the humidity has made them uncomfortable. They identified the following diseases that are climate change-related (according to rank): diarrhea, gastroenteritis, asthma, and fever/flu. Other less frequently cited diseases were chest pains, heat stroke, skin disease, headache, difficult breathing, and rheumatism.

With respect to **livelihood,** following are some of the effects of bad weather conditions on the livelihood of islanders: (i) poorer fish harvest of fishers, resulting in lower earnings; (ii) inability of fishers to venture into deeper waters, where they can catch more fish, because of the big waves and strong winds; (iii) inability of farmers to plant crops due to extreme heat; (iv) delays in work due to bad weather; and (v) higher incidence of diseases, such as respiratory illnesses.

Around 254 (80%) respondents said that temperature and rainfall changes have affected their business/livelihood because they cannot work properly with the extreme heat or heavy rains. Such weather conditions have especially affected fishers, who comprise majority of the respondents. Of the respondents engaged in agriculture, 27 (9%) reported reduced harvests due to the very dry soil and limited water during summer. Two respondents recounted that their animals died from extreme heat.

Bad weather conditions also cause unfavorable environmental conditions, such as the following: (i) Large amount of trash along the shoreline as a result of the strong winds and waves; (ii) movement of the shoreline closer to human settlements; (iii) increasing coastal (sand) erosion; (iv) saline water in wells, especially during rainy days, and dry wells during the hot months; (v) proliferation of insects that are vectors of diseases like dengue; (vi) increasing plant mortality due to the severe heat and lack of water; and (vii) crowding of local populations.

2. Target Habitats and Resources: Conditions, Trends, Threats, and Recommended Solutions

a. Marine Resources and Habitats

Fishery resources. The five Turtle Islands had a total of 226 fishermen-respondents, with 109 coming from Taganak, 73 from Bakkungan, 20 from Lihiman, and 7 from Langaan. Almost 60% (135) of the respondents observed that most of their catch consists of fish staying in the upper water column

[4] These are the perceptions of the respondents and may not be the same as the actual instrument-based observations.

[5] Note that the total number of responses exceeds 100% because some respondents (presumably operating more than one type of fishing gear) gave two answers.

[6] The total number of responses is 104% because some respondents gave more than one answer.

(pelagic) like tuna, mackerel (alumahan, hasa-hasa), anchovies (dilis), and round scad (galunggong). Around 30% of the fishers (68) said that they get mixed species both from the top and bottom of the water column, while the rest (14%) reported that they catch bottom dwelling species (demersal)[5].

Around 52% (117) said that their average catch is 3-8 kg/day, with the lowest average catch cited by 20% (46)at below 3 kg/day. On the other hand, 31% (70) said that they catch more than 8 kg/day[6]. About half (51%) of the fisher-respondents (116) said that most of their catch consists of juvenile fish, and about 44% (99) of the fishers often catch undersized, immature fish. Only a few (14) fishers (16% of total) reported catching mostly big fish.[7]

More than half (52%)of the respondents (118) said that they see few or none of the juveniles of commercially important species, and there is no fixed season or time of the year when these species appear. However, 47% (107) have observed some of these commercially important fish species during the peak season, but did not identify the species. Only eight respondents (4%) claimed seeing an abundance of these fish species during the peak months.[8] Majority (86%) of the respondents (195) have observed a drastic change in their catch composition over the last 20 years, while 14% (30 fishers) said that there has been little or no change at all.

Almost 90% (201) of the fisher-respondents use gillnet *(pante),* hook and line *(kawil),* and *sudsod.* Around 10% (22) use fixed and mobile types of fishing gear, while 3% (5) use only fixed or stationary gears.[9]

Around 37% (83) of them reported that more than 50% of their fish catch consists of wave-resistant species (e.g., wrasse, parrotfish, damselfish, and acanthurids). More than half (57%) of the respondents (128) said that 15-50% of fishes caught are wave-resistant species. The rest (12%) reported that less than 15% of their catch consists of wave-resistant fish species like butterfly fish and damselfish.[10]

Around 30% (68) of the respondents estimate that 5-10% of the total fish density in their area consists of reef fishes. However, 63% (143) claimed that reef fishes comprise less than 5% of the total fish density in their area. Only 10% (23) said that reef fishes constitute more than 10% of total fish density. A substantial percentage (63%) of the total respondents declared that reef fishes constitute only 5% of the overall fish density, while 30% (68) of the respondents stated that reef fishes comprise 5-10% of the total fish density in the area. Only 10% (23) of respondents said that reef fishes constitute more than 10% of the total fish density.[11]

Only 27% (or 85 out of 316 respondents) answered the question on the severity of climate change impacts on the fisheries. Of those who responded, 91% (77) said that the impact on fisheries is low, while 8% (7) said that it has been moderate. Only one respondent said that the impact of climate change is high. As to how future climate threats will affect the fisheries (the target resource), 84% (70) believed the impact would be high, while 16% (13) said that the effect of climate threats would be moderate.

The fisher-respondents attribute the observed decline in fish populations, especially of commercially valuable species, in the islands to the use of illegal fishing techniques, such as *hulbot-hulbot* (Danish seine fishing), a method of fishing that uses a seine, a large net with sinkers on the bottom and floats on the top edge, that hangs vertically in the water; cyanide fishing, and *tampasak.* Other factors include competition from Malaysian trawlers and other commercial fishing boats that fish in their waters, as well as the use of “superlight” by some commercial fishers.

[7] The total number of responses is slightly over 100%, as three fishers selected two choices.
[8] The total number of responses slightly exceeds 100% as a few respondents gave two answers.
[9] The total number of responses is more than 100% since three respondents selected two choices.
[10] Some respondents selected two choices; hence, the total responses exceeded 100%.
[11] The total number of responses is more than 100% as some respondents selected two choices.

The respondents, therefore, strongly recommended that the local government take immediate action to address the problems. They suggested that the LGU seek help from the military to stop illegal fishing and the entry of illegal fishers into Taganak. They also proposed the conduct of regular patrols in the area to catch violators of fishing regulations. Another proposed measure is the prohibition of the use of compressors in fishing. Most importantly, they recommended that fisheries laws be fully implemented.

Turtles. Taganak and Lihiman islands identified sea turtles as a target resource. They noted that the condition of turtle populations in their islands is poor and nesting sites are getting fewer. They also noticed that the number of turtles has gone down, and attributed this decline to the following factors: (i) Malaysian trawlers and Chinese fishing boats that poach on sea turtles; (ii) illegal collection of eggs; (iii) sand quarrying; (iv) trawl fishing; and (v) docking of boats on the shoreline and the presence of objects, such as drums, that impede the movement of nesting turtles.

Of the 316 respondents, only 2% (7) provided answers to questions relating to climate change impacts on sea turtles. Around 70% (5) said that impacts on sea turtles will be low; 57% (4) predicted that future impacts will be moderate; and 29% (2) said the effect will be high.

Respondents commented that it is impossible for the locals to solve these problems without help from the government. The government (local and, presumably, national) must step in to prevent the entry of trawlers and assign patrols to monitor turtle nesting and protect the animals. The local government should also identify specific docking areas for boats.

Coral reefs. Most of the respondents in the five islands identified coral reefs among their most important resources. Around 65% (148) of respondents estimated that 25-50% of their coastal waters have coral reefs; while 15% (33) stated that the area occupied by coral reefs is more than 50%. Some 20% (46) think that the area of coral reefs in their locality is less than 25% of the total area.[12]

About 54% (122) of the respondents stated that the coral reefs are of medium size (presumably fringing reefs), while 33% (75) said the coral reefs in their locality occur in small, isolated patches. Only 14% (31) of fishers said that the coral reefs in their locality are big and occupying a large area of the coastal waters.[13]

The fisher-respondents said that the reefs in their islands are in poor condition and that the degradation is continuing. They cited the use of illegal or destructive fishing practices, which scrape the sea bottom and damage the reefs, such as *tampasak* and *hulbot-hulbot,* as well as the use of dynamite, cyanide, and compressor fishing.

Of the 119 (38%) respondents who gave their opinion on the severity of past climate change impacts on corals, 93 (78%) said that past impacts were low, while 25 (21%) said the impacts were moderate. Only one person said that the effects were high. Of the 114 (36%) who responded to the question on future climate change impacts on corals, 19 (17%) said that future impacts would be moderate, but 95 (83%) believed that corals would be greatly affected by future climate-change-related threats.

The following recommendations were offered by the respondents to mitigate climate change effects on the coral reefs: (i) stronger implementation of fishery laws by the local government, (ii) penalizing violators of fishery laws, (iii) patrolling near shore waters to deter illegal fishers, (iv) coral rehabilitation/replanting, and (v) issuance of fisheries ordinances.

Mangroves. Boan island is the only island in TIWS with a sizeable mangrove stand (roughly 150 mature trees dominated by *Sonneratia alba (pagatpat)*—based on a 2015 visit by the ADB-RETA team. Non-climate-related threats to the mangrove resources in the islands include the cutting of mangrove trees for

[12] The total number of responses exceeds 100% as one respondent selected two choices.
[13] The total number of responses slightly exceed 100% since two fishers selected two answers.

charcoal-making and firewood and the destruction of mangrove saplings by some fishing boats docked in the area.

All the 15 (5%) respondents, who answered the question on past and future climate change impacts on mangroves, said that past impacts had been moderate. The same number of people believed that future climate change threats on mangroves would remain moderate. Nevertheless, they suggested the (i) planting of mangroves (although they will need seedlings for this purpose) and (ii) relocating the docking area of boats away from the mangrove stands.

The sea. Only the respondents from Taganak identified the sea as a target habitat/resource, explaining that their livelihood and basic activities are all tied up with the sea. The respondents said that dumping garbage into the sea causes water pollution, and cited the problem of waste disposal in Taganak. They suggested the passage of an ordinance on solid waste management by the local government.

Sand, rocks, and stones. These resources were identified as target resources only by respondents in Taganak. They have observed the faster rate of shoreline erosion and disappearance of rocks and stones along the coastline, which they attributed to the quarrying that is being done by the locals for sale of sand to buyers in Dambilah, also known as Taganak Poblacion, one of the barangays.

Only five (2%) respondents shared their observations on past and future climate change impacts on the aforementioned resources. All of them said that past impacts were low, but future impacts would be high. They, therefore, cited the need for the local government to pass an ordinance to regulate quarrying in their area.

b. Terrestrial Resources

Crops and vegetation. These were identified as target resources by respondents from three islands (Boan, Lihiman, and Bakkungan), who consider them as a significant source of income, next to fishing. The crops grown in Boan, Lihiman, and Bakkungan are banana, corn, eggplant, cassava, and watermelon, to mention a few.

The respondents identified the following as non-climate-related threats to their crop resources: (i) decreasing harvest of fruits/crops; (ii) animals foraging or destroying their crops/vegetation; (iii) pests, such as worms and insects, destroying the crops/vegetation; and (iv) lack of farming implements

Of 32 (10%) respondents who shared their views on previous climate change impacts on crops, 22 (69%) said that the impacts were moderate, while 9 (28%) said the impacts were low. Future climate impacts will be moderate according to 27 (84%) respondents and low according to 3 (9%) respondents. The respondents request the local government to provide them with fertilizers and pesticide sprays and suggest that the government should fence off the crop plantations to prevent the entry of foraging animals.

Trees. Trees constitute another target resource in the islands, and one of the important tree species is *agoho (Casuarina equisetifolia),* a pine-like native tree commonly seen along the coastlines of TIWS. Respondents shared their concern about their tree resources, which they reported to be getting degraded and diminishing each year because of continuous cutting. They said that *agoho* is difficult to propagate or to cultivate because of the severe heat.

Respondents identified the following as non-climate-related threats to the tree population in the islands: (i) cutting of trees by residents to make charcoal, firewood, and fish traps, and/or to build houses; and (ii) foraging of young plants by animals.

Only 29 (9%) answered the questions related to the effects of climate change effects on trees. Of this number, 69% (20) said the effects were moderate while 31% (9) said that the effects were minimal. On the severity of future impacts, 83% (24) were of the view that the effect of climate change on trees in the future would be moderate, while 14% (4) believed that the impact would be high. Nevertheless, the respondents suggested the following measures to protect the natural tree population in the islands: (i) conducting a tree planting program; (ii) sourcing seeds from authorized agencies; and (iii) implementation of measures to protect the remaining tree resources.

3. Target Socioeconomic Resources

The respondents identified the following target socioeconomic resources in their islands: health, fishing, clean water, farming, settlements, and livelihood and small businesses.

The health of the locals in the five islands is affected by changes in climate. During the hot or dry season, a lot of people get sick, and changing weather makes the people vulnerable to diseases like fever, diarrhea, hypertension, colds, cough, heatstroke, and headache. In the remote islands (Boan, Lihiman, and Bakkungan), a major concern of respondents is the difficulty of bringing the sick to the health clinic in Taganak, especially during the rainy season when the winds are strong and the waves are big. The severe heat they experience during the dry season also delays the response to health emergencies. Respondents also reported the increase in salinity in their deep wells during the rainy season, which they think is somehow related to the higher incidence of diseases. During the dry season, the wells dry up.

Fisher-respondents claimed that they cannot go fishing in deep waters due to strong winds and high waves during the rainy season. Consequently, their catch suffers. During the dry season, the extreme heat can also affect their health and fishing activities.

In the three islands of Boan, Lihiman, and Bakkungan, respondents involved in farming said that they cannot grow vegetables and crops during a severe dry season as the land turns very dry, and bats eat the remaining vegetation.

Taganak and Bakkungan respondents observed that traditional settlements are getting overcrowded, and many residents get sick because of the congestion. As a result, more families are building their houses along the shoreline and dump their trash/waste everywhere. There is poor discipline among the residents where solid waste management is concerned.

The Taganak and Bakkungan respondents also said that climate change has been affecting small businesses and livelihoods in their areas, as bad weather conditions prevent them from doing their work or making a living.

4. Communities' Adaptive/Coping Capacity

Estimates of population density in the islands varied among the fisher-respondents. Half of them said that there are around 200-400 people per square kilometer (km^2) in their island, while 18% (41) said that there are less than 200 people per km^2. Ten fishers (4%)—two from Bakkungan, one from Taganak, and seven from Boan—estimated that there are more than 400 people per km^2 in their island.

Some 248 respondents (77% of total) admitted that their families do not do anything when there is a disaster, other than stay at home and wait for the hazard to subside. Only three respondents said that their families go to the designated evacuation centers during emergencies, while two respondents said that they contact their barangay officials for help, especially for food and shelter. According to one LGU respondent, there is only one evacuation center with facilities and shelter (presumably in Taganak). Around 19% (60) of the respondents said that rationing of food and water is one of the services that the LGU provides during natural disasters. One respondent added that providing health services and medicines is another form of assistance done by the barangay.

V. HAZARD AND RISK MAPPING

A. Methods and Limitations

The elevation data used in hazard (flood, landslide, and SLR) assessments were sourced from JAXA. The elevation data have a resolution of 30 m horizontally (30 m mesh) and were compiled using images acquired by the Advanced Land Observing Satellite (ALOS). The administrative boundaries were obtained from the Philippine Geographic Information System Clearing House (PhilGIS).[14] Spatial distribution of population in the Turtle Islands was taken from Digital Globe satellite imageries. Collection of groundtruth data, conduct of field survey, and assessment of population exposure to various hazards in the Turtle Islands were conducted from 17-21 July 2016.

All the hazard susceptibility maps produced show the location of the hazards and the extent of area covered. Vulnerability of the area was determined based on the exposure level of the population to various hazards. All hazard maps are only indicative and do not necessarily equate with the hazards present in the area. LGUs can only use the maps for localized emergency response and landuse planning. Caution must be exercised in the use of the maps. They should not be used for insurance and bank appraisal purposes or for emergency life-and-death situations.

The climate projections of the Turtle Islands were adopted from various secondary data, specifically projections from Tawi-Tawi Province (PAGASA, n.d.) and even East Sabah Region (MetMalaysia, 2009) since there is no weather station in the municipality, and local climate projections in the Turtle Islands are absent.

1. Climate Projections

Climate projections of seasonal temperature and rainfall in Tawi-Tawi are provided in two time periods—historical climate (1971-2000) and projected future climate (2011-2040)based on the statistical downscaling of three global climate models (GCMs) (BCM2, CNCM3, and MPEH5) and two greenhouse gas (GHG) emission scenarios (SRES A1B and A2 and PAGASA, n.d.). On the other hand, climate projections in East Sabah are provided in three time periods representing the first quarter (2020-2029), middle (2050-2059), and end of the 21st century (2090-2099) relative to 1990-1999 period using SRES A1B (MetMalaysia, 2009).

In IPCC (2007), SRES A2 (high-range emission scenario) connotes that society is based on self-reliance, a continuously growing population, anda regionallyoriented economic development, but with fragmented per capita economic growth and technological change. SRES A1B (medium-range emission scenario) indicates a future world with a very rapid economic growth, with the global population peaking in mid-century and declining thereafter, and there is a rapid introduction of new and more efficient technologies with energy generation balanced across all sources. For purposes of discussion in this report, medium-range(SRES A1B) and high-range (SRES A2) emission scenarios will be used.

The initial climate projection maps of the Turtle Islands and vicinity were obtained from the Manila Observatory and then reconstructed for a geographic information system (GIS) overlay. The maps were modeled after RegCM4 under the RCP8.5 scenario, which corresponds to the high-range emission scenario and is characterized by increasing GHG emissions that lead to high GHG concentrations over time (Riahi et al., 2011). It should be noted that the climate projection maps are not representations of the climate projections made by PAGASA (n.d.).

[14] https://www.philgis.org/

2. Floods and Landslides

Landslide and flood hazard maps in the Philippines are usually obtained from the Mines and Geosciences Bureau (MGB). However, none of these are currently available for the Turtle Islands. To produce hazard susceptibility maps, the elevation data were subjected to various analysis in accordance with the landslide and flood susceptibility parameters set by MGB using GIS software (Tables 3 and 4). However, not all these parameters were used due to the scarcity of available data, such as soil characteristics and rock mass strength in landslide. Data on frequency or return period are also not available; thus the probability of occurrence in the future cannot be estimated with an acceptable level of reliability. In addition, the flood hazard maps produced are only indicative for large flood events and are useful only in determining places to avoid during extreme heavy rainfall.

3. Earthquake-Related Hazards

Rapid Earthquake Damage Assessment System (REDAS) software was used to produce seismic hazard maps for the study area. REDAS is a hazard and risk simulation software developed by the Philippine Institute of Volcanology and Seismology (PHIVOLCS),which aims to provide quick and near real-time simulated earthquake hazard map information before and immediately after an earthquake. However, due to the limitations of the built-in Shuttle Radar Topography Mission (SRTM) elevation data within the software and the relatively small size of the study area, only small-scale maps of ground shaking and tsunami hazards were produced.

The simulated maps were based on a worst case scenario from a major seismic source zone. It was assumed that a magnitude 8.0 earthquake occurred, emanating from the Sulu Trench, with the epicenter 115 km NNW of Bongao, Tawi-Tawi, and 138 km east of the Turtle Islands and the hypocenter at an underwater depth of 40 km. The tsunami magnitude was calculated using the Abe (1989) empirical equation. Simulated hazard maps were displayed in PEIS.

Table 3. Standardized Landslide Susceptibility Parameters Set by MGB

Parameters	Susceptibility		
	Low	**Moderate**	**High**
Slope gradient	Low to moderate (<18°)	Moderate to steep (18°-35°)	Steep to very steep (>35°)
Weathering/soil	Slight to moderate	Moderate	Intense; soil usually non-cohesive
Rock mass strength	Very good to good	Fair	Poor to very poor
Ground stability	Stable with no identified landslide scars, either old, recent, or active	Existing soil creep and other indications for possible landslide occurrence	Evident active or inactive landslides; present tension cracks, bulges, terracettes, and/or seepages
Human-initiated effects			May be an aggravating factor

Table 4. Standardized Flood Susceptibility Parameters Set by MGB

Parameters	Susceptibility		
	Low	Moderate	High
Flood height	Areas likely to experience flood heights of <0.5 m	Areas likely to experience flood heights of 0.5-1 m	Areas likely to experience flood heights >than 1 m
Flood duration	Areas likely to experience flooding of <1 day	Areas likely to experience flooding of 1-3 days	Areas likely to experience flooding of >3 days
Landform/geomorphic feature	Low hills and gentle slopes	Fluvial terraces, alluvial fans, and in-filled valleys	Topographic lows, i.e.,active and abandoned river channels, areas along river banks
Geomorphic feature	Low hills and gentle slopes	Fluvial terraces, alluvial fans, and in-filled valleys	Topographic lows, i.e. active and abandoned river channels, areas along river banks
Drainage density	Sparse- to moderately-spaced drainage	Moderately-spaced drainage	Closely-spaced drainage
Prone to flashflood	No	No	Maybe

4. Sea Level Rise

Using the same elevation data from JAXA, SLR maps were generated based on four simulation scenarios of 1.0 m, 2.0 m, 4.0 m, and 6.0 m SLR with the aid of a GIS software.

B. Climate Change and Natural Hazard Characterization

1. Climate Projections in Tawi-Tawi

Seasonal temperature change. In the absence of local climate projections in the Turtle Islands, projected climate data were derived from Tawi-Tawi Province (PAGASA, n.d.). Although the municipality of the Turtle Islands is part of Tawi-Tawi, projections in the latter are only indicative and do not necessarily equate to actual climate projections in the former.

Tables 5-8 summarize the projected changes in seasonal maximum and minimum temperatures under medium-range and high-range emission scenarios. The seasonal variations are defined as:

- DJF(December, January, February) or northeast monsoon, locally known as amihan season;
- MAM (March, April, May)orsummer or transition season;
- JJA (June, July, August)or summer west monsoon, locally known as *habagat*; and
- SON (September, October, November) transition from *habagat* to amihan.

Table 5. Projected Maximum Temperature Increase (°C) Under Medium-Range Emission Scenario in 2011-2040 Based on 1971-2000 Historical Values (PAGASA, n.d.)

Global Climate Models	Historical Climate (1971-2000)				Future Climate (2011-2040)			
	DJF	MAM	JJA	SON	DJF	MAM	JJA	SON
BCM2	32.1	32.5	31.1	31.6	0.4	0.6	0.5	0.4
CNCM3	32.2	32.6	31.1	31.7	0.5	0.7	0.8	0.6
MPEH5	32.1	32.6	31.0	31.7	0.5	0.5	0.8	0.4

Table 6.Projected Maximum Temperature Increase (°C) Under High-Range Emission Scenario in 2011-2040 Based on 1971-2000 Historical Values (PAGASA, n.d.)

Global Climate Models	Historical Climate (1971-2000)				Future Climate (2011-2040)			
	DJF	MAM	JJA	SON	DJF	MAM	JJA	SON
BCM2	32.1	32.5	31.1	31.6	0.4	0.6	0.6	0.4
CNCM3	32.2	32.6	31.1	31.7	0.6	0.6	0.5	0.5
MPEH5	32.1	32.6	31.0	31.7	0.6	0.4	0.8	0.4

Table 7. Projected Minimum Temperature Increase (°C) Under Medium-Range Emission Scenario in 2011- 2040 Based on 1971-2000 Historical Values (PAGASA, n.d.)

Global Climate Models	Historical Climate (1971-2000)				Future Climate (2011-2040)			
	DJF	MAM	JJA	SON	DJF	MAM	JJA	SON
BCM2	25.3	25.2	24.2	24.5	0.2	0.3	0.4	0.3
CNCM3	25.4	25.3	24.2	24.6	0.4	0.3	0.5	0.6
MPEH5	25.3	25.2	24.1	24.6	0.4	0.3	0.4	0.3

Table 8. Projected Minimum Temperature Increase (°C) Under High-Range Emission Scenario in 2011-2040 Based on 1971-2000 Historical Values (PAGASA, n.d.)

Global Climate Models	Historical Climate (1971-2000)				Future Climate (2011-2040)			
	DJF	MAM	JJA	SON	DJF	MAM	JJA	SON
BCM2	25.3	25.2	24.2	24.5	0.1	0.4	0.4	0.2
CNCM3	25.4	25.3	24.2	24.6	0.3	0.3	0.4	0.5
MPEH5	25.3	25.2	24.1	24.6	0.3	0.3	0.4	0.3

The average maximum temperatures in Tawi-Tawi from 1971-2000, based on the three GCMs, were 32.1-32.2°C in DJF, 32.5-32.6°C in MAM, 31.0-31.1°C in JJA, and 31.6-31.7°C in SON (Tables 5 and 6). The average minimum temperatures from 1971-2000 were 25.3-25.4°C in DJF, 25.2-25.3°C in MAM, 24.1-24.2°C in JJA, and 24.5-24.6°C in SON (Tables 7 and 8). Thus, the coldest months in Tawi-Tawi are June, July, and August, and the hottest months are March, April, and May.

Projected highest increases in maximum temperatures in the medium-range emission scenario from 2011-2040 relative to historical (1971-2000) values are 0.6°C in MAM on BCM2 and 0.8°C in JJA on both CNCM3 and MPEH5 (Table 5). In the high-range emission scenario, the maximum temperatures will increase, at their highest, by 0.6°C in MAM and JJA on BCM2, by 0.6°C in DJF and MAM on CNCM3, and by 0.8°C in JJA on MPEH5 (Table 6).

The minimum temperatures under the medium-range emission scenario will increase by a maximum of 0.4°C in JJA on BCM2, 0.6°C in SON on CNCM3, and 0.4°C in DJF and JJA on MPEH5 (Table 7). For the high-range emission scenario, minimum temperatures are expected to be much warmer by 0.4°C in MAM and JJA on BCM2, 0.5°C in SON on CNCM3, and 0.4°C in JJA on MPEH5 (Table 8).

In general, present-day temperatures in Tawi-Tawi are expected to increase by a maximum of 0.8°C from 2011-2040. This means that the change in temperatures shown in the projections above under the medium-range emission scenario is already being experienced at present. Note that all GCMs under both emission scenarios are plausible to happen in the future. The highest temperature increase for both scenarios is projected during habagat or JJA season.

Furthermore, the Manila Observatory (2005) ranks the province as 8th among the top 20 provinces at risk from projected temperature increase based on projected 2080 climatology. The neighboring provinces of Sulu and Basilan are the top two provinces at risk. In addition, current temperatures in the Western Mindanao regions, ARMM, and Zamboanga Peninsula are expected to exceed the critical 2.0°C threshold by 2050 (PAGASA, 2011).

Seasonal rainfall changes. In addition to projected changes in seasonal maximum and minimum temperatures, there will also be changes in seasonal rainfall in the future. Tables 9 and 10 summarize the seasonal rainfall change from 2011-2040 under medium-range and high-range emission scenarios. Rainfall data indicate that Tawi-Tawi receives the most rainfall from June to August. However, such data do not correlate to the meager rainfall data obtained from Baguan *(see Climate subsection in baseline profile).*

Table 9. Projected Changes in Seasonal Rainfall (%) Under Medium-Range Emission Scenario in 2011-2040 Based on 1971-2000 Historical Values (PAGASA, n.d.)

Global Climate Models	Historical Climate (1971-2000)				Future Climate (2011-2040)			
	DJF	MAM	JJA	SON	DJF	MAM	JJA	SON
BCM2	7.8	75.7	313.9	165.0	26.1	-7.7	-3.2	4.7
CNCM3	13.1	55.2	396.6	161.9	86.0	35.6	22.0	32.4
MPEH5	5.1	42.9	374.9	143.3	59.4	45.4	14.9	39.4

Table 10. Projected Changes in Seasonal Rainfall (%) Under High-Range Emission Scenario in 2011-2040 Based on 1971-2000 Historical Values (PAGASA, n.d.).

Global Climate Models	Historical Climate (1971-2000)				Future Climate (2011-2040)			
	DJF	MAM	JJA	SON	DJF	MAM	JJA	SON
BCM2	7.8	75.7	313.9	165.0	13.6	-8.1	2.8	4.3
CNCM3	13.1	55.2	396.6	161.9	14.5	30.9	5.2	17.4
MPEH5	5.1	42.9	374.9	143.3	6.3	45.7	-4.8	43.0

Projected rainfall data under a medium-range emission scenario indicates that Tawi-Tawi will experience more rains during DJF in 2011-2040 relative to 1971-2000 values—26.1% more on BCM2, 86% more on CNCM3, and 59.4% more on MPEH5 (Table 9). Under a high-range emission scenario, the province will experience wetter summer seasons on CNCM3 and MPEH5 models: 30.9% and 45.7% more rainfall in 2011-2040, respectively (Table 10). It must be noted that all GCMs in both emission scenarios could happen in the future.

Overall, Tawi-Tawi is projected to have increased rainfall in the period, 2011-2040. Similarly, the change in rainfall shown in the projections above under a medium-range emission scenario is already being experienced in the area. ARMM and Zamboanga Peninsula are the only regions in Mindanao that are projected to experience an increase in rainfall in 2020 (PAGASA, 2011).

2. Climate Projections in East Sabah Region

The Turtle Islands lies only 44 km north of Sandakan in the East Sabah region of East Malaysia. Owing to its proximity, climate scenarios in the region can also be indicative of projections in the Turtle Islands (MetMalaysia, 2009).

Tables 11 and 12 show the projected annual mean temperature increase and rainfall change, respectively, under a medium-range emission scenario in 2020-2029, 2050-2059, and 2090-2099 relative to the 1990-1999 period. Baseline (1990-1999) values were not provided by MetMalaysia (2009).

Table 11. Projected Annual Mean Temperature Increase (°C) Under Medium-Range Emission Scenario Relative to the 1990-1999 Period (MetMalaysia, 2009)

Region	2020-2029	2050-2059	2090-2099
East Sabah	1.0	1.7	2.8

Table 12. Projected Annual Rainfall Changes (%) Under Medium-Range Emission Scenario Relative to the 1990-1999 Period (MetMalaysia, 2009)

Region	2020-2029	2050-2059	2090-2099
East Sabah	-17.5	-12.8	-3.6

The projected increase in mean temperature in East Sabah is 1.0°C in 2020-2029, 1.7°C in 2050-2059, and 2.8°C in 2090-2099 (Table 12). Rainfall projections suggest that the region will receive less rainfall: 17.5% less in 2020-2029, 12.8% less in 2050-2059, and 3.6% less in 2090-2099 (Table 13).

A detailed comparison with the climate projections in East Sabah and Tawi-Tawi was not made due to the absence of baseline values for the climate projections in East Sabah. However, both projections conclude that there will be an increase in temperatures in the future. On the other hand, rainfall projections indicate that East Sabah will experience drier periods in 2020-2029,while Tawi-Tawi, in general, will be wetter from 2011-2040.

3. Climate Change Projections Using a Regional Climate Model

The climate projection maps were modeled after RegCM4 under RCP8.5 or the high-range emissions scenario. It must be noted, however, that maps presented here are not representations of the climate projections made by PAGASA (n.d.)

Average annual temperature. Projections show that from a 28-30°C annual average temperature over the period, 1971-2000, in the Turtle Islands (Figure 7), the annual average temperature will increase to 30-32°C in 2011-2040 and 2036-2065 (Figures 8 and 9). Likewise, the northern and southern portions of Sandakan, which experienced annual average temperatures of 26-28°C and 28-30°C in 1971-2000, respectively, will be warmer by 2°C in 2011-2040 and 2036-2065.

Figure 7. Historical Average Annual Temperature in the Turtle Islands and Vicinity, 1971-2000

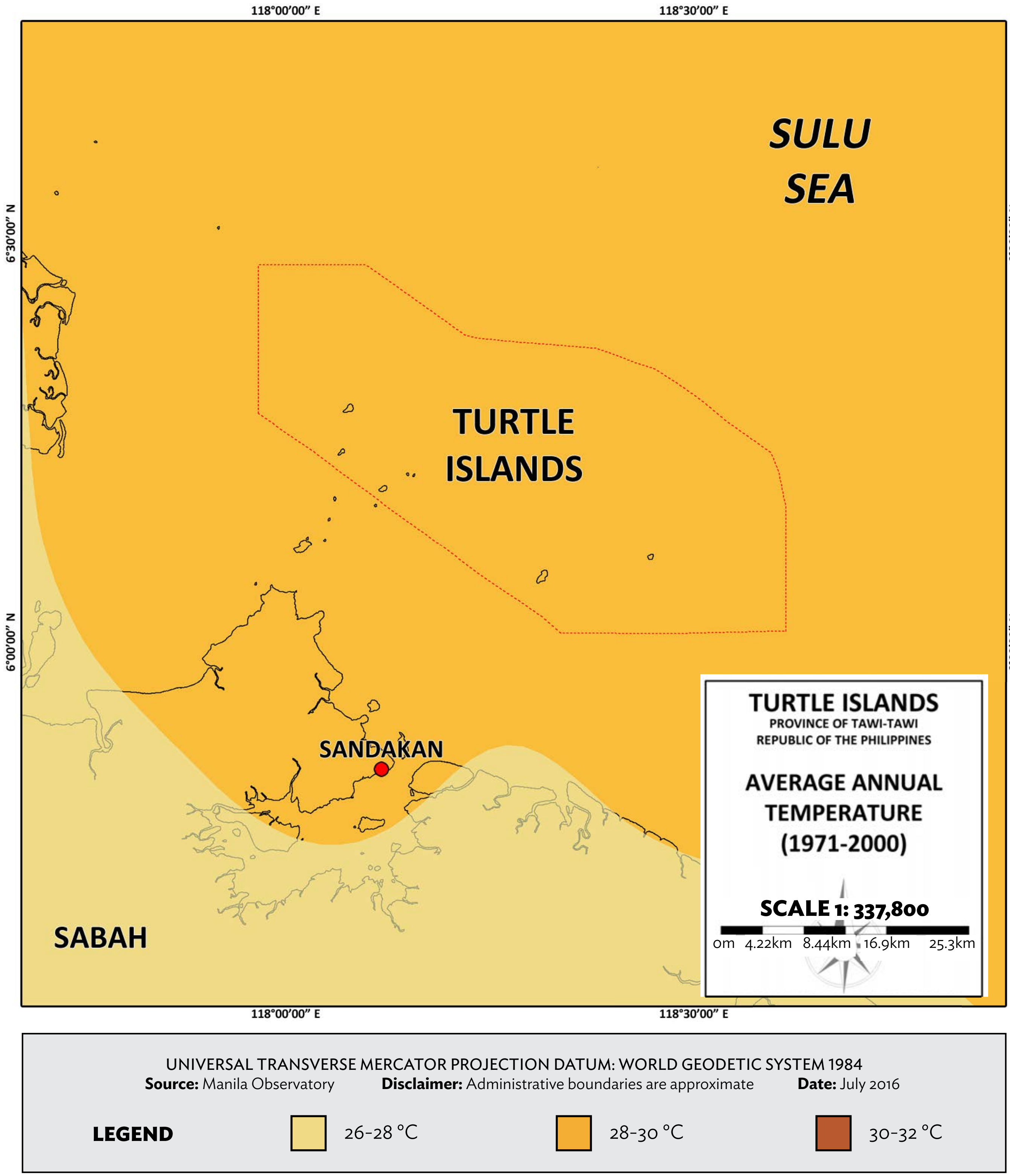
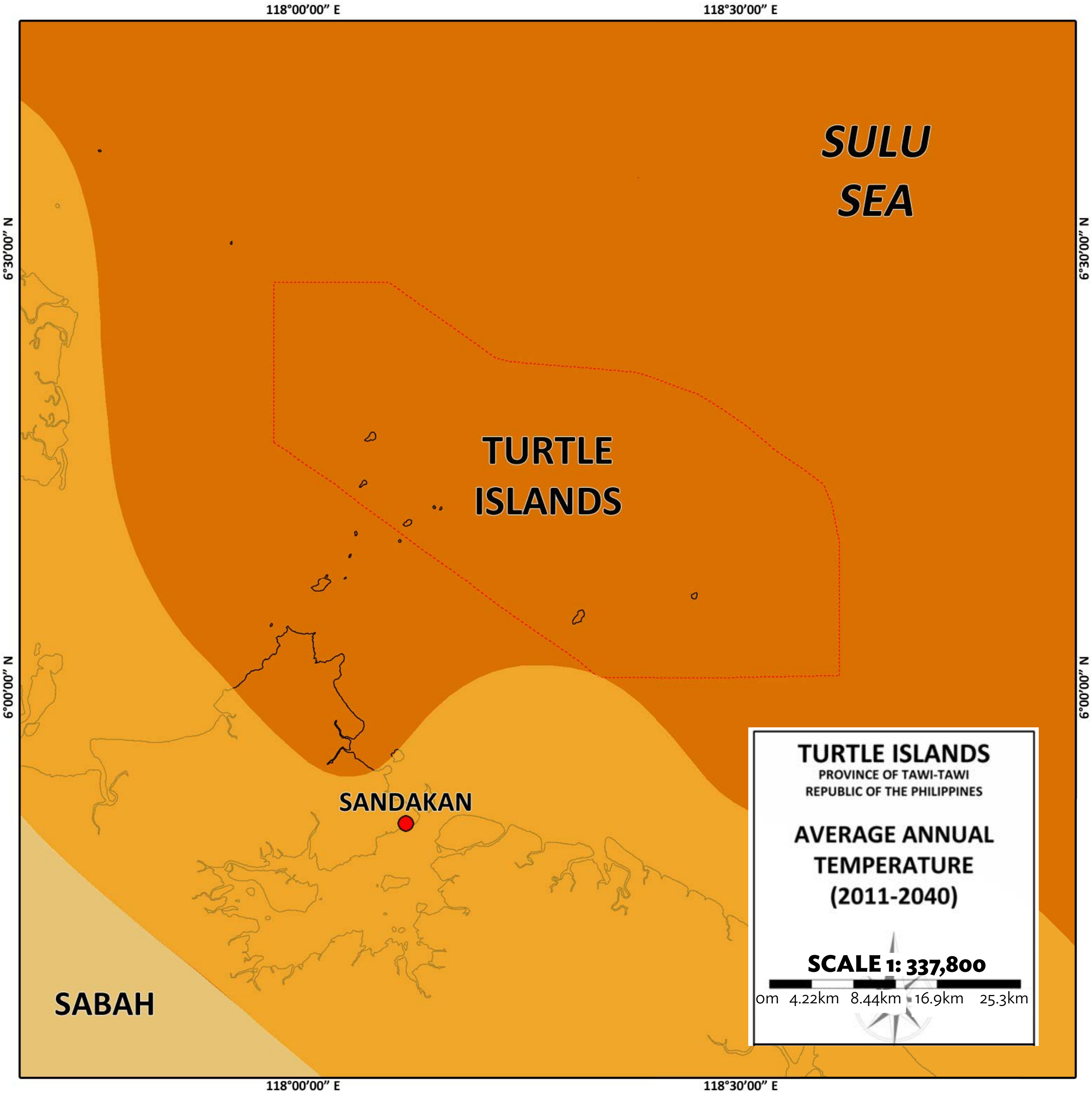


Figure 8. Projected Average Annual Temperature in the Turtle Islands and Vicinity, 2011-2040

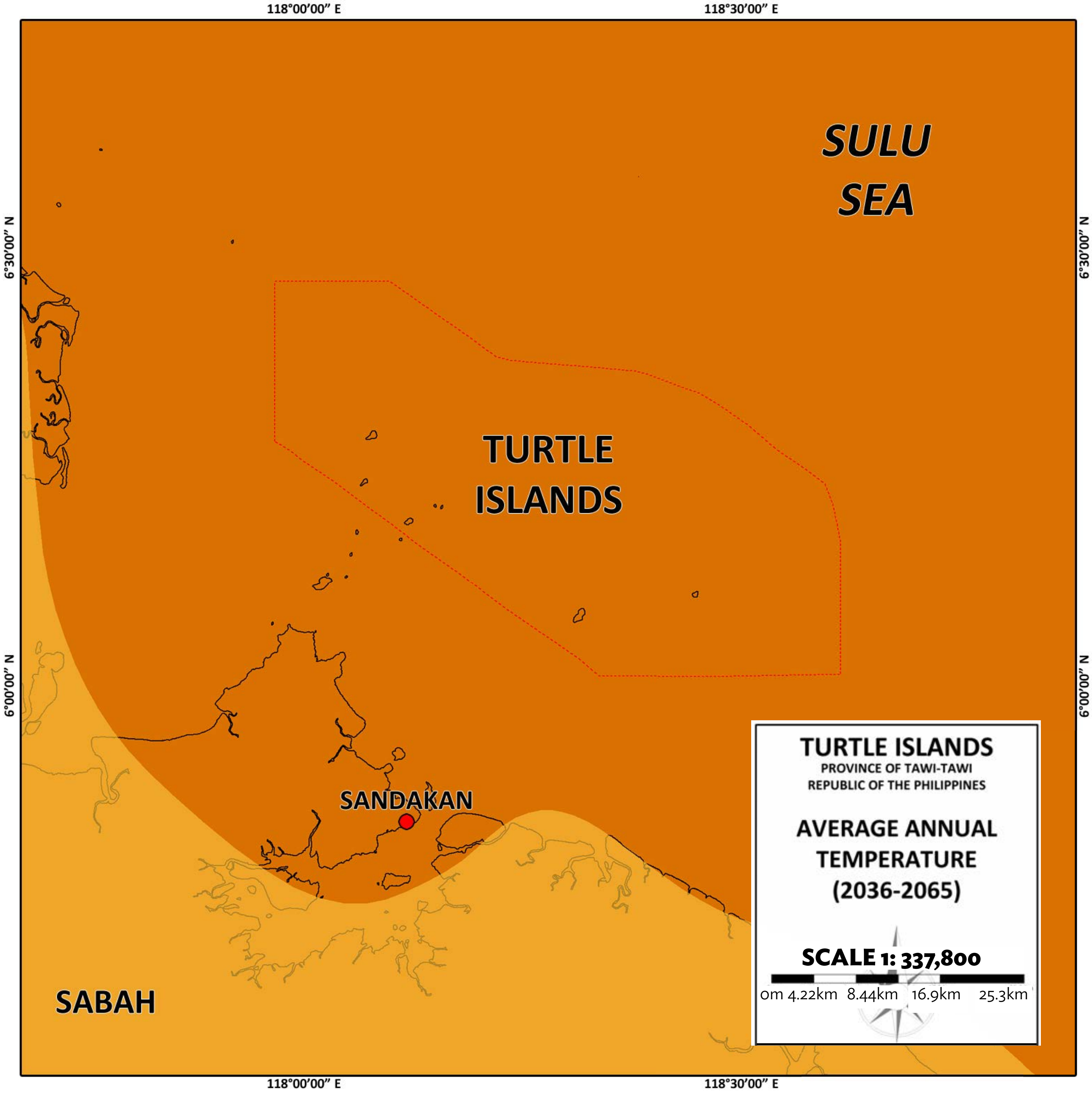


UNIVERSAL TRANSVERSE MERCATOR PROJECTION DATUM: WORLD GEODETIC SYSTEM 1984

Source: Manila Observatory **Disclaimer:** Administrative boundaries are approximate **Date:** July 2016

LEGEND 26-28 °C 28-30 °C 30-32 °C

Figure 9. Projected Average Annual Temperature in the Turtle Islands and Vicinity, 2036-2065



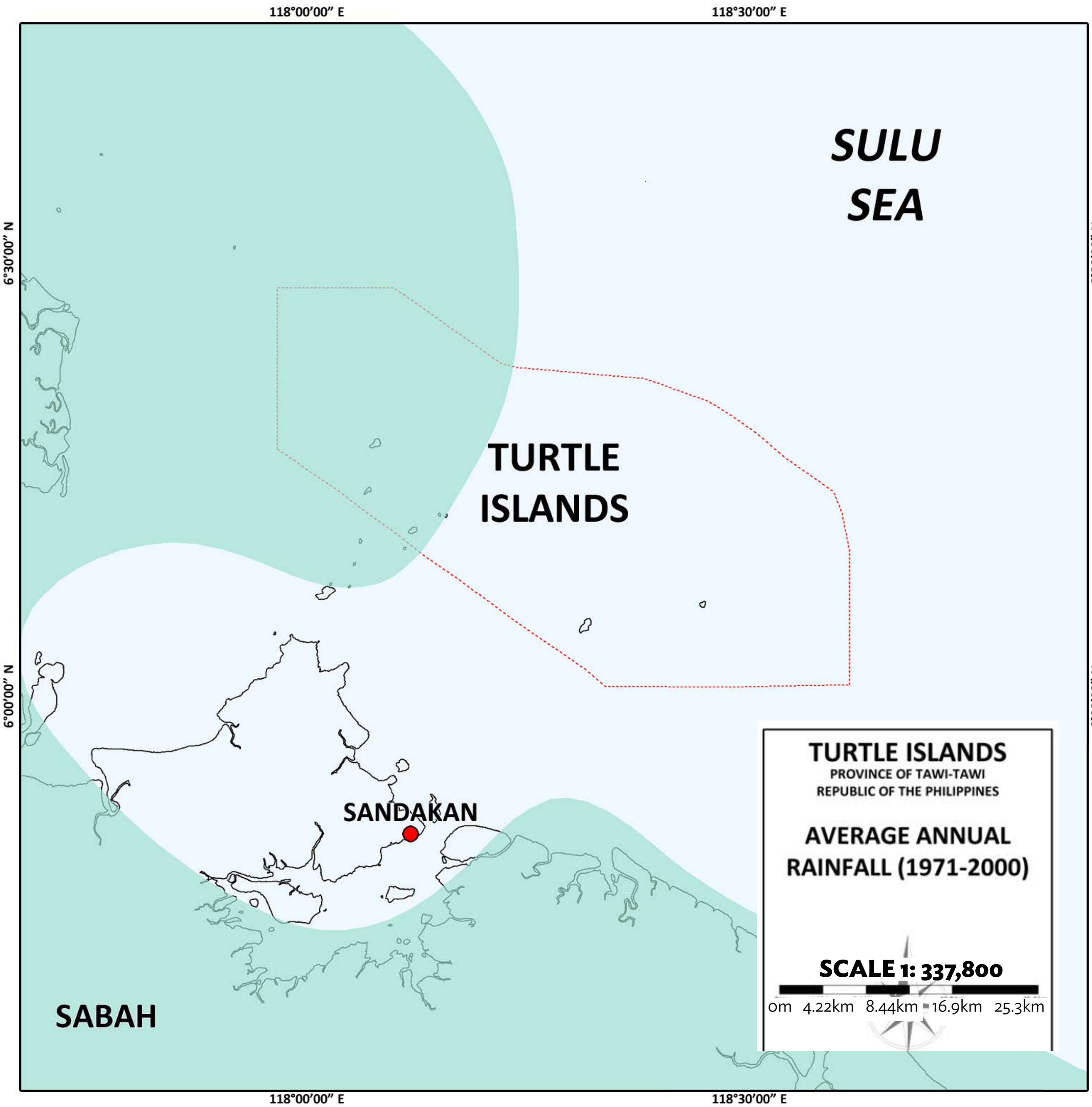
UNIVERSAL TRANSVERSE MERCATOR PROJECTION DATUM: WORLD GEODETIC SYSTEM 1984

Source: Manila Observatory **Disclaimer:** Administrative boundaries are approximate **Date:** July 2016

LEGEND 26-28 °C 28-30 °C 30-32 °C

Average annual rainfall. Islands on the western portion of the Turtle Islands experienced an average annual rainfall of 200-400 mm in the period, 1971-2000, whereas islands on the eastern part received less rainfall of below 200 mm (Figure 10). Projections show no significant change in average annual rainfall in the Turtle Islands from 2011-2040 and 2036-2065 (Figures 11 and 12).

Figure 10. Historical Average Annual Rainfall in the Turtle Islands and Vicinity, 1971-2000



UNIVERSAL TRANSVERSE MERCATOR PROJECTION DATUM: WORLD GEODETIC SYSTEM 1984

Source: Manila Observatory **Disclaimer:** Administrative boundaries are approximate **Date:** July 2016

LEGEND below 200 mm 200-400 mm

Figure 11. Projected Average Annual Rainfall in the Turtle Islands and Vicinity, 2011-2040

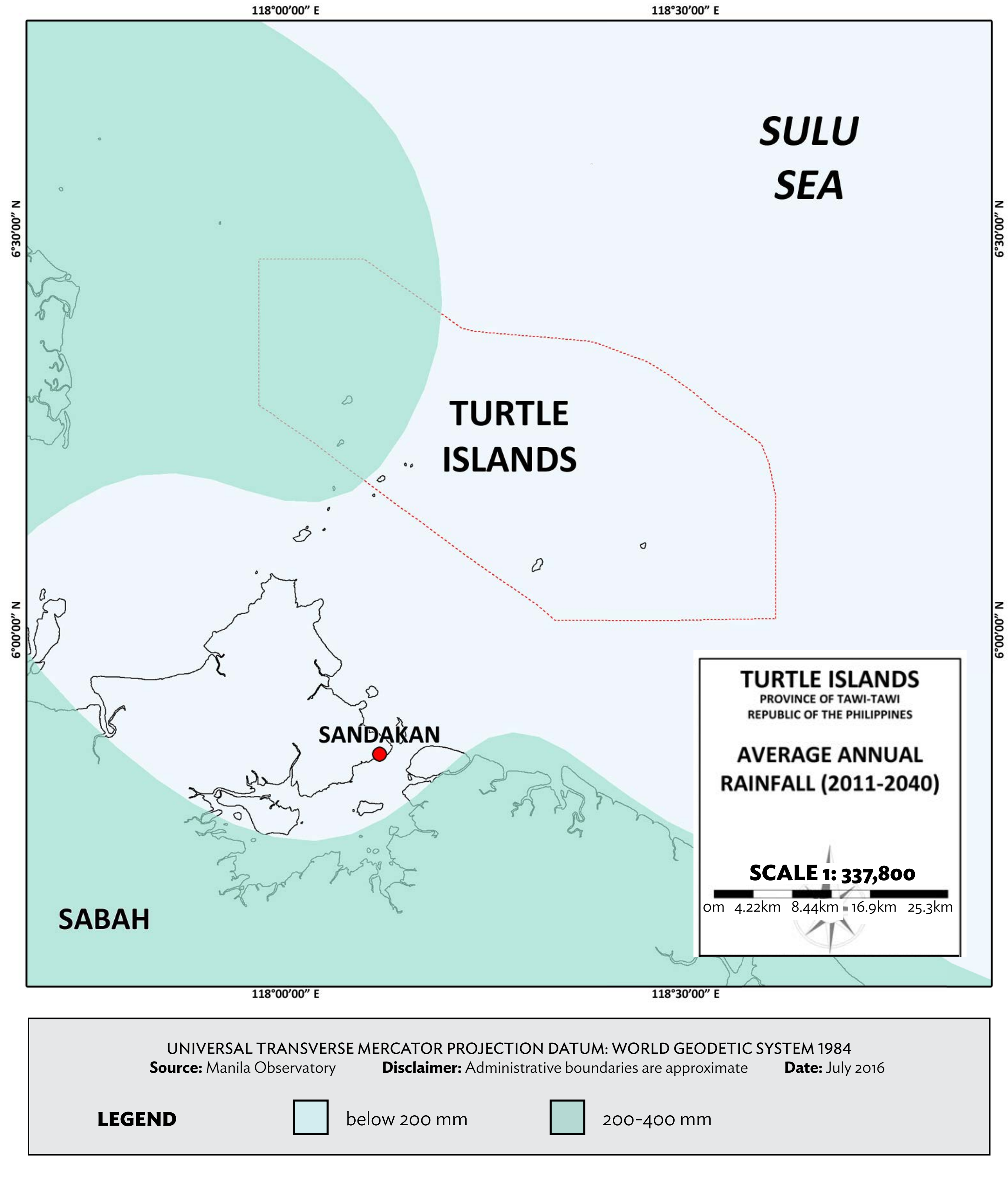
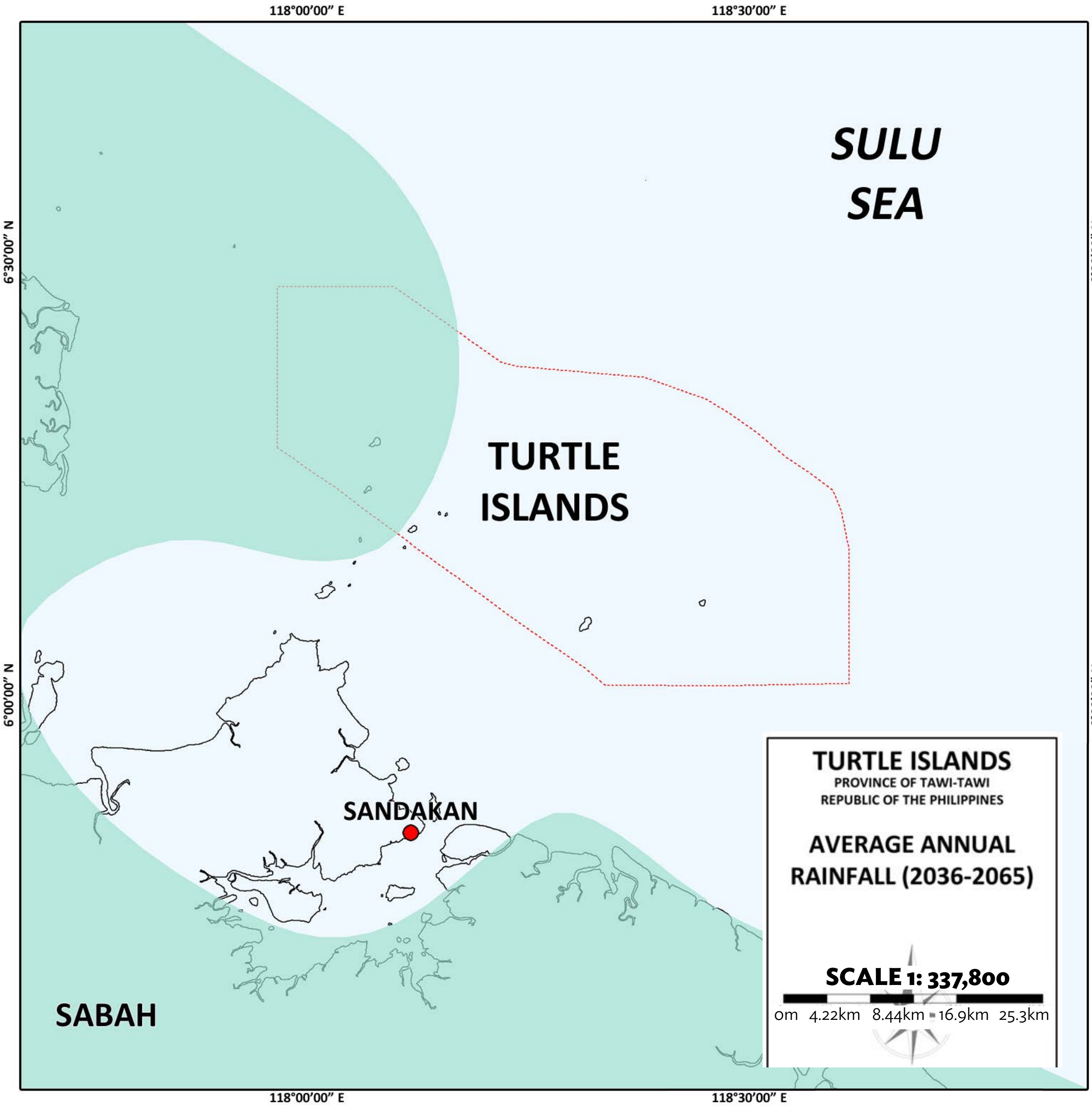


Figure 12. Projected Average Annual Rainfall in the Turtle Islands and Vicinity, 2036-2065



UNIVERSAL TRANSVERSE MERCATOR PROJECTION DATUM: WORLD GEODETIC SYSTEM 1984

Source: Manila Observatory **Disclaimer:** Administrative boundaries are approximate **Date:** July 2016

LEGEND below 200 mm 200-400 mm

4. Floods and Landslides

Flooding has occurred throughout the recorded history of the Philippines. It is the result of the low-lying nature of much of the terrain and the frequency of tropical cyclones (Bankoff, 2003). In a typical year, about 20 tropical cyclones enter the Philippine area of responsibility (PAR) (Brown *et al.,* 1991). A comparative historical analysis of the total number of tropical cyclones experienced by each major region reveals that Mindanao (including Tawi-Tawi) receives, by far, the lowest number of tropical cyclones and a higher percentage of milder events proportionately than any other region (Census, 1920; Kitamoto, n.d.). Nevertheless, Mindanao has been hit by strong and destructive tropical cyclones in recent years: Typhoon Pablo (International name: Bopha) in 2012 and Tropical Storm Sendong (International name: Washi) in 2011. Both caused massive flooding and landslides that killed many people.

In addition to flooding, landslides also occur frequently during or following periods of heavy rainfall, usually brought about by tropical cyclones. Approximately one-third of the land area of the Philippines consists of steep mountains and slopes, making it prone to landslides. In the main island of Tawi-Tawi, only about less than 10% of the land area has either moderate or high susceptibility to landslide. Susceptibility to both landslide and flood hazards of the Turtle Islands is discussed in the Hazard Susceptibility Assessment section.

5. Earthquake-Related Hazards

The Philippines lies within the Circum-Pacific belt, commonly known as the Ring of Fire, a seismically active region, where around 75% of the world's seismic energy is released. Thus, the country experiences strong and frequent earthquakes. The effects of earthquakes include ground shaking, landslides, liquefaction, and tsunami.

Tawi-Tawi, Sulu, and Basilan are the three provinces that are at highest risk from tsunamis (Manila Observatory, 2005 with data from PHIVOLCS). These provinces in the Sulu Archipelago are highly susceptible to tsunamis owing to their location between two nearby trenches: the Sulu Trench and the Cotabato Trench. Moreover, these provinces rank among the 20 most densely populated provinces in the country—Sulu (10th), Tawi-Tawi (18th), and Basilan (19th)—and, thus, have very high vulnerability (PSA, 2016). Turtle Islands, in particular, is about 130 km and 580 km west of the Sulu Trench and the Cotabato Trench, respectively.

In history, strong earthquakes have been recorded in and near the Sulu Archipelago. In fact, the strongest earthquakes that hit the country occurred on 20 and 21 September 1897 in the Sulu Sea between Sulu and Basilan. The earthquakes were given estimated magnitudes of 8.6 and 8.7, respectively (Duda, 1965; Richter, 1958). Both earthquakes triggered tsunamis with a maximum run-up elevation of 7 m (Soloviel and Go, 1974). On 15, August 1918, a magnitude 8.3 (M8.3) earthquake occurred in Celebes Sea (Duda, 1965), which triggered a tsunami with a maximum run-up elevation of 7.2 m (Iida, 1984). Other significant earthquakes that occurred along the Sulu Trench in the past 50 years (PHIVOLCS, personal communication, May 2016) are the following: (i) M5.6 on 18 May 1966; (ii) M5.7 on 28 April 1973; (iii) M7.4 on 23 February 1975; (iv) M5.8 on 21 November 1977; and (v) M6.1 on 14 June 1978. In addition, various seismicity maps of the Philippines also reveal earthquakes off the coast of the East Sabah region and near the Turtle Islands.

6. Sea Level Rise

Global SLR has been identified as one of the major threats associated with global climate change (Stocker *et al.,* 2013; Nicholls and Cazenave, 2010). On average, sea levels around the world rise by 1.7-3.1 mm/yr (Bindoff et al., 2007; Casenave and Nerem, 2004). However, the regional SLR is expected to be higher due to local climate and topographical conditions.

In the Philippines, SLR measurements are well above average. According to the World Meteorological Organization (WMO), sea levels in the country are projected to rise between 7.6-10.2 mm/yr, almost three times the global average. The assessment conducted by Rietbroek *et al.* (2015) of regional changes in SLR concluded that sea levels in the Philippines are rising by as high as 14.7±4.4 mm/yr, almost five times the global average. Assuming that these trends apply to the Turtle Islands, the projected SLR is 3.8-7.4 cm in 2020, 0.27-0.51 m in 2050, and 0.65-1.25 m in 2100.

A study conducted by NAHRIM (2010) indicates that, in Sabah, the projected SLR in 2100 is 0.69-1.06 m, with the maximum value occurring in low-lying areas, river mouths, and estuaries in the east coast. The rate of SLR in Sandakan is 4.84 mm/yr. Based on data from the US National Oceanographic and Atmospheric Administration (NOAA) Laboratory for Satellite Altimetry, mean SLR in the Indonesian region (indicative for the Turtle Islands) rose by 4.8±0.4 – 5.5±0.4 mm/yr from 1992-2016. With these trends, the sea level in the Turtle Islands is projected to rise by 1.9-2.2 cm in 2020, 0.16-0.19 m in 2050, and 0.40-0.46 m in 2100.

VI. HAZARD SUSCEPTIBILITY ASSESSMENT

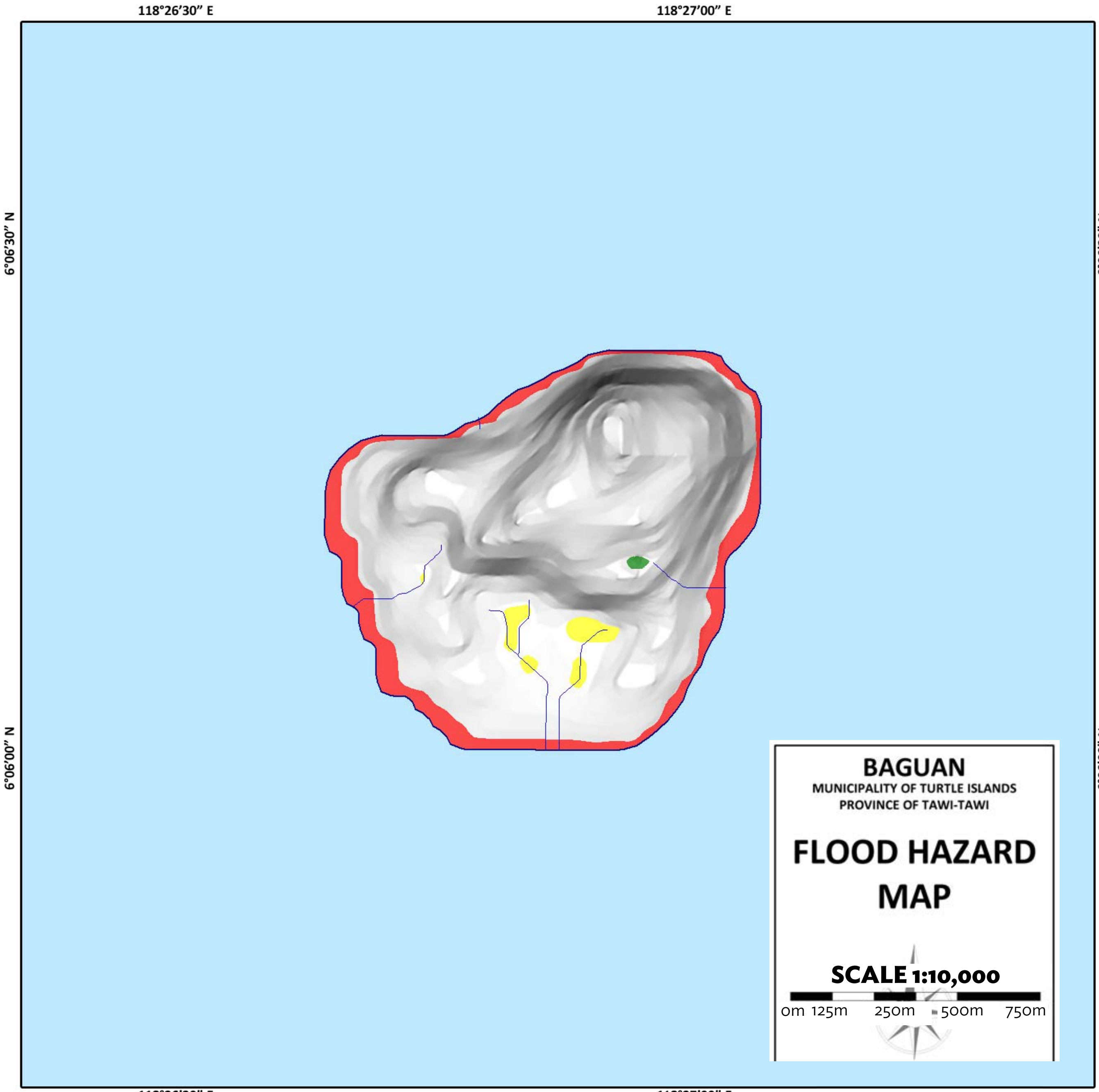
A. Flood Hazard

The areas of the six major islands exposed to flooding are given in Table 13 and depicted in Figures 13-17. About 12.6% of the total land area of the Turtle Islands has high susceptibility to floods. Langaan and Lihiman are the only islands with 20% or more of their total areas exposed to floods at a high susceptibility level at 33% and 20.3%, respectively. A large chunk of the area that is highly susceptible to flood is in coastal areas as a result of coastal flooding. Among several factors that contribute to coastal flooding are high astronomical tide levels, SLR due to climate change, and tsunamis.

Table 13. Area of the Islands Exposed to Flood at Various Susceptibility Levels

Island	Area (ha)	Area exposed to flood (ha)					
		Low	%	Mod	%	High	%
Baguan	31.64	0.58	1.82	0.05	0.16	3.52	11.11
Boan	64.80	0.39	0.60	0.78	1.20	6.78	10.46
G. Bakkungan	43.61	0.28	0.64	0.00	0.00	7.22	16.56
Langaan	7.16	0.08	1.10	0.00	0.00	2.36	32.96
Lihiman	26.88	0.45	1.66	0.03	0.12	5.47	20.35
Taganak	123.93	0.72	0.58	0.16	0.13	12.33	9.95
Total	298.02	2.49	0.84	1.02	0.34	37.68	12.64

Figure 13. Flood Hazard Susceptibility Map of Baguan



UNIVERSAL TRANSVERSE MERCATOR PROJECTION DATUM: WORLD GEODETIC SYSTEM 1984

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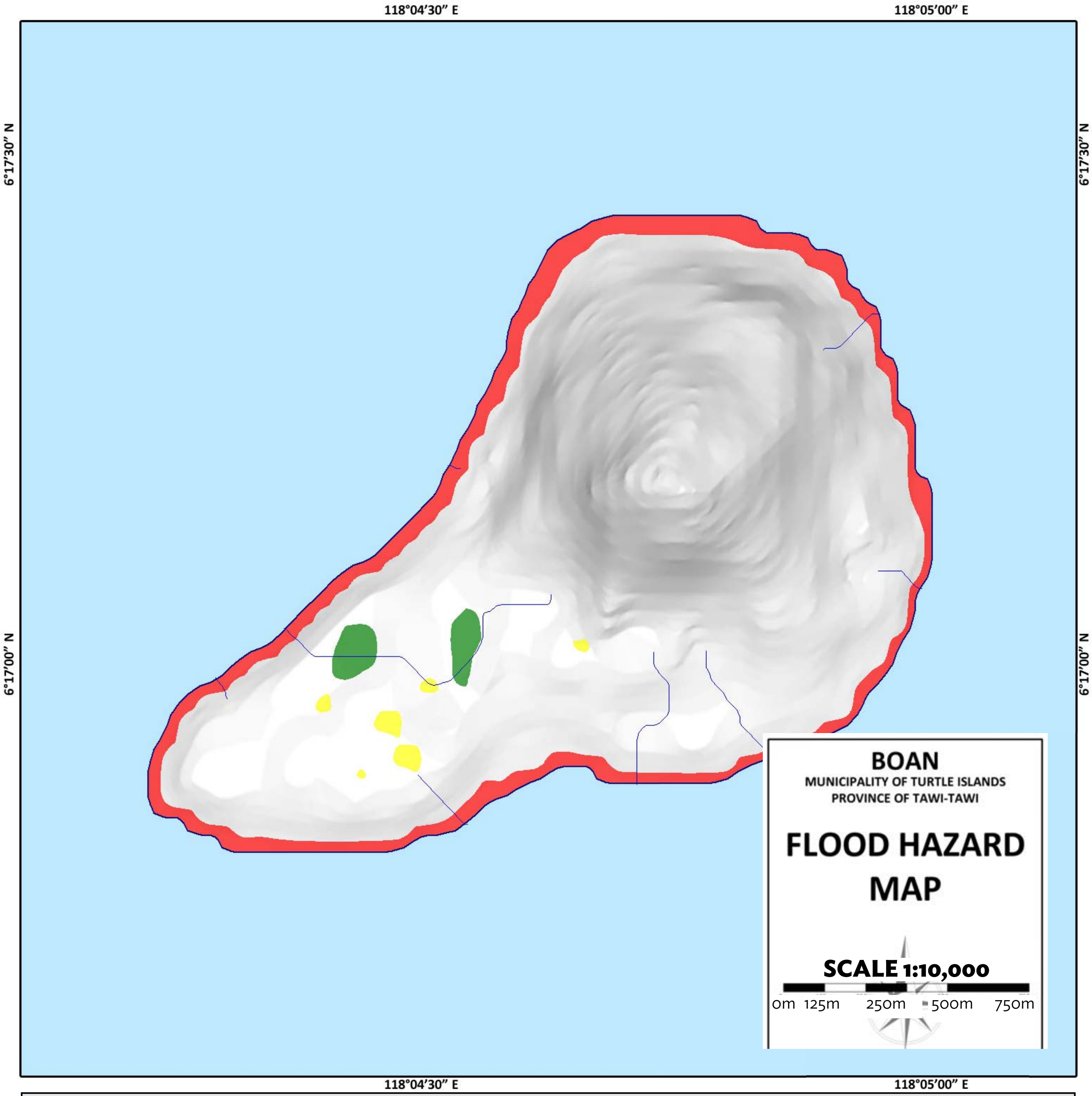
LEGEND

channel | shoreline | low susceptibility | moderate susceptibility | high susceptibility

Areas with less than 0.5 m flood height such as low hills and gentle slopes have low flood susceptibility rating. Areas with 0.5 to 1 m flood height such as fluvial terraces, alluvial fans, and in-filled valleys have moderate flood susceptibility rating. Areas with greater than 1 m flood height have high flood susceptibility rating. These areas are immediately flooded during heavy rains of several hours and include landforms of topographic lows such as active and abandoned river channels, and areas along river banks. In this case, coastal areas are mainly at high risk of coastal flooding as a result of high tides and storm surges.

Figure 14. Flood Hazard Susceptibility Map of Boan



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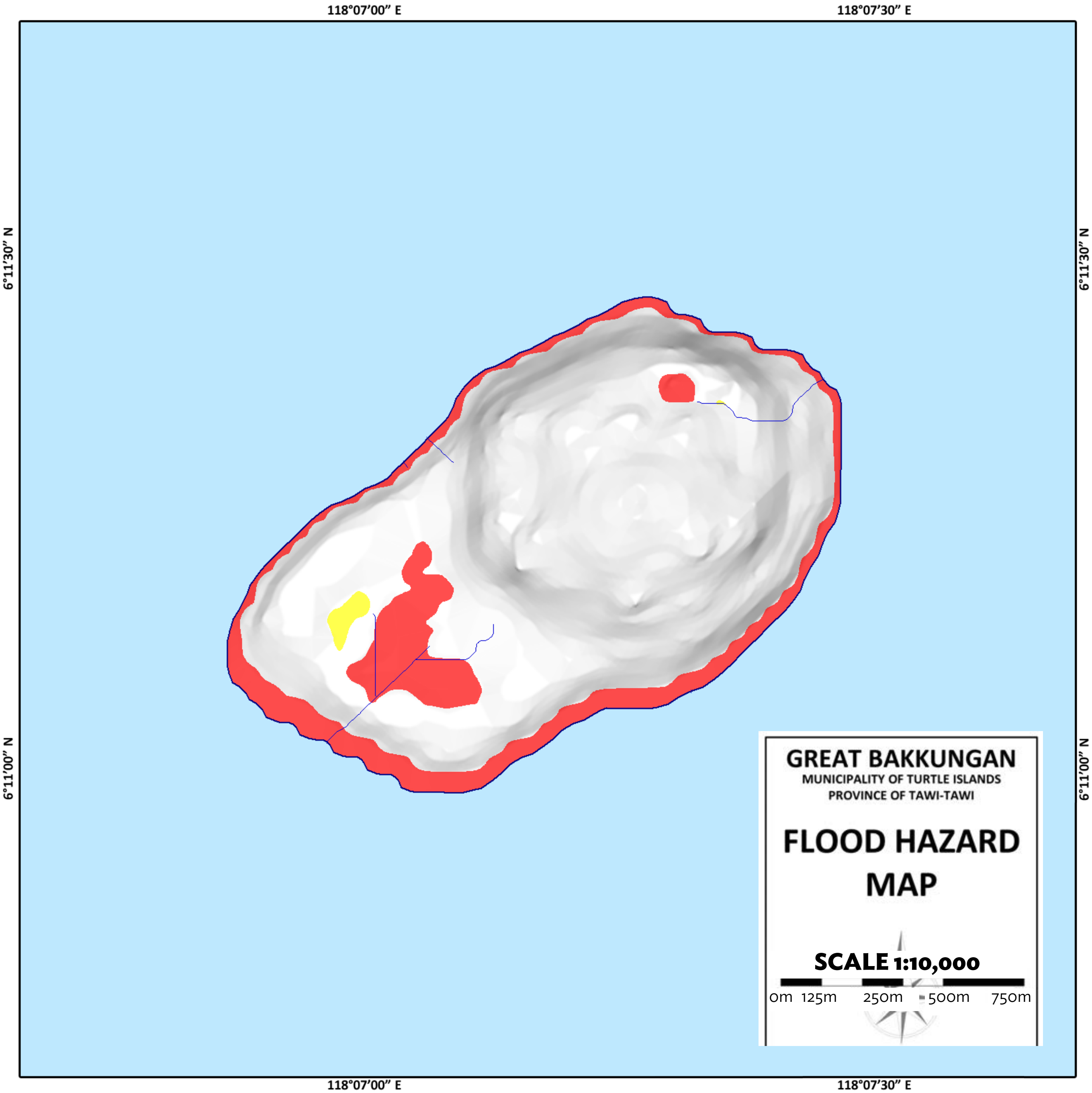
LEGEND

— channel — shoreline low susceptibility moderate susceptibility high susceptibility

Areas with less than 0.5 m flood height such as low hills and gentle slopes have low flood susceptibility rating. Areas with 0.5 to 1 m flood height such as fluvial terraces, alluvial fans, and in-filled valleys have moderate flood susceptibility rating. Areas with greater than 1 m flood height have high flood susceptibility rating. These areas are immediately flooded during heavy rains of several hours and include landforms of topographic lows such as active and abandoned river channels, and areas along river banks. In this case, coastal areas are mainly at high risk of coastal flooding as a result of high tides and storm surges.

Figure 15. Flood Hazard Susceptibility Map of Great Bakkungan



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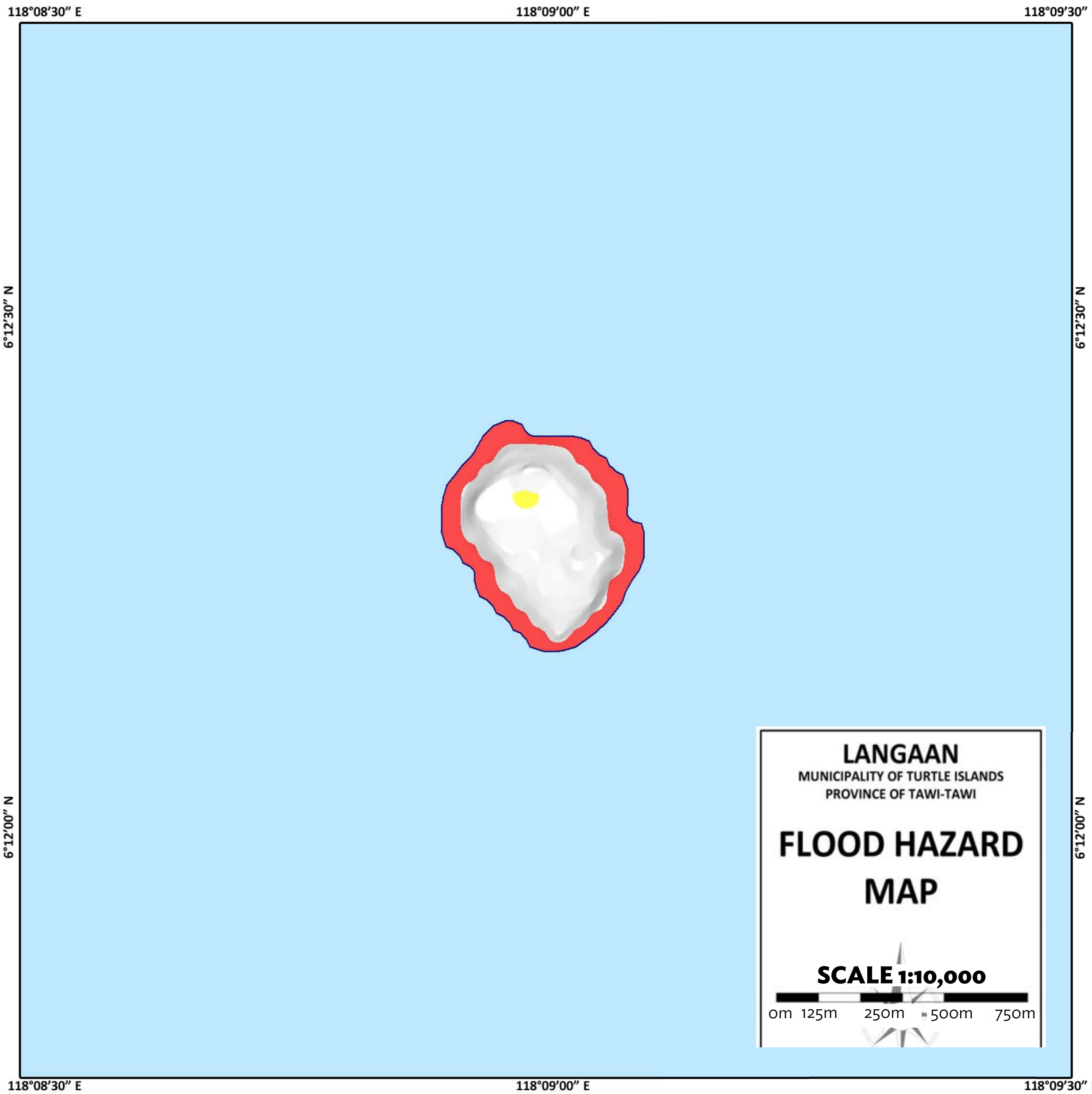
LEGEND

channel | shoreline | low susceptibility | moderate susceptibility | high susceptibility

Areas with less than 0.5 m flood height such as low hills and gentle slopes have low flood susceptibility rating. Areas with 0.5 to 1 m flood height such as fluvial terraces, alluvial fans, and in-filled valleys have moderate flood susceptibility rating. Areas with greater than 1 m flood height have high flood susceptibility rating. These areas are immediately flooded during heavy rains of several hours and include landforms of topographic lows such as active and abandoned river channels, and areas along river banks. In this case, coastal areas are mainly at high risk of coastal flooding as a result of high tides and storm surges.

Figure 16. Flood Hazard Susceptibility Map of Langaan



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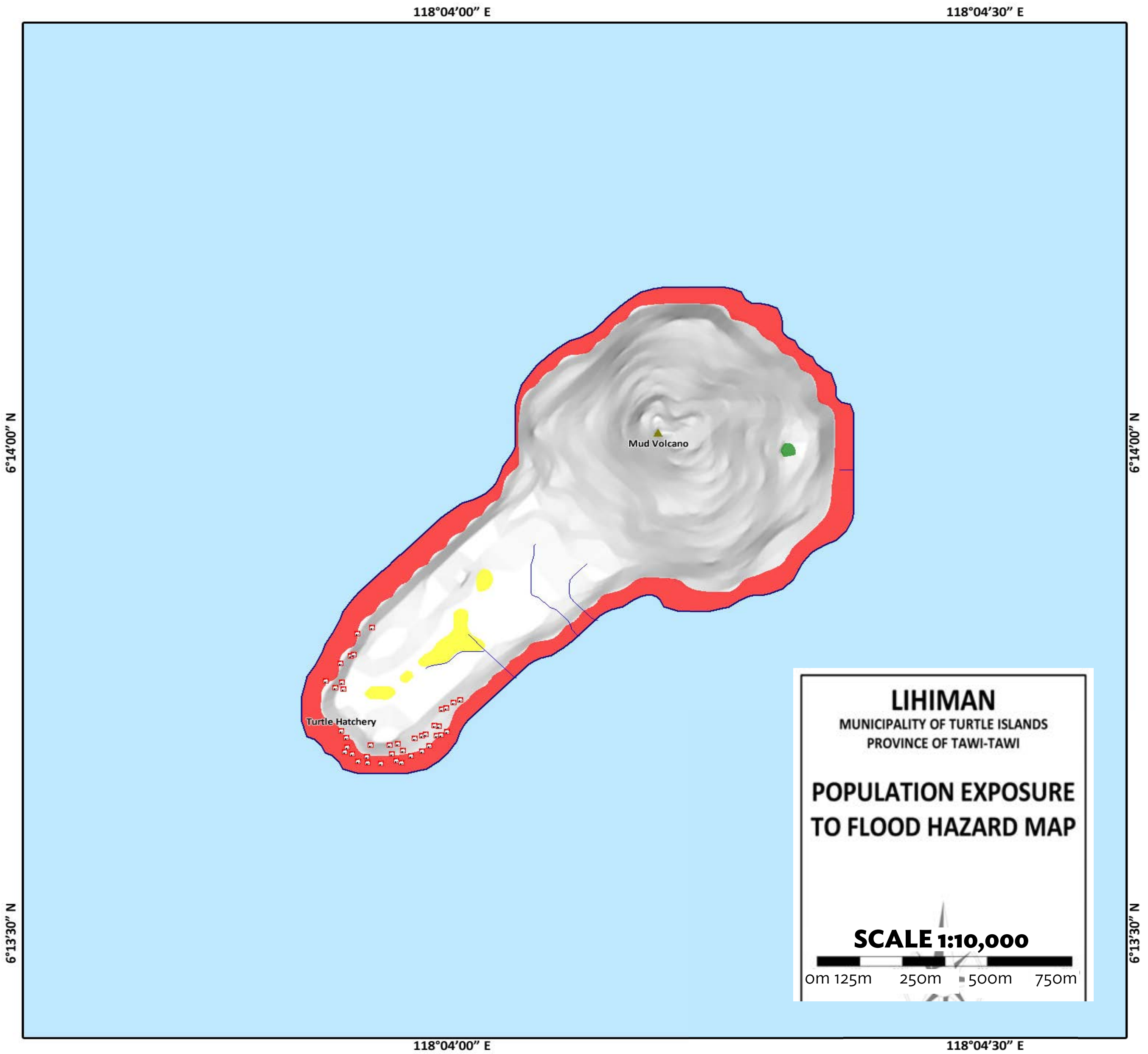
LEGEND

channel | shoreline | low susceptibility | moderate susceptibility | high susceptibility

Areas with less than 0.5 m flood height such as low hills and gentle slopes have low flood susceptibility rating. Areas with 0.5 to 1 m flood height such as fluvial terraces, alluvial fans, and in-filled valleys have moderate flood susceptibility rating. Areas with greater than 1 m flood height have high flood susceptibility rating. These areas are immediately flooded during heavy rains of several hours and include landforms of topographic lows such as active and abandoned river channels, and areas along river banks. In this case, coastal areas are mainly at high risk of coastal flooding as a result of high tides and storm surges.

Figure 17. Flood Hazard Susceptibility Map of Lihiman



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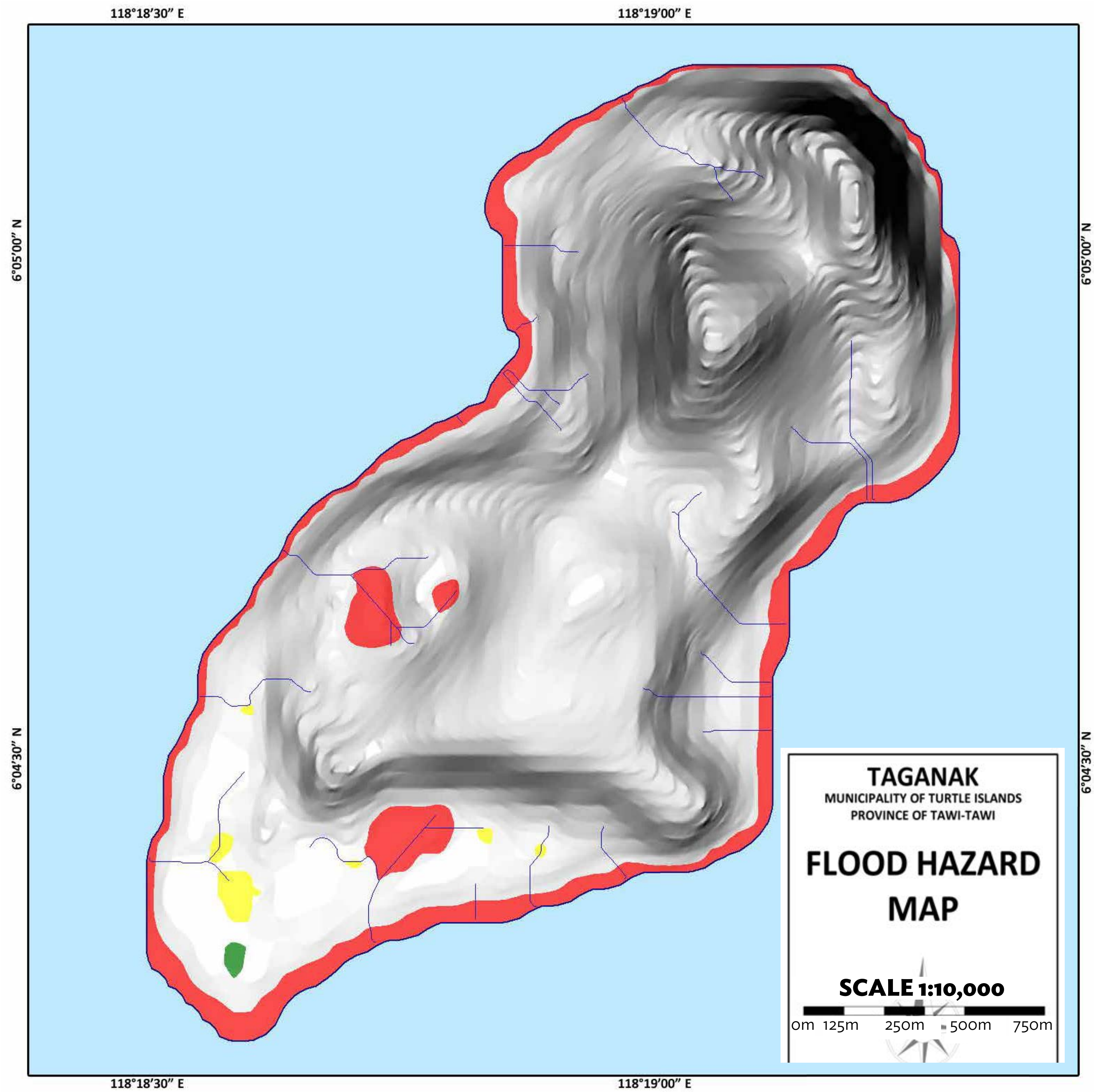
LEGEND

channel	shoreline	structure
low susceptibility	moderate susceptibility	high susceptibility

Areas with less than 0.5 m flood height such as low hills and gentle slopes have low flood susceptibility rating. Areas with 0.5 to 1 m flood height such as fluvial terraces, alluvial fans, and in-filled valleys have moderate flood susceptibility rating. Areas with greater than 1 m flood height have high flood susceptibility rating. These areas are immediately flooded during heavy rains of several hours and include landforms of topographic lows such as active and abandoned river channels, and areas along river banks. In this case, coastal areas are mainly at high risk of coastal flooding as a result of high tides and storm surges.

Figure 18. Flood Hazard Susceptibility Map of Taganak



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LEGEND

channel | shoreline | low susceptibility | moderate susceptibility | high susceptibility

Areas with less than 0.5 m flood height such as low hills and gentle slopes have low flood susceptibility rating. Areas with 0.5 to 1 m flood height such as fluvial terraces, alluvial fans, and in-filled valleys have moderate flood susceptibility rating. Areas with greater than 1 m flood height have high flood susceptibility rating. These areas are immediately flooded during heavy rains of several hours and include landforms of topographic lows such as active and abandoned river channels, and areas along river banks. In this case, coastal areas are mainly at high risk of coastal flooding as a result of high tides and storm surges.

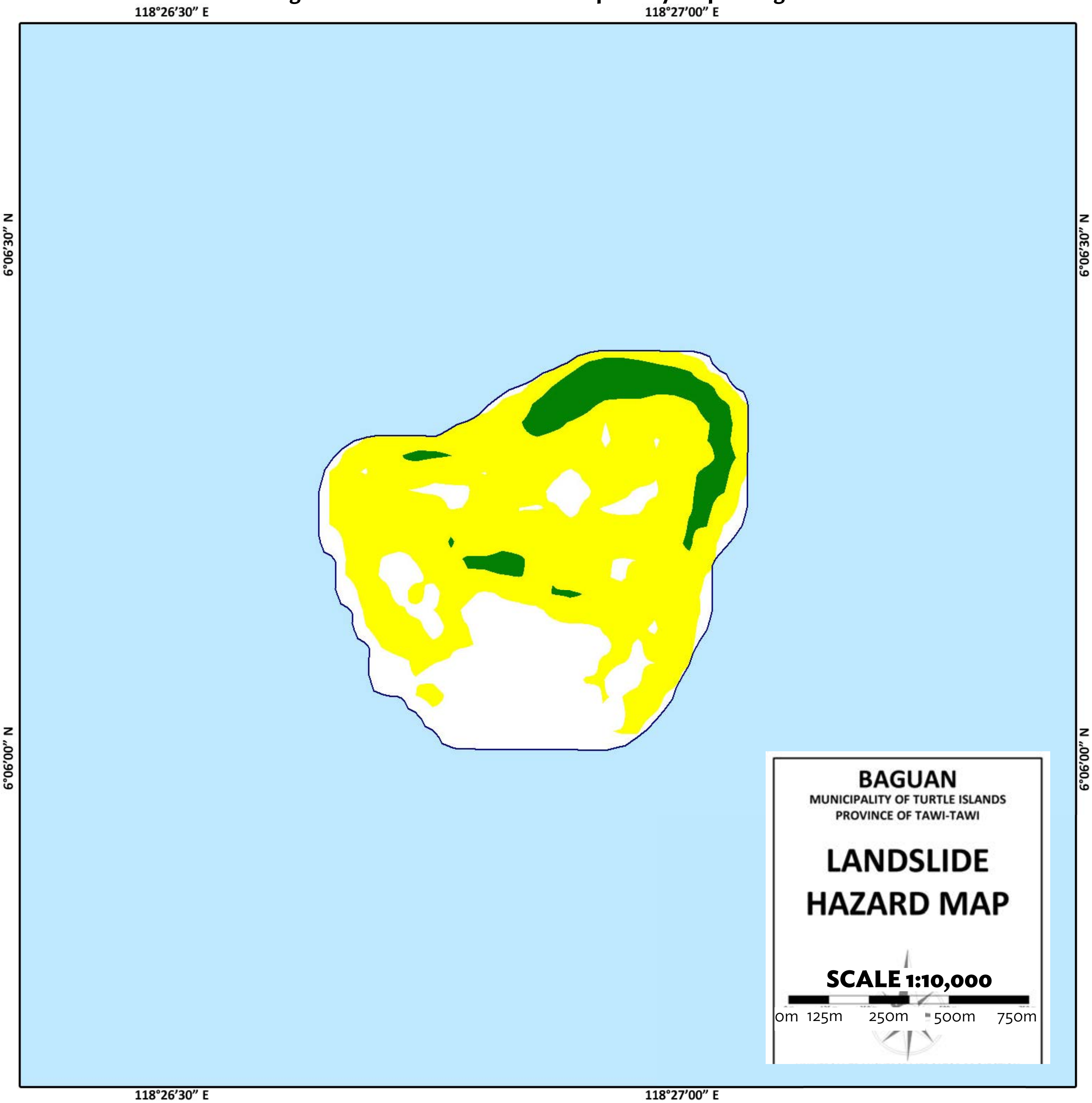
B. Landslide Hazard

Only a small portion (0.9%) of the total land area of the six major islands is highly susceptible to landslide; 11.7% is moderately susceptible; and 54.2% is minimally susceptible (Table 14). Landslide hazard maps of the six islands are presented in Figures 19-24. Among the islands, only Taganak has a large area exposed to moderate (25.8%) and high susceptibility (2.2%) to landslide (Figure 18). Taganak is characterized by a high topographic relief with a coastal plain at the southwestern end, a plateau-like feature in the central portion, and steep slopes at the northeastern end (Figure 68 in Appendix). The northeastern end of Baguan, typified by a low hill with very strong slopes, has also moderate susceptibility (9.2%) to landslide (Figure 19).

Table 14. Area of the Islands Exposed to Landslide at Various Susceptibility Levels

Island	Area (ha)	Area exposed to flood (ha)					
		Low	%	Mod	%	High	%
Baguan	0	0.00	0.00	0.00	0.00	0.00	0.00
Boan	816	4.90	0.60	9.79	1.20	85.35	10.46
G. Bakkungan	1104	7.07	0.64	0.00	0.00	182.32	16.56
Langaan	112	1.23	1.10	0.00	0.00	36.92	32.96
Lihiman	200	3.32	1.66	0.24	0.12	40.70	20.35
Taganak	3017	17.50	0.58	3.92	0.13	300.19	9.95
Total	5249	34.01	0.65	13.95	0.27	645.98	12.31

Figure 19. Landslide Hazard Susceptibility Map of Baguan



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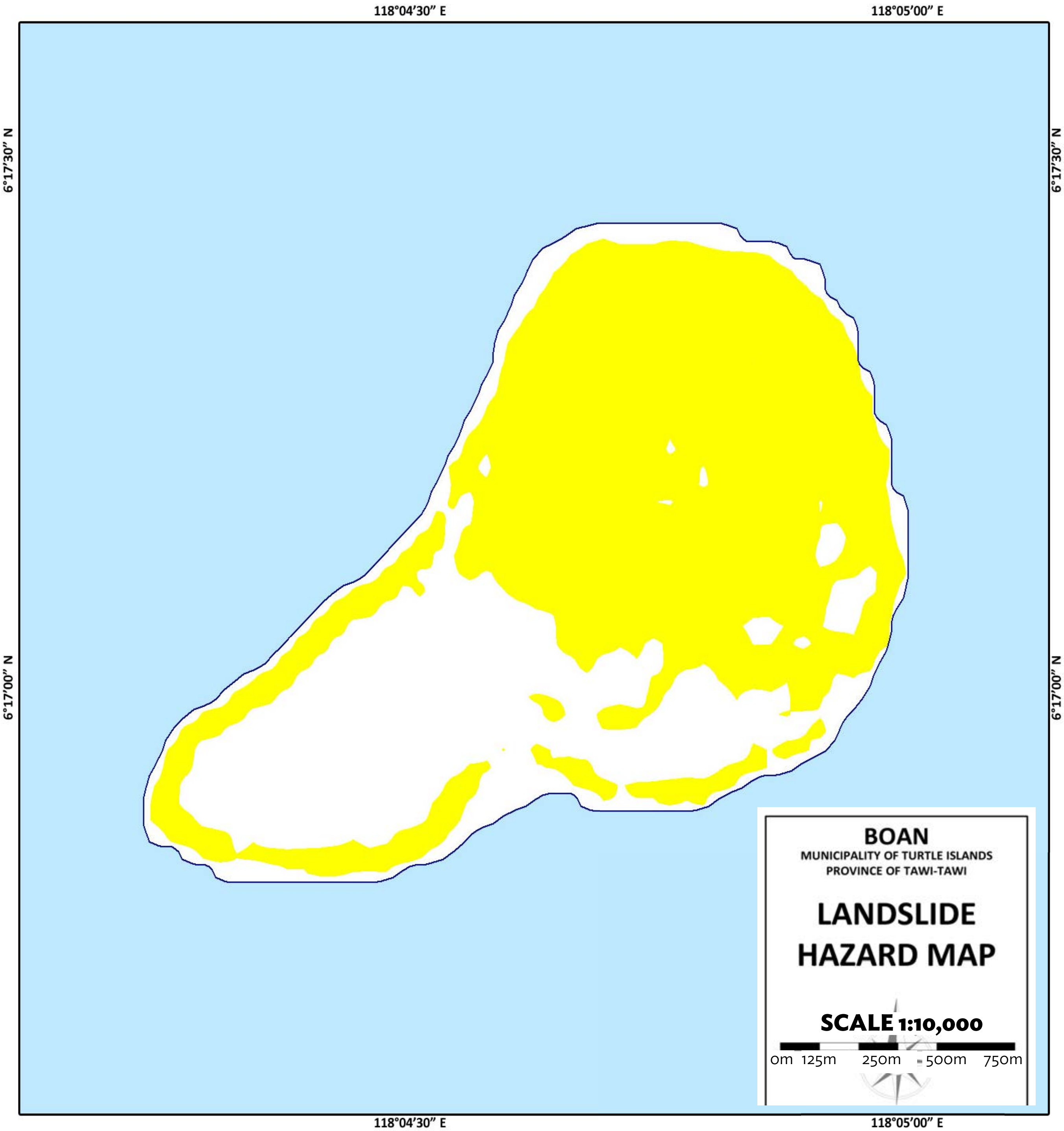
LEGEND

channel | shoreline | low susceptibility | moderate susceptibility | high susceptibility

Areas with low landslide susceptibility rating have low to gentle slopes and lack tension cracks. Areas with moderate landslide susceptibility rating have inactive/old landslides and tension cracks that are located away from the community. These areas usually have moderate slopes. Areas with high landslide susceptibility rating have active/recent landslides and tension cracks that would directly affect the community. Areas with steep slopes and drainage that are prone to landslide damming are also highly susceptible to landslides.

Figure 20. Landslide Hazard Susceptibility Map of Boan



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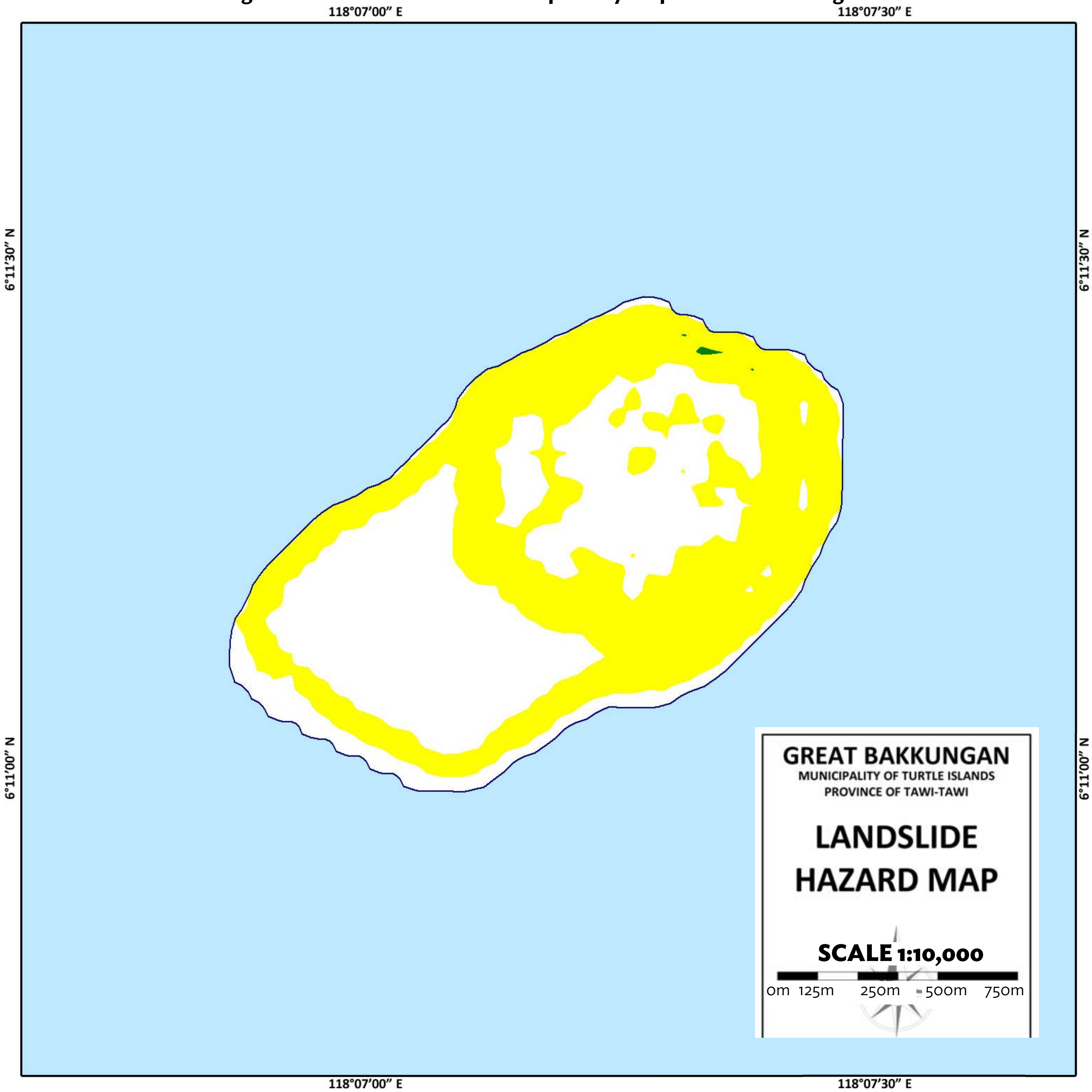
LEGEND

channel, shoreline, low susceptibility, moderate susceptibility, high susceptibility

Areas with low landslide susceptibility rating have low to gentle slopes and lack tension cracks. Areas with moderate landslide susceptibility rating have inactive/old landslides and tension cracks that are located away from the community. These areas usually have moderate slopes. Areas with high landslide susceptibility rating have active/recent landslides and tension cracks that would directly affect the community. Areas with steep slopes and drainage that are prone to landslide damming are also highly susceptible to landslides.

Figure 21. Landslide Hazard Susceptibility Map of Great Bakkungan



UNIVERSAL TRANSVERSE MERCATOR PROJECTION DATUM: WORLD GEODETIC SYSTEM 1984

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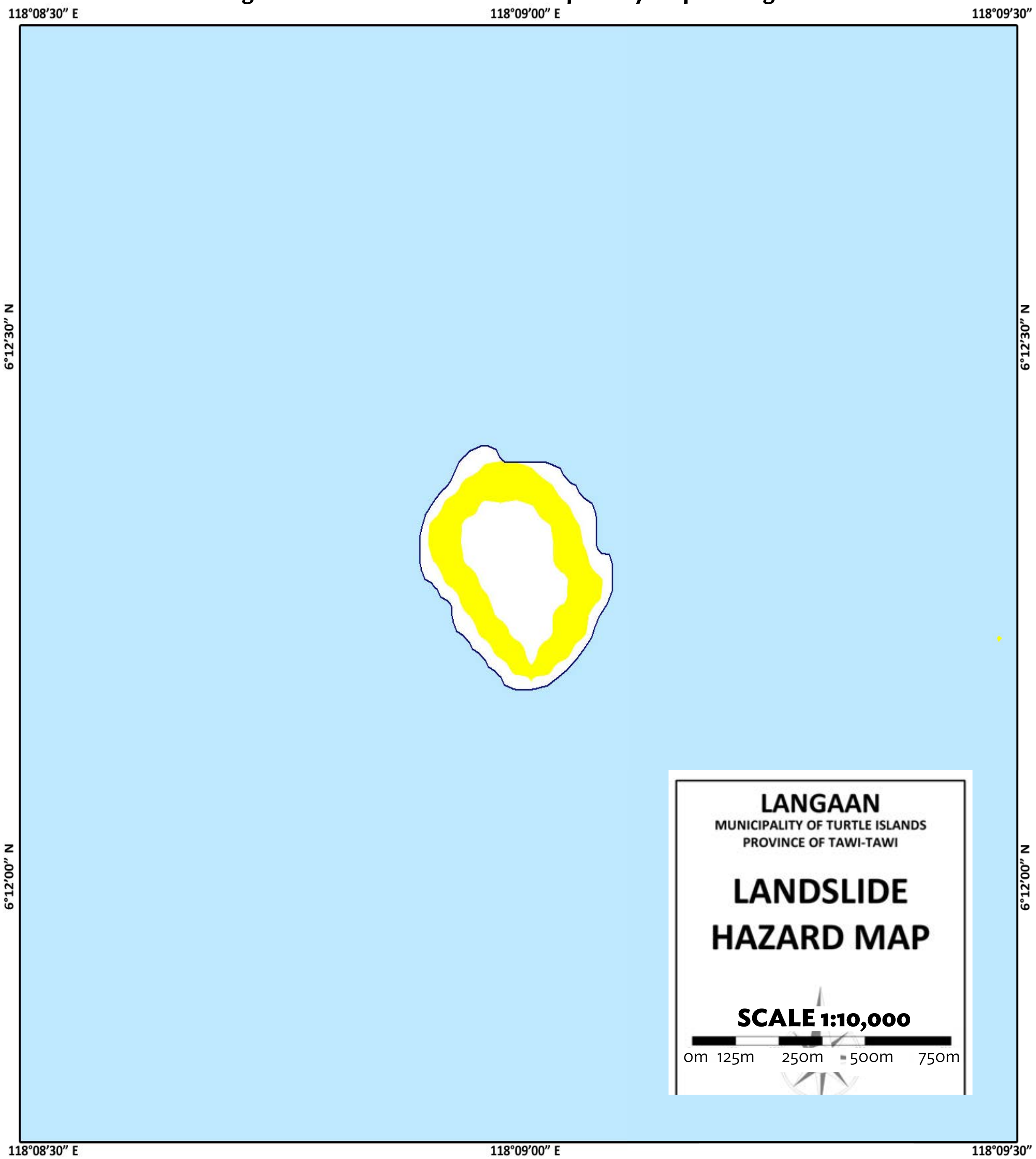
LEGEND

channel, shoreline, low susceptibility, moderate susceptibility, high susceptibility

Areas with low landslide susceptibility rating have low to gentle slopes and lack tension cracks. Areas with moderate landslide susceptibility rating have inactive/old landslides and tension cracks that are located away from the community. These areas usually have moderate slopes. Areas with high landslide susceptibility rating have active/recent landslides and tension cracks that would directly affect the community. Areas with steep slopes and drainage that are prone to landslide damming are also highly susceptible to landslides.

Figure 22. Landslide Hazard Susceptibility Map of Langaan



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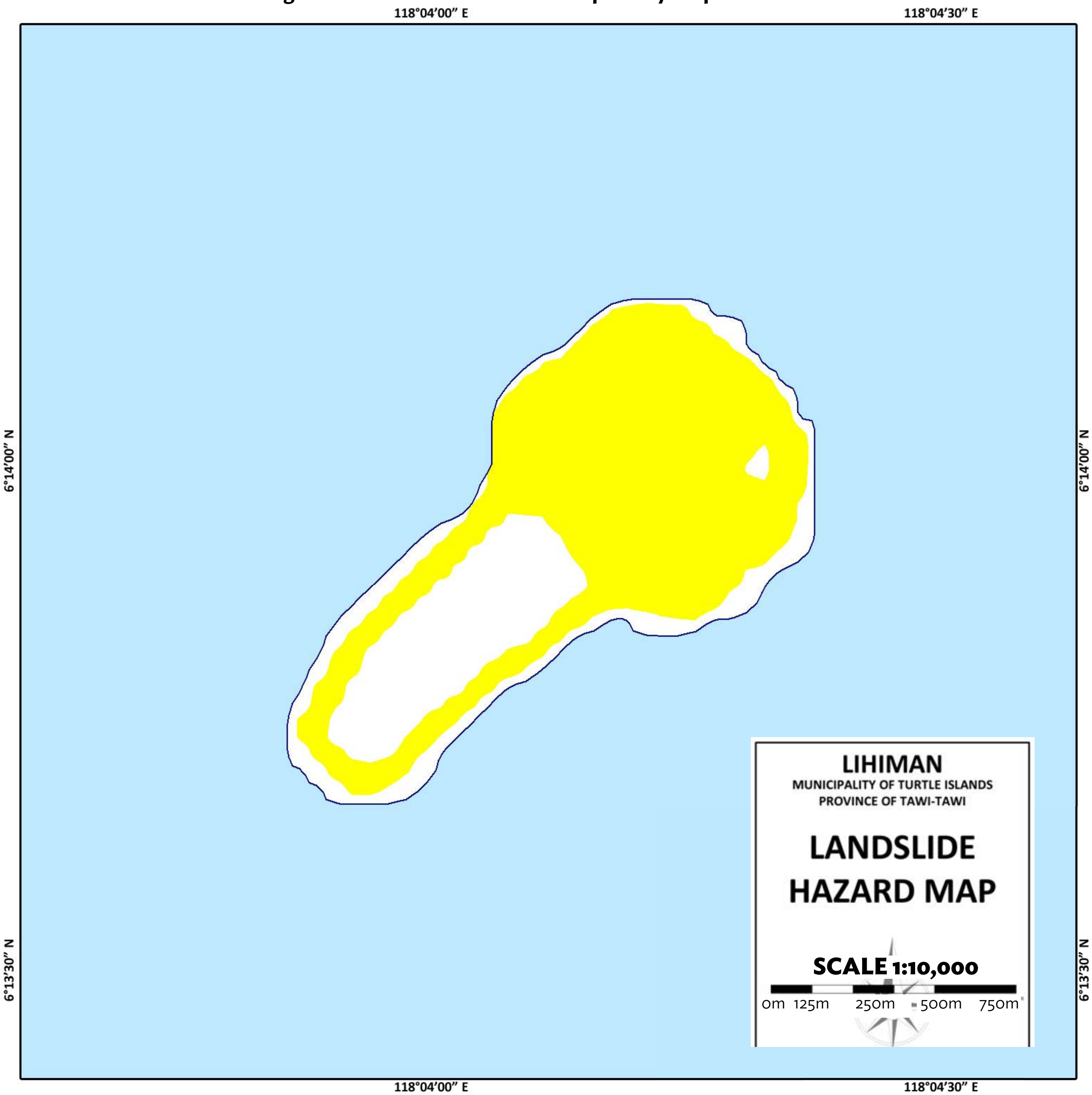
LEGEND

- channel
- shoreline
- low susceptibility
- high susceptibility
- moderate susceptibility

Areas with low landslide susceptibility rating have low to gentle slopes and lack tension cracks. Areas with moderate landslide susceptibility rating have inactive/old landslides and tension cracks that are located away from the community. These areas usually have moderate slopes. Areas with high landslide susceptibility rating have active/recent landslides and tension cracks that would directly affect the community. Areas with steep slopes and drainage that are prone to landslide damming are also highly susceptible to landslides.

Figure 23. Landslide Hazard Susceptibility Map of Lihiman



UNIVERSAL TRANSVERSE MERCATOR PROJECTION DATUM: WORLD GEODETIC SYSTEM 1984

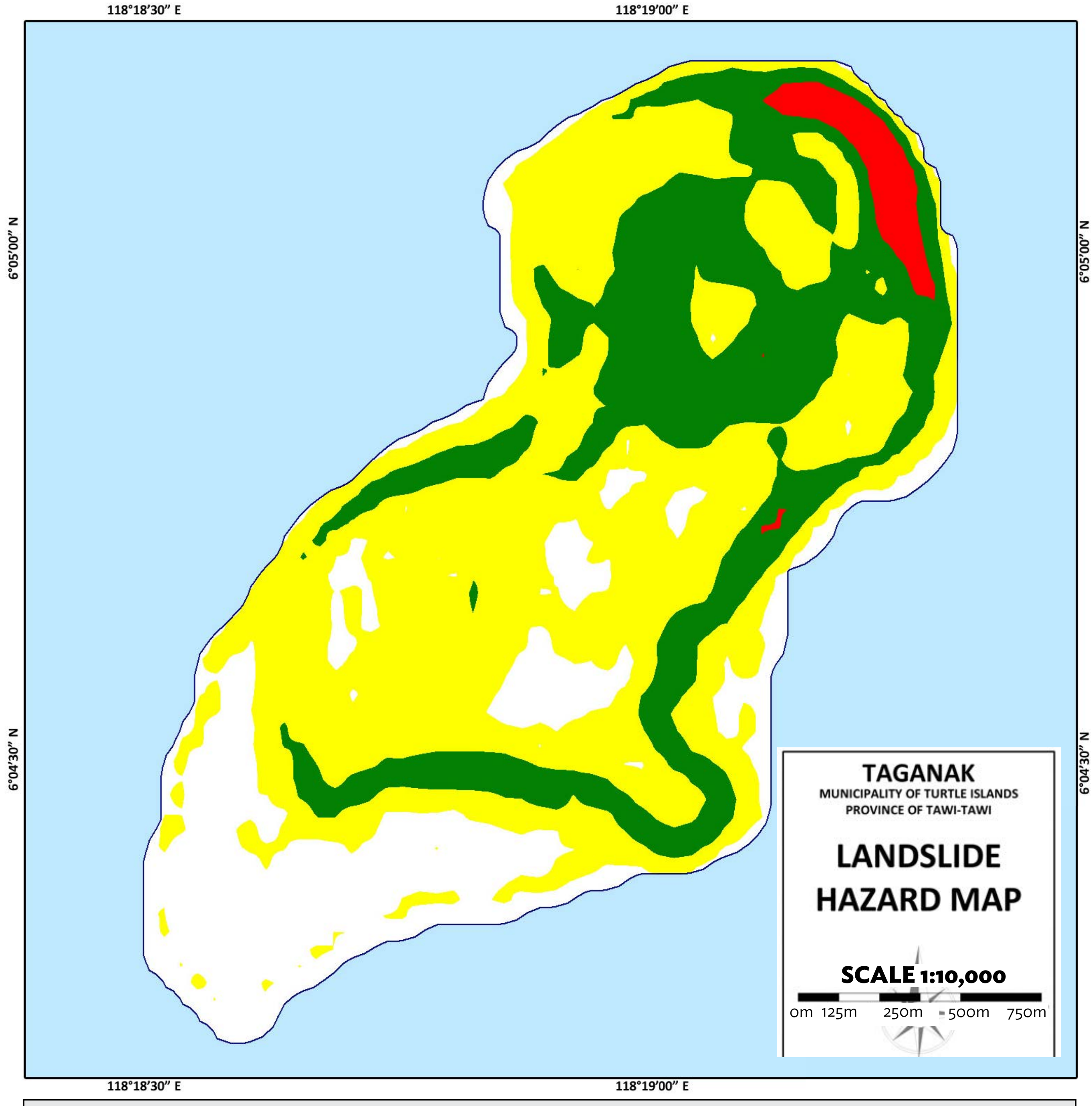
Source: ALOS Global Digital Surface Model © JAXA **Disclaimer:** Administrative boundaries are approximate **Date:** July 2016

LEGEND

channel | shoreline | low susceptibility | moderate susceptibility | high susceptibility

Areas with low landslide susceptibility rating have low to gentle slopes and lack tension cracks. Areas with moderate landslide susceptibility rating have inactive/old landslides and tension cracks that are located away from the community. These areas usually have moderate slopes. Areas with high landslide susceptibility rating have active/recent landslides and tension cracks that would directly affect the community. Areas with steep slopes and drainage that are prone to landslide damming are also highly susceptible to landslides.

Figure 24. Landslide Hazard Susceptibility Map of Taganak



UNIVERSAL TRANSVERSE MERCATOR PROJECTION DATUM: WORLD GEODETIC SYSTEM 1984

Source: ALOS Global Digital Surface Model © JAXA **Disclaimer:** Administrative boundaries are approximate **Date:** July 2016

LEGEND

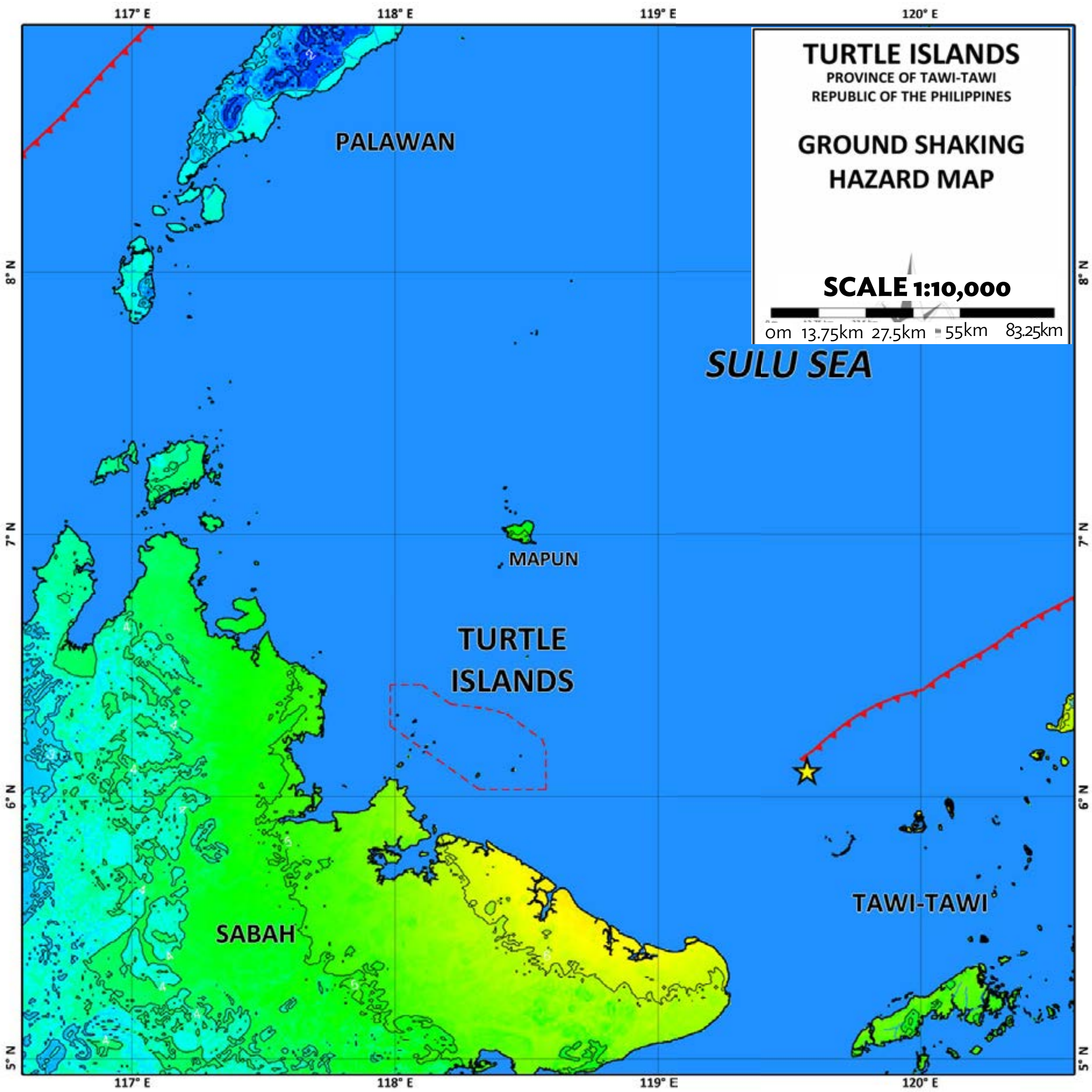
channel, shoreline, low susceptibility, moderate susceptibility, high susceptibility

Areas with low landslide susceptibility rating have low to gentle slopes and lack tension cracks. Areas with moderate landslide susceptibility rating have inactive/old landslides and tension cracks that are located away from the community. These areas usually have moderate slopes. Areas with high landslide susceptibility rating have active/recent landslides and tension cracks that would directly affect the community. Areas with steep slopes and drainage that are prone to landslide damming are also highly susceptible to landslides.

C. Earthquake-Related Hazards

Ground shaking and tsunami hazard maps were simulated in the event of an M8.0 earthquake in the Sulu Trench with focus at a 40 km depth (Figures 25 and 26). Intensity V and VI in PEIS are expected to be felt in the Turtle Islands. Intensity V is characterized by strong ground shaking and is generally felt by most people indoors and outdoors, while Intensity VI is distinguished by very strong ground shaking, slightly damaged poorly built man-made structures, and limited rock falls. A tsunami with run-up elevation of 7 m will hit Tawi-Tawi Island, while estimated run-ups of 5-6 m will strike the Turtle Islands (Figures 26).

Figure 25. Groundshaking Hazard Susceptibility Map of the Turtle Islands and Vicinity



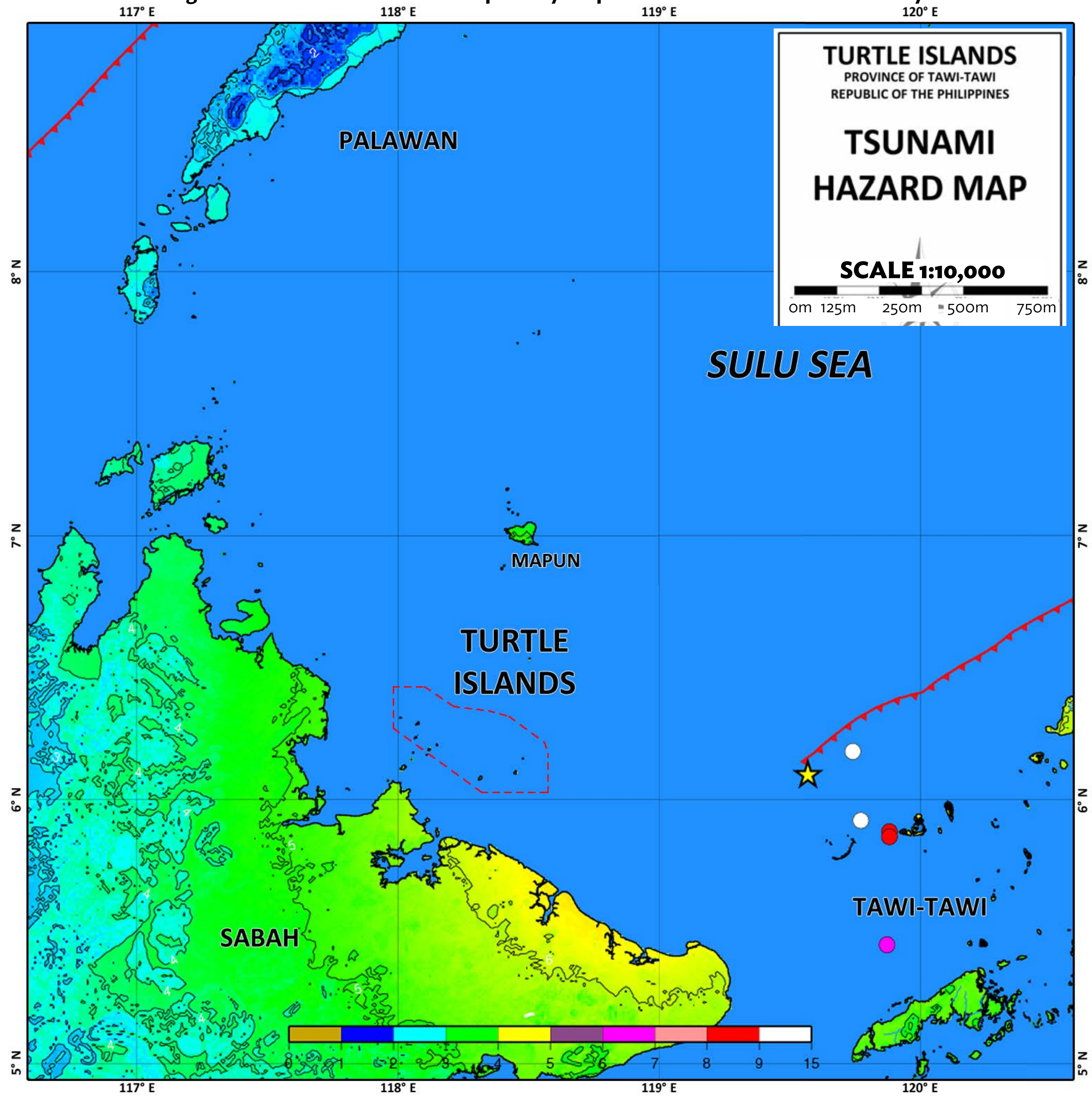
UNIVERSAL TRANSVERSE MERCATOR PROJECTION DATUM: WORLD GEODETIC SYSTEM 1984

Source: PHIVOLCS **Disclaimer:** Administrative boundaries are approximate **Date:** June 2016

LEGEND
- ☆ Epicenter
- Intensity II
- Intensity III
- Intensity IV
- Intensity V
- Intensity VI

This map is based on worst case scenario from major seismic source zones.
Source: Sulu Trench Depth of Focus (km): 40 Magnitude: M8.0

Figure 26. Tsunami Hazard Susceptibility Map of the Turtle Islands and Vicinity



UNIVERSAL TRANSVERSE MERCATOR PROJECTION DATUM: WORLD GEODETIC SYSTEM 1984

Source: PHIVOLCS **Disclaimer:** Administrative boundaries are approximate **Date:** June 2016

LEGEND

- Epicenter
- Intensity II
- Intensity III
- Intensity IV
- Intensity V
- Intensity VI

This map is based on worst case scenario from major seismic source zones.
Source: Sulu Trench
Depth of Focus (km): 40
Magnitude: M8.0

VII. HAZARD EXPOSURE ASSESSMENT

Although the spatial distribution of population and structures is depicted on the maps, the computation of population exposure to various hazards (i.e. flood, landslide, and SLR) was still based on population density. The method was utilized since data on spatial distribution are still insufficient and only approximate. The limitation of this method is that it is assumed that the population is evenly distributed in a given area.

A. Population Exposure to Flood Hazard

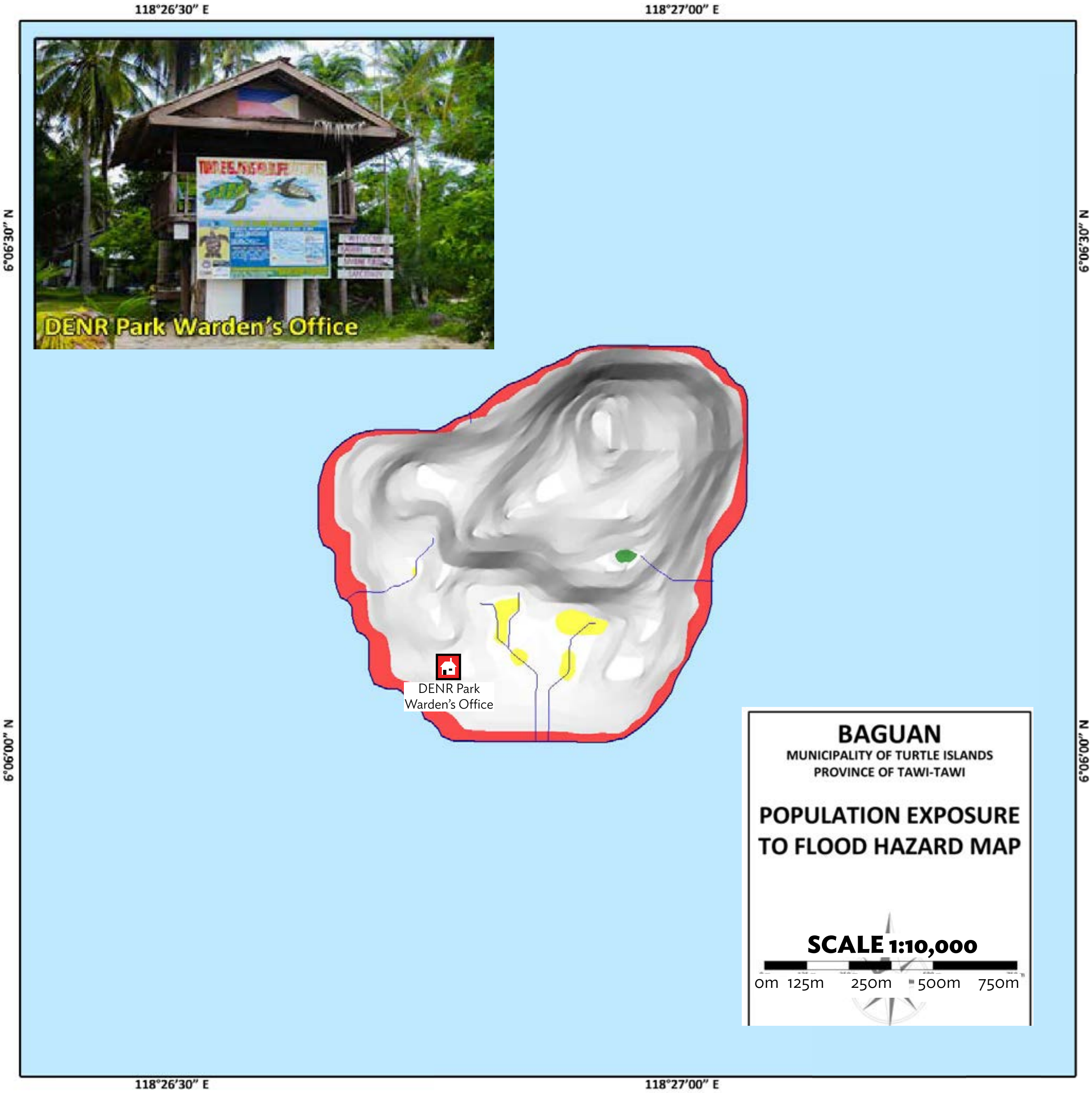
The population of the six major islands exposed to flooding is presented in Table 15 and depicted in Figures 27-32. About 12.3% of the total population (645) of the Turtle Islands is exposed to high flood susceptibility, of whom 46% (300) and 28% (182) reside in Taganak and Great Bakkungan, respectively. Islands with 20% or more of their population exposed to flood at high susceptibility level include Langaan (33% or 36 out of 112) and Lihiman (20.3% or 40 out of 200). Overall, 13.2% of the total population (692) is exposed to low, moderate, and high flood susceptibility.

Table 15. Population of the Islands Exposed to Flood at Various Susceptibility Levels

Island	Population	Population exposed to flood					
		Low	%	Mod	%	High	%
Baguan	0	0.00	0.00	0.00	0.00	0.00	0.00
Boan	816	484.54	59.38	0.00	0.00	0.00	0.00
G. Bakkungan	1104	558.73	50.61	0.66	0.06	0.00	0.00
Langaan	112	48.81	43.58	0.00	0.00	0.00	0.00
Lihiman	200	129.72	64.86	0.00	0.00	0.00	0.00
Taganak	3017	1485.87	49.25	777.48	25.77	67.58	2.24
Total	5249	2707.68	51.58	778.14	14.82	67.58	1.29

Several significant landmarks in Taganak (viz., turtle hatchery, Municipal Police Station, Coast Guard Sub-station, and Turtle Islands National High School (TINHS) are exposed to flood at high susceptibility level (Figure 33). The hatchery, police station, and coast guard sub-station are all situated along the eastern coast of the island; whereas TINHS is located on a topographic low on the coastal plain. Locals affirmed that during heavy and prolonged rainfall, TINHS is immediately flooded. Large waves combined with high astronomical tide can cause extensive flooding on structures along the coast.

Figure 27. Population Exposure to Flood Hazard Susceptibility Map of Baguan



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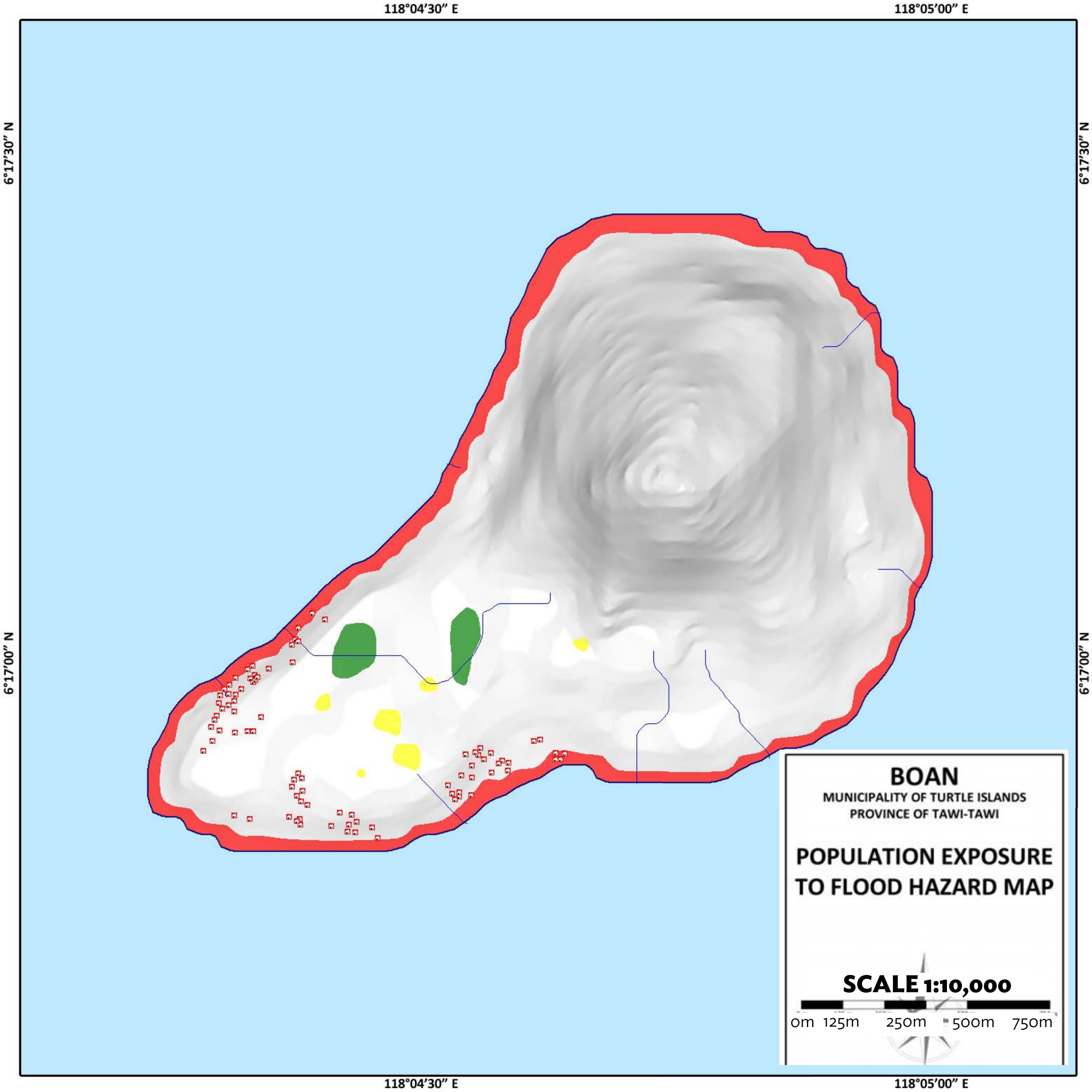
LEGEND

channel	shoreline	structure
low susceptibility	moderate susceptibility	high susceptibility

Areas with less than 0.5 m flood height such as low hills and gentle slopes have low flood susceptibility rating. Areas with 0.5 to 1 m flood height such as fluvial terraces, alluvial fans, and in-filled valleys have moderate flood susceptibility rating. Areas with greater than 1 m flood height have high flood susceptibility rating. These areas are immediately flooded during heavy rains of several hours and include landforms of topographic lows such as active and abandoned river channels, and areas along river banks. In this case, coastal areas are mainly at high risk of coastal flooding as a result of high tides and storm surges.

Figure 28. Population Exposure to Flood Hazard Susceptibility Map of Boan



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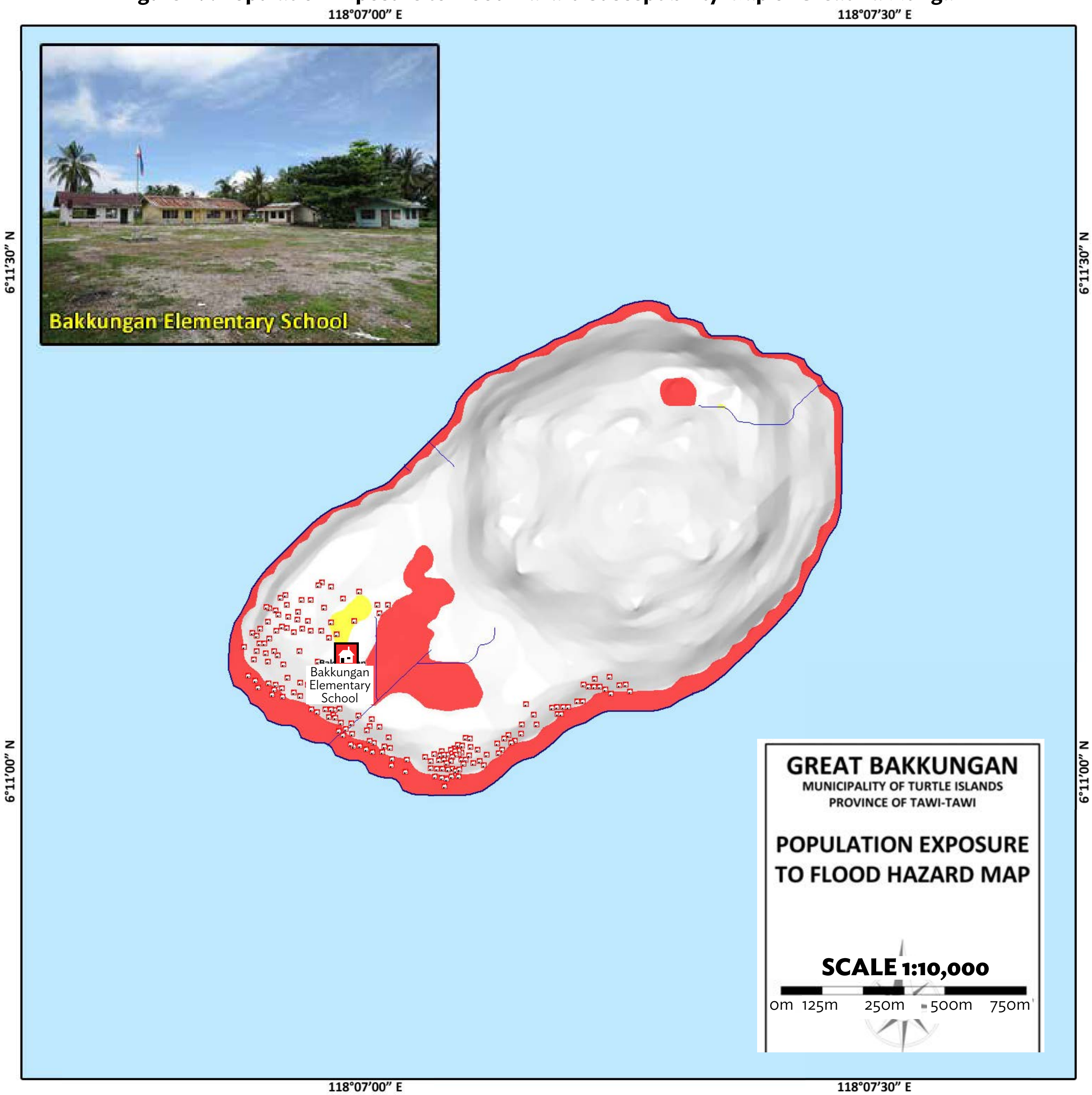
LEGEND

channel · shoreline · structure

low susceptibility · moderate susceptibility · high susceptibility

Areas with less than 0.5 m flood height such as low hills and gentle slopes have low flood susceptibility rating. Areas with 0.5 to 1 m flood height such as fluvial terraces, alluvial fans, and in-filled valleys have moderate flood susceptibility rating. Areas with greater than 1 m flood height have high flood susceptibility rating. These areas are immediately flooded during heavy rains of several hours and include landforms of topographic lows such as active and abandoned river channels, and areas along river banks. In this case, coastal areas are mainly at high risk of coastal flooding as a result of high tides and storm surges.

Figure 29. Population Exposure to Flood Hazard Susceptibility Map of Great Bakkungan



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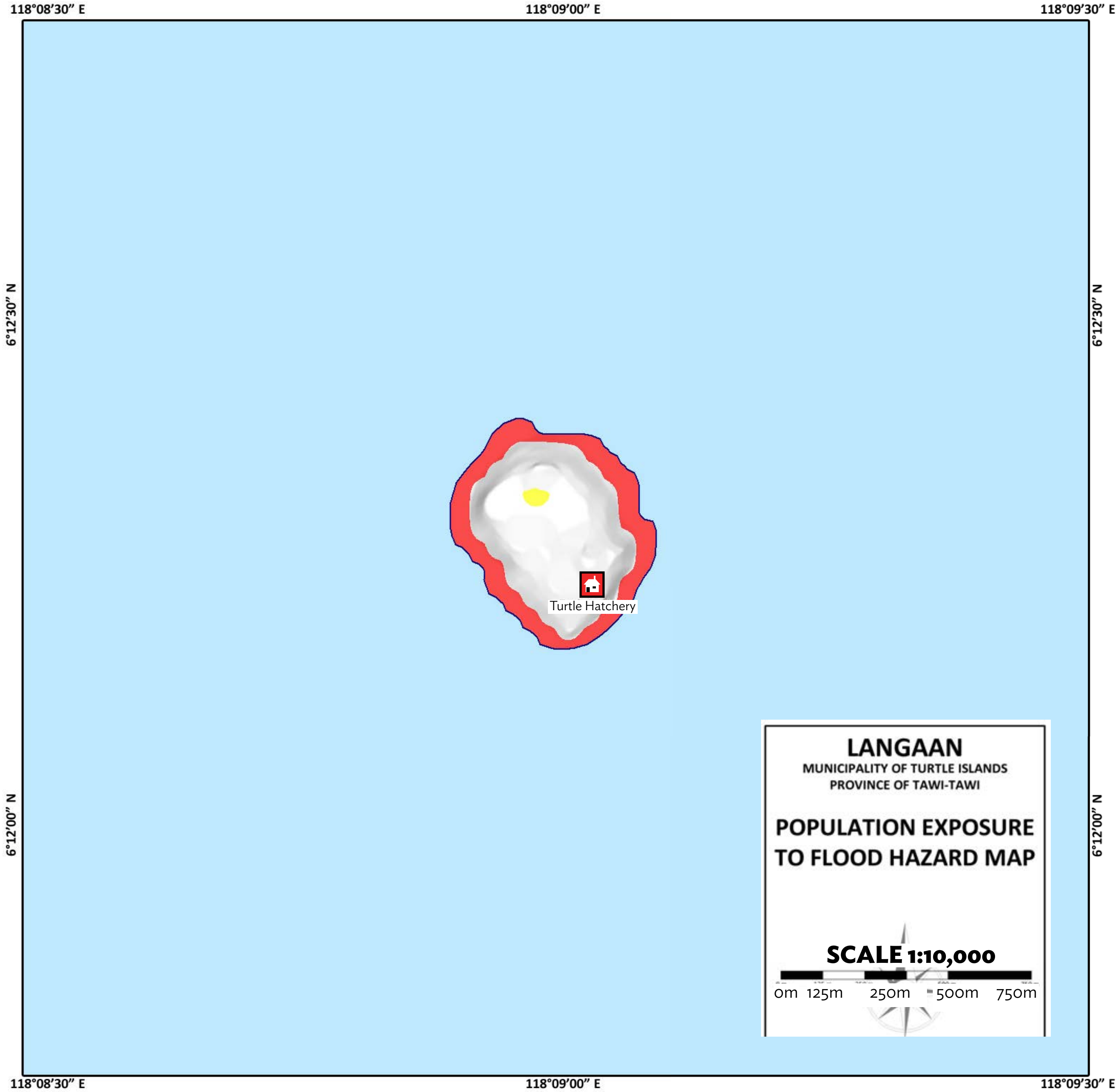
LEGEND

channel	shoreline	structure
low susceptibility	moderate susceptibility	high susceptibility

Areas with less than 0.5 m flood height such as low hills and gentle slopes have low flood susceptibility rating. Areas with 0.5 to 1 m flood height such as fluvial terraces, alluvial fans, and in-filled valleys have moderate flood susceptibility rating. Areas with greater than 1 m flood height have high flood susceptibility rating. These areas are immediately flooded during heavy rains of several hours and include landforms of topographic lows such as active and abandoned river channels, and areas along river banks. In this case, coastal areas are mainly at high risk of coastal flooding as a result of high tides and storm surges.

Figure 30. Population Exposure to Flood Hazard Susceptibility Map of Langaan



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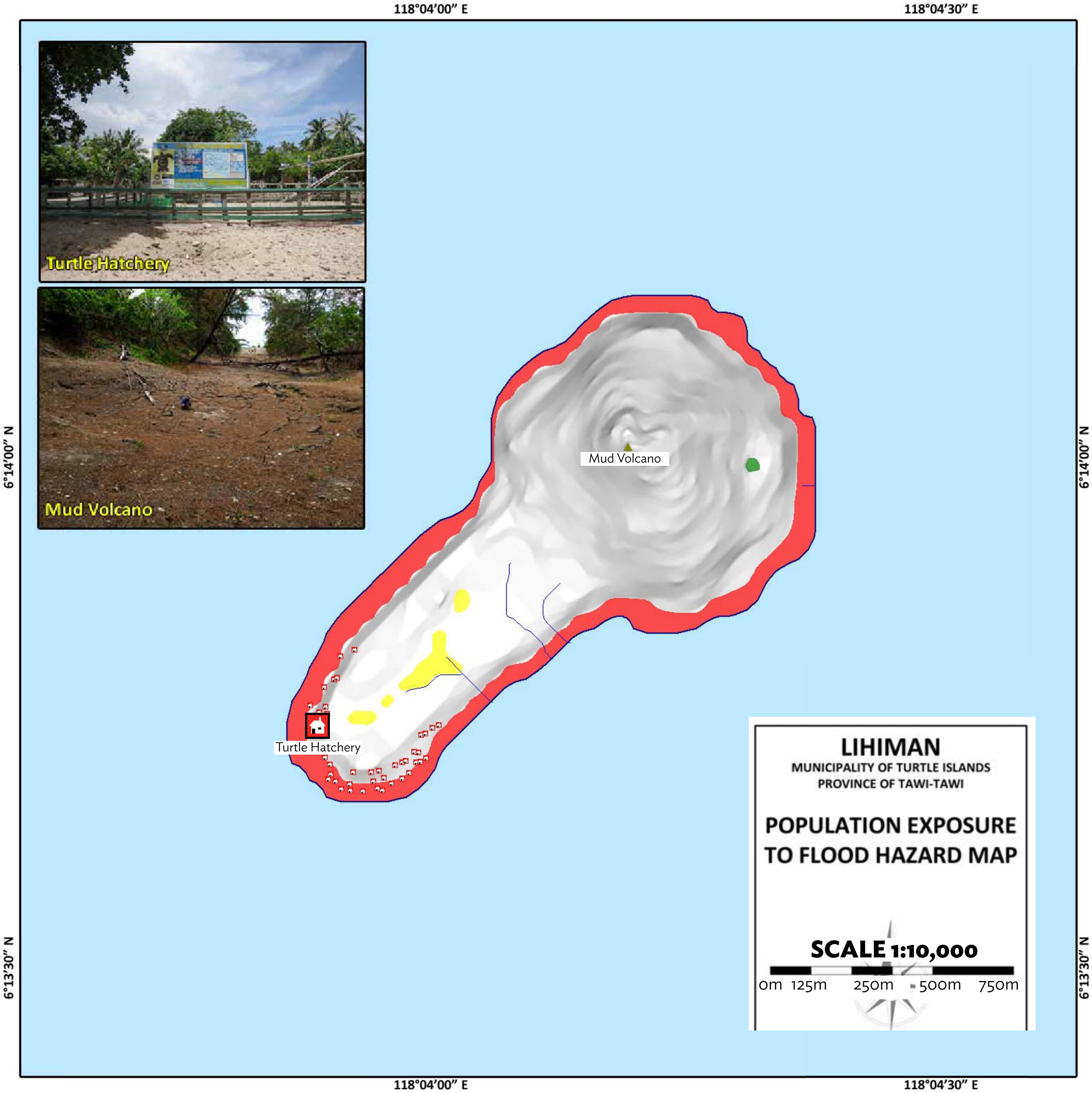
LEGEND

- channel
- shoreline
- structure
- low susceptibility
- moderate susceptibility
- high susceptibility

Areas with less than 0.5 m flood height such as low hills and gentle slopes have low flood susceptibility rating. Areas with 0.5 to 1 m flood height such as fluvial terraces, alluvial fans, and in-filled valleys have moderate flood susceptibility rating. Areas with greater than 1 m flood height have high flood susceptibility rating. These areas are immediately flooded during heavy rains of several hours and include landforms of topographic lows such as active and abandoned river channels, and areas along river banks. In this case, coastal areas are mainly at high risk of coastal flooding as a result of high tides and storm surges.

Figure 31. Population Exposure to Flood Hazard Susceptibility Map of Lihiman



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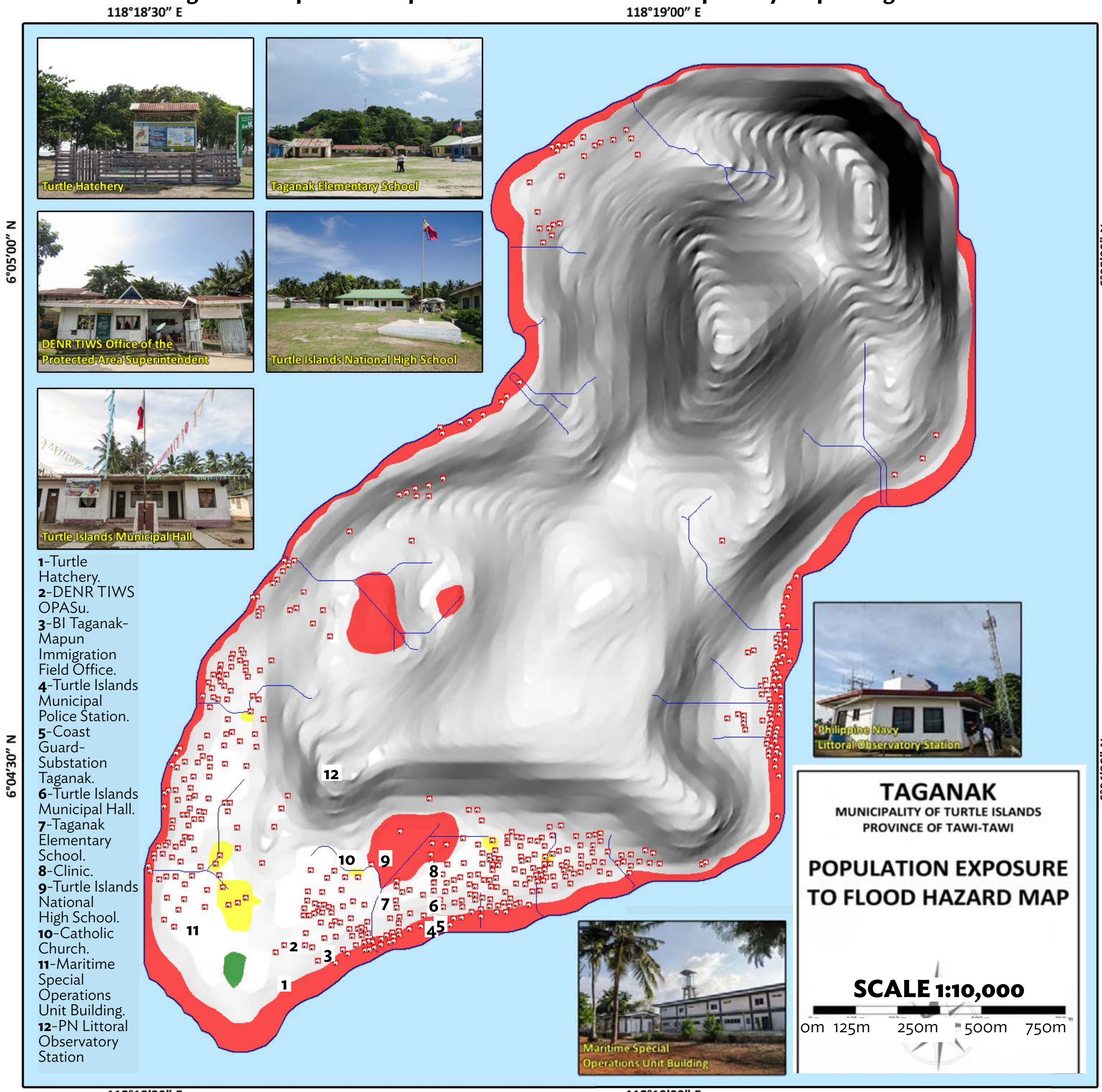
LEGEND

- channel
- shoreline
- structure
- low susceptibility
- moderate susceptibility
- high susceptibility

Areas with less than 0.5 m flood height such as low hills and gentle slopes have low flood susceptibility rating. Areas with 0.5 to 1 m flood height such as fluvial terraces, alluvial fans, and in-filled valleys have moderate flood susceptibility rating. Areas with greater than 1 m flood height have high flood susceptibility rating. These areas are immediately flooded during heavy rains of several hours and include landforms of topographic lows such as active and abandoned river channels, and areas along river banks. In this case, coastal areas are mainly at high risk of coastal flooding as a result of high tides and storm surges.

Figure 32. Population Exposure to Flood Hazard Susceptibility Map of Taganak



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LEGEND

- channel
- shoreline
- structure
- low susceptibility
- moderate susceptibility
- high susceptibility

Areas with less than 0.5 m flood height such as low hills and gentle slopes have low flood susceptibility rating. Areas with 0.5 to 1 m flood height such as fluvial terraces, alluvial fans, and in-filled valleys have moderate flood susceptibility rating. Areas with greater than 1 m flood height have high flood susceptibility rating. These areas are immediately flooded during heavy rains of several hours and include landforms of topographic lows such as active and abandoned river channels, and areas along river banks. In this case, coastal areas are mainly at high risk of coastal flooding as a result of high tides and storm surges.

Table 16. Population of the islands exposed to landslide at various susceptibility levels

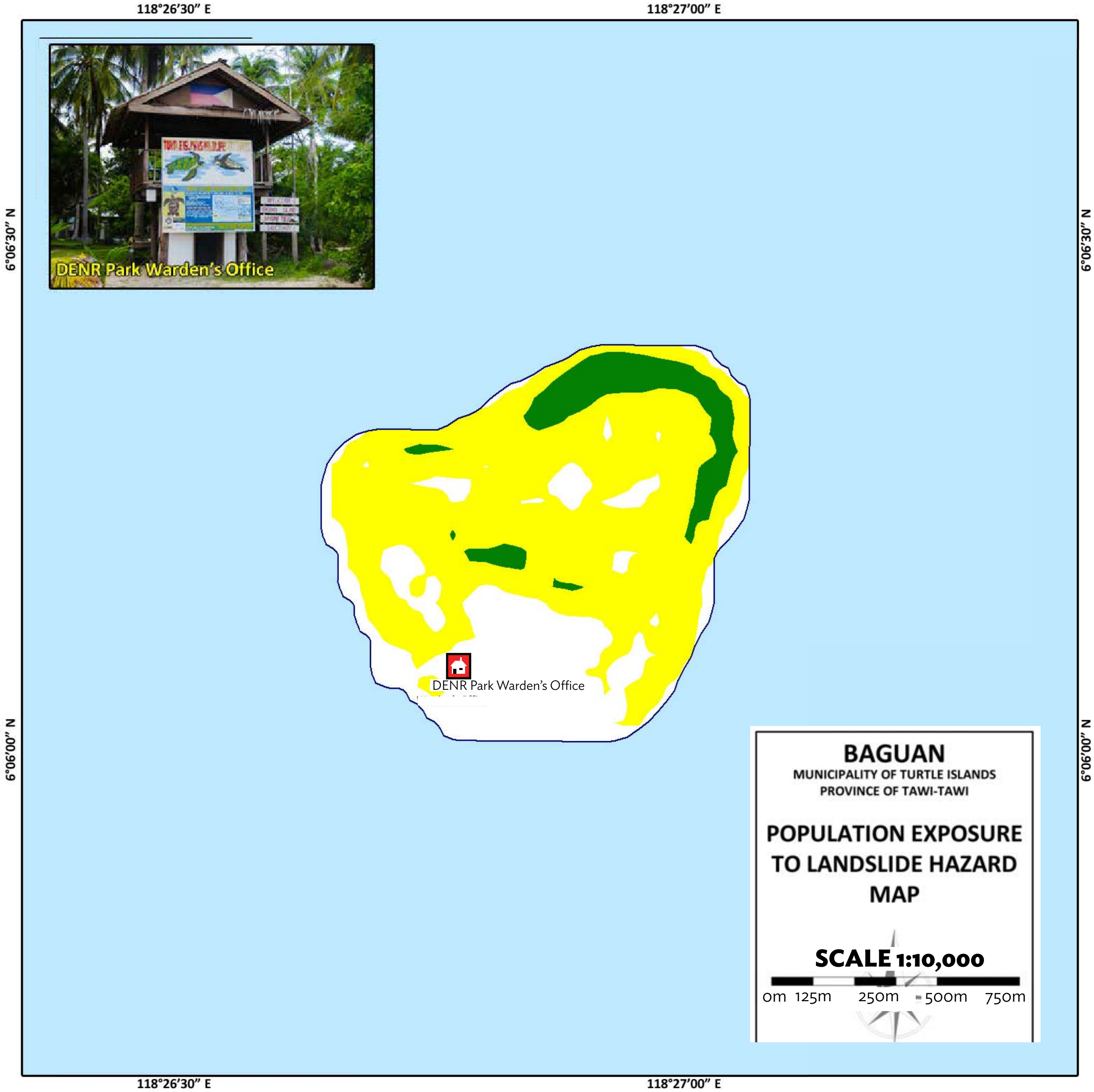
Island	Population	Population exposed to flood					
		Low	%	Mod	%	High	%
Baguan	0	0.00	0.00	0.00	0.00	0.00	0.00
Boan	816	484.54	59.38	0.00	0.00	0.00	0.00
G. Bakkungan	1104	558.73	50.61	0.66	0.06	0.00	0.00
Langaan	112	48.81	43.58	0.00	0.00	0.00	0.00
Lihiman	200	129.72	64.86	0.00	0.00	0.00	0.00
Taganak	3017	1485.87	49.25	777.48	25.77	67.58	2.24
Total	5249	2707.68	51.58	778.14	14.82	67.58	1.29

B. Population Exposure to Landslide Hazard

Only 1.3% of the of the total population (67) of the Turtle Islands is exposed to high landslide susceptibility, 14.8% (778) to moderate landslide susceptibility, and 51.6% (2707) to low landslide susceptibility (Table 16). Maps of population exposure to landslide hazard are shown in Figures 33 to 38.

Among the six major islands, only Taganak has its population exposed to land slide at moderate (25.8% or 777 out of 3017) and high susceptibility levels (2.2% or 67 out of 3017) (Figure 38). The littoral observatory station in Taganak sits on the edge of a plateau-like feature with very strong slopes. Structural damages on the concrete stairs going to the observatory station and tension cracks on the slope were observed, indicating active ground movement on the slope. Erosions along the road in Sitio Limao-limao were also observed. The north eastern end of Baguan is moderately susceptible to landslide, but there is no population exposed to the hazard since there are no people living on the island, except park wardens assigned at the DENR station (Figure 33).

Figure 33. Population Exposure to Landslide Hazard Susceptibility Map of Baguan



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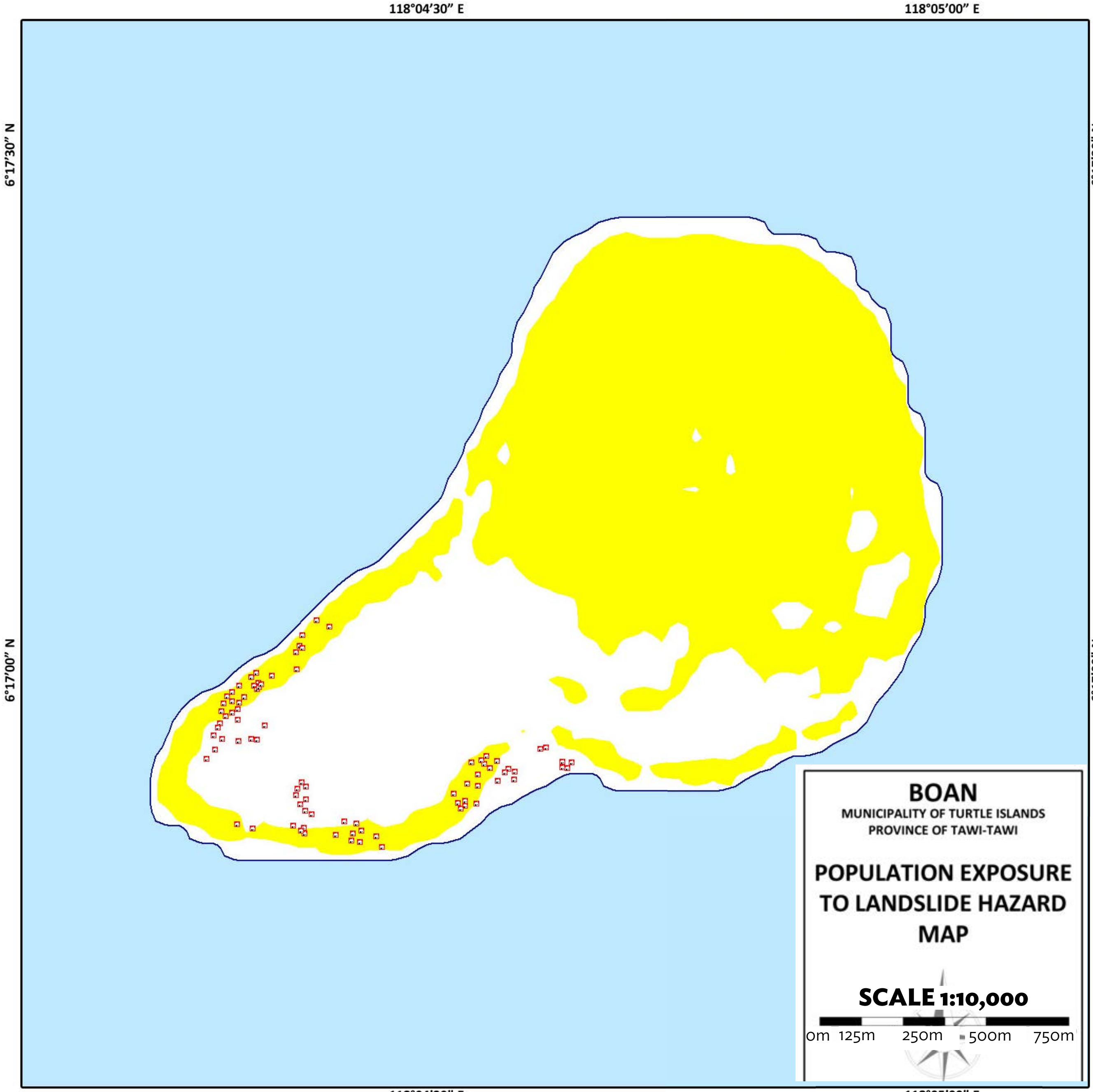
LEGEND

- shoreline
- structure
- low susceptibility
- moderate susceptibility
- high susceptibility

Areas with low landslide susceptibility rating have low to gentle slopes and lack tension cracks. Areas with moderate landslide susceptibility rating have inactive/old landslides and tension cracks that are located away from the community. These areas usually have moderate slopes. Areas with high landslide susceptibility rating have active/recent landslides and tension cracks that would directly affect the community. Areas with steep slopes and drainage that are prone to landslide damming are also highly susceptible to landslides.

Figure 34. Population Exposure to Landslide Hazard Susceptibility Map of Boan



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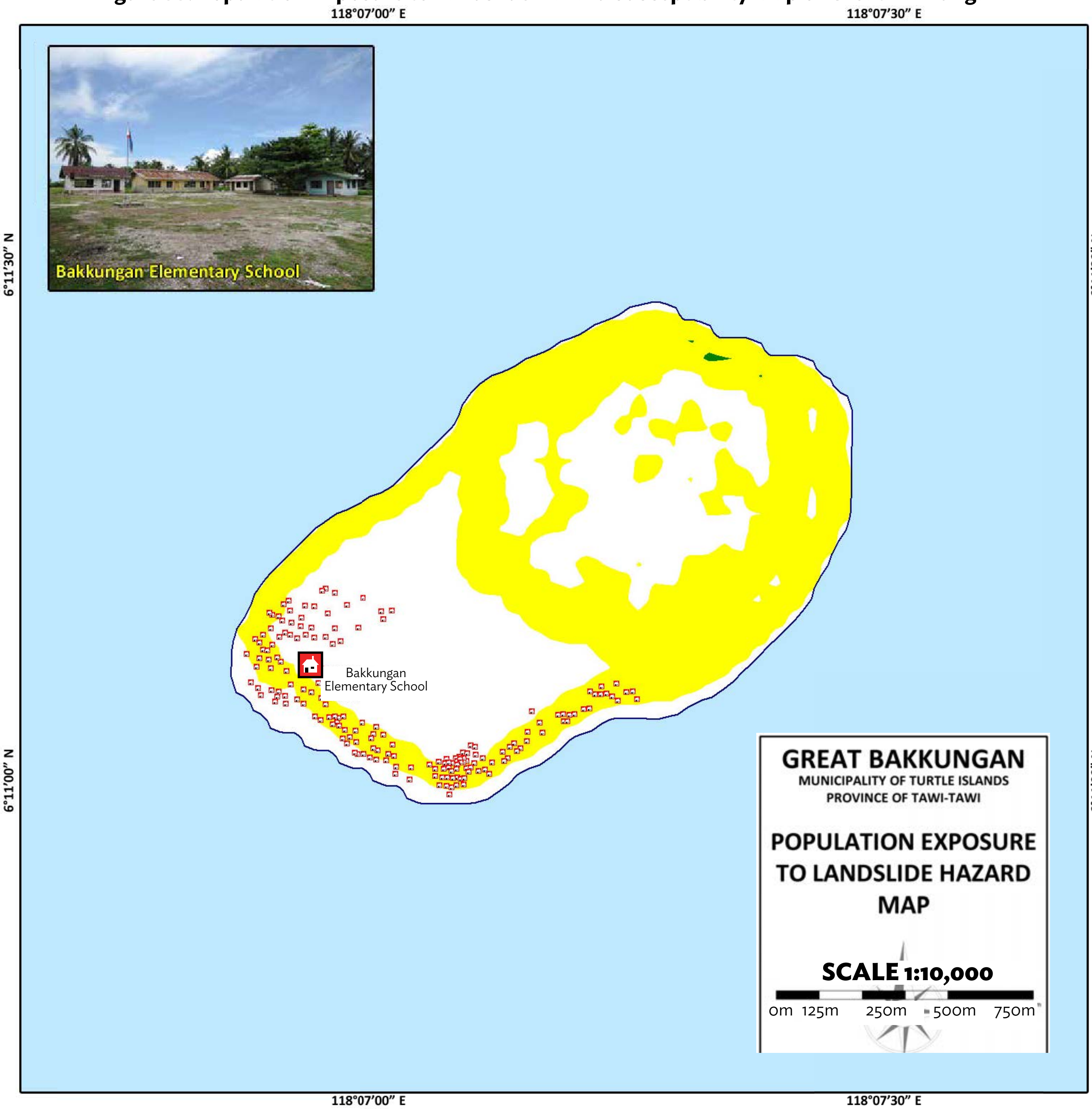
LEGEND

- shoreline
- structure
- low susceptibility
- moderate susceptibility
- high susceptibility

Areas with low landslide susceptibility rating have low to gentle slopes and lack tension cracks. Areas with moderate landslide susceptibility rating have inactive/old landslides and tension cracks that are located away from the community. These areas usually have moderate slopes. Areas with high landslide susceptibility rating have active/recent landslides and tension cracks that would directly affect the community. Areas with steep slopes and drainage that are prone to landslide damming are also highly susceptible to landslides.

Figure 35. Population Exposure to Landslide Hazard Susceptibility Map of Great Bakkungan



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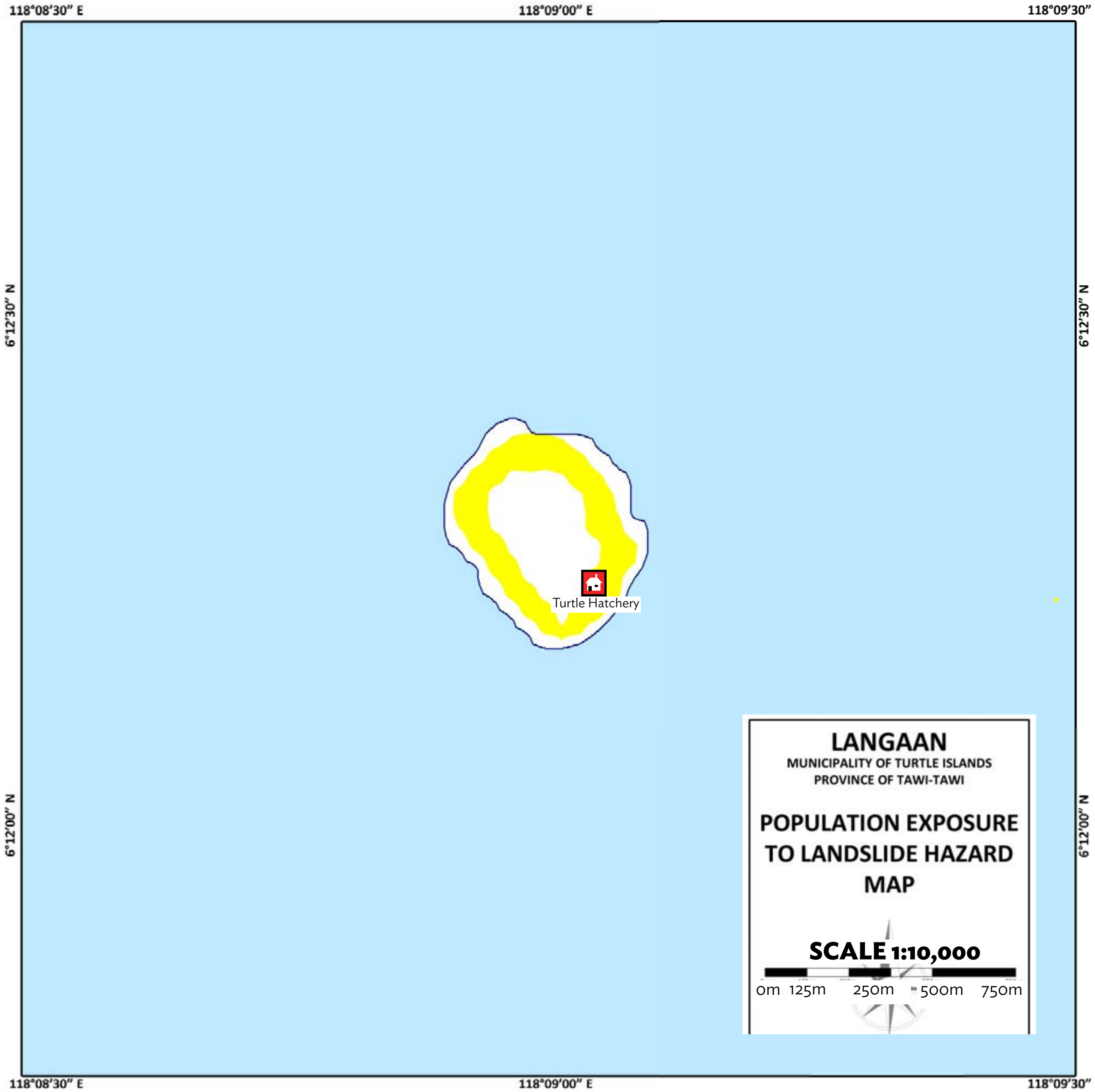
LEGEND

- shoreline
- structure
- low susceptibility
- moderate susceptibility
- high susceptibility

Areas with low landslide susceptibility rating have low to gentle slopes and lack tension cracks. Areas with moderate landslide susceptibility rating have inactive/old landslides and tension cracks that are located away from the community. These areas usually have moderate slopes. Areas with high landslide susceptibility rating have active/recent landslides and tension cracks that would directly affect the community. Areas with steep slopes and drainage that are prone to landslide damming are also highly susceptible to landslides.

Figure 36. Population Exposure to Landslide Hazard Susceptibility Map of Langaan



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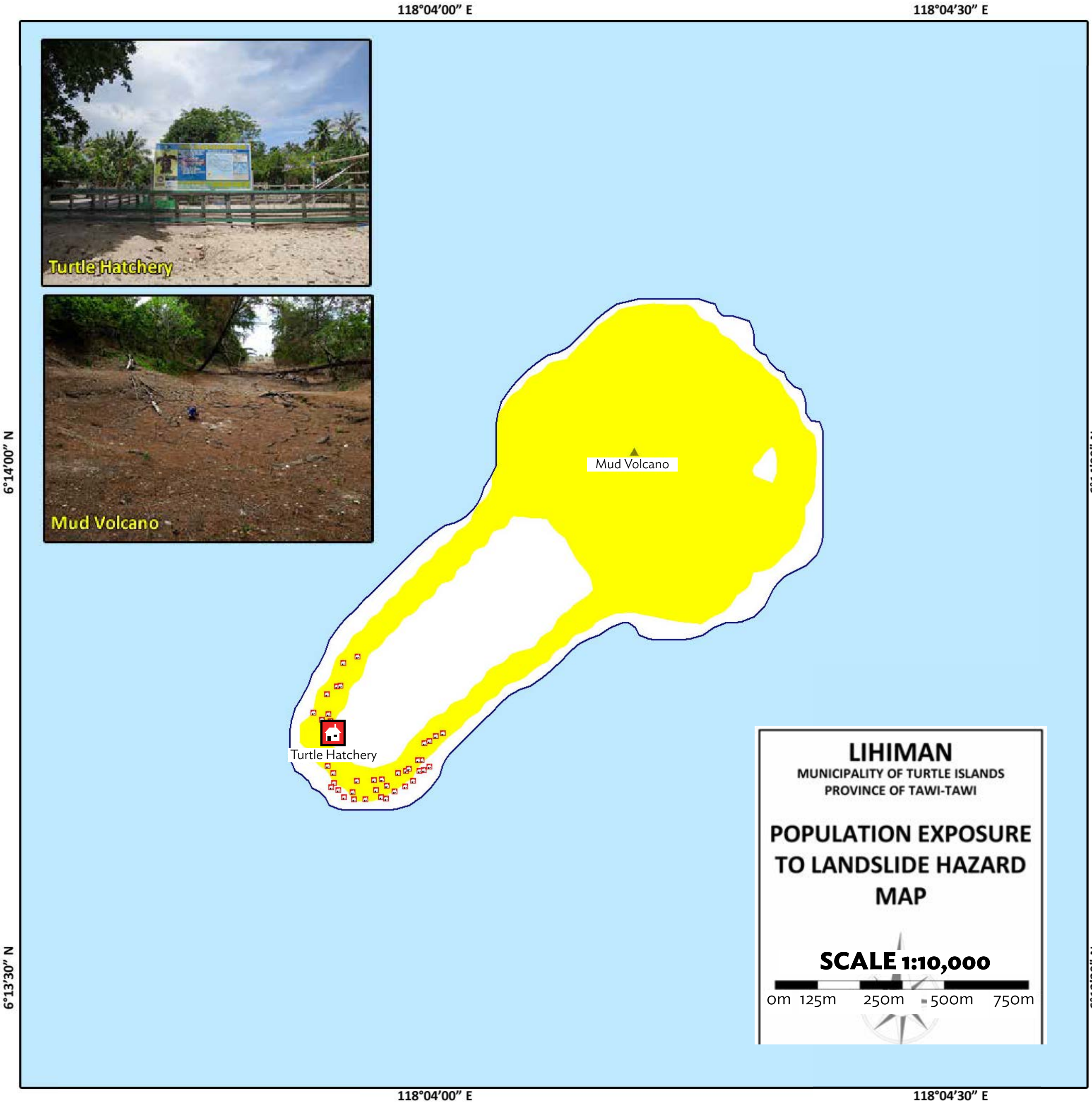
LEGEND

- shoreline
- structure
- low susceptibility
- moderate susceptibility
- high susceptibility

Areas with low landslide susceptibility rating have low to gentle slopes and lack tension cracks. Areas with moderate landslide susceptibility rating have inactive/old landslides and tension cracks that are located away from the community. These areas usually have moderate slopes. Areas with high landslide susceptibility rating have active/recent landslides and tension cracks that would directly affect the community. Areas with steep slopes and drainage that are prone to landslide damming are also highly susceptible to landslides.

Figure 37. Population Exposure to Landslide Hazard Susceptibility Map of Lihiman



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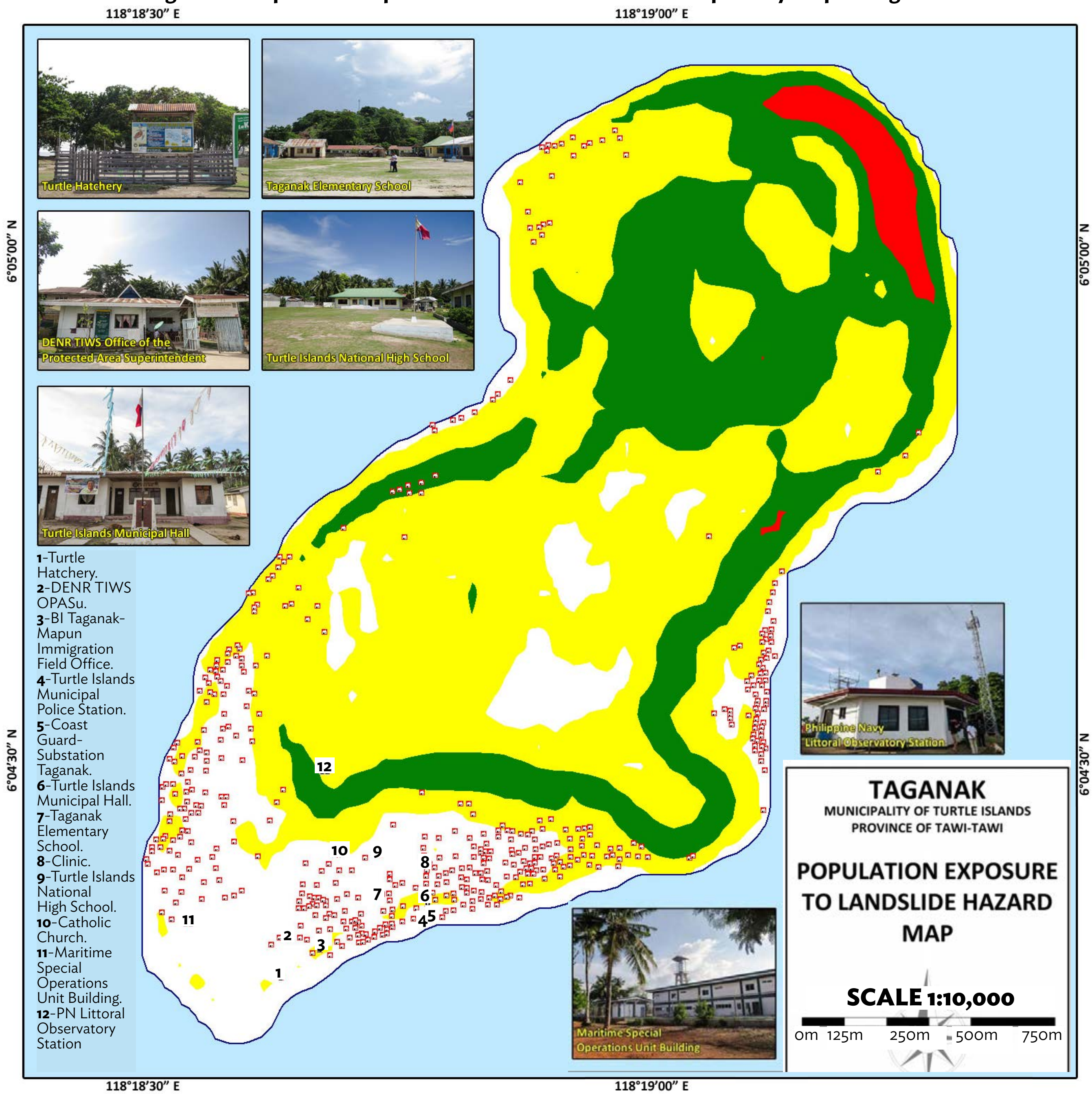
LEGEND

- shoreline
- structure
- low susceptibility
- moderate susceptibility
- high susceptibility

Areas with low landslide susceptibility rating have low to gentle slopes and lack tension cracks. Areas with moderate landslide susceptibility rating have inactive/old landslides and tension cracks that are located away from the community. These areas usually have moderate slopes. Areas with high landslide susceptibility rating have active/recent landslides and tension cracks that would directly affect the community. Areas with steep slopes and drainage that are prone to landslide damming are also highly susceptible to landslides.

Figure 38. Population Exposure to Landslide Hazard Susceptibility Map of Taganak



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LEGEND

- shoreline
- structure
- low susceptibility
- moderate susceptibility
- high susceptibility

Areas with low landslide susceptibility rating have low to gentle slopes and lack tension cracks. Areas with moderate landslide susceptibility rating have inactive/old landslides and tension cracks that are located away from the community. These areas usually have moderate slopes. Areas with high landslide susceptibility rating have active/recent landslides and tension cracks that would directly affect the community. Areas with steep slopes and drainage that are prone to landslide damming are also highly susceptible to landslides.

C. Population Exposure to Sea Level Rise

The area and population exposed to SLR at 1.0 m, 2.0 m, 4.0 m, and 6.0 m depths are summarized in Tables 17 and 18, respectively. All these scenarios are not expected to occur in this lifetime. As most projections say that warming of the Earth will persist and likely accelerate, scientists expect sea level to rise by as much as 2 m by 2100.

Table 17. Area of the Islands Exposed to SLR at Various Depths

Island	Area (ha)	Area exposed to sea level rise (ha)							
		1 m	%	2 m	%	4 m	%	6 m	%
Baguan	31.6	3.4	10.6	4.9	15.5	9.7	30.6	13.4	42.3
Boan	64.8	6.5	10.1	9.2	14.2	14.3	22.1	21.9	33.9
G. Bakkungan	43.6	4.5	10.4	6.0	13.8	8.4	19.4	14.6	33.4
Langaan	7.2	2.3	32.2	2.8	38.7	3.5	49.2	4.6	64.1
Lihiman	26.9	5.3	19.7	6.5	24.3	8.4	31.1	14.4	53.7
Taganak	123.9	9.4	7.6	13.6	10.9	26.9	21.7	35.9	28.9
Total	298.0	31.4	10.5	42.9	14.4	71.2	23.9	104.8	35.2

Table 18. Population of the Islands Exposed to SLR at Various Depths

Island	Area (ha)	Population exposed to sea level rise							
		1 m	%	2 m	%	4 m	%	6 m	%
Baguan	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Boan	816	82.0	10.1	115.5	14.2	179.9	22.1	276.2	33.9
G. Bakkungan	1104	114.8	10.4	151.9	13.8	213.7	19.4	368.3	33.4
Langaan	112	36.1	32.2	43.4	38.7	55.1	49.2	71.8	64.1
Lihiman	200	39.5	19.7	48.6	24.3	62.2	31.1	107.3	53.7
Taganak	3017	229.6	7.6	330.1	10.9	653.8	21.7	873.1	28.9
Total	5249	502.0	9.6	689.4	13.1	1165	22.2	1697	32.3

1. Sea Level Rise of 1.0 m

SLR maps at 1.0 m are shown in Figures 39-44. At a 1.0 m SLR, 10.5% of the total land area of the Turtle Islands will be submerged in water, possibly affecting 9.6% (502) of the current population. At this depth, the turtle hatcheries in Lihiman and Taganak, Turtle Islands Municipal Police Station, Coast Guard Sub-station Taganak, and other properties along the coast of the Turtle Islands, will be inundated. Owing to its small land area, almost one-third (32.2%) of Langaan will be exposed to a 1.0 m SLR.

Figure 39. Population Exposure to SLR of 1.0 m in Baguan

CONTOUR INTERVAL 10 M WITH SUPPLEMENTARY CONTOURS AT 5 M INTERVALS

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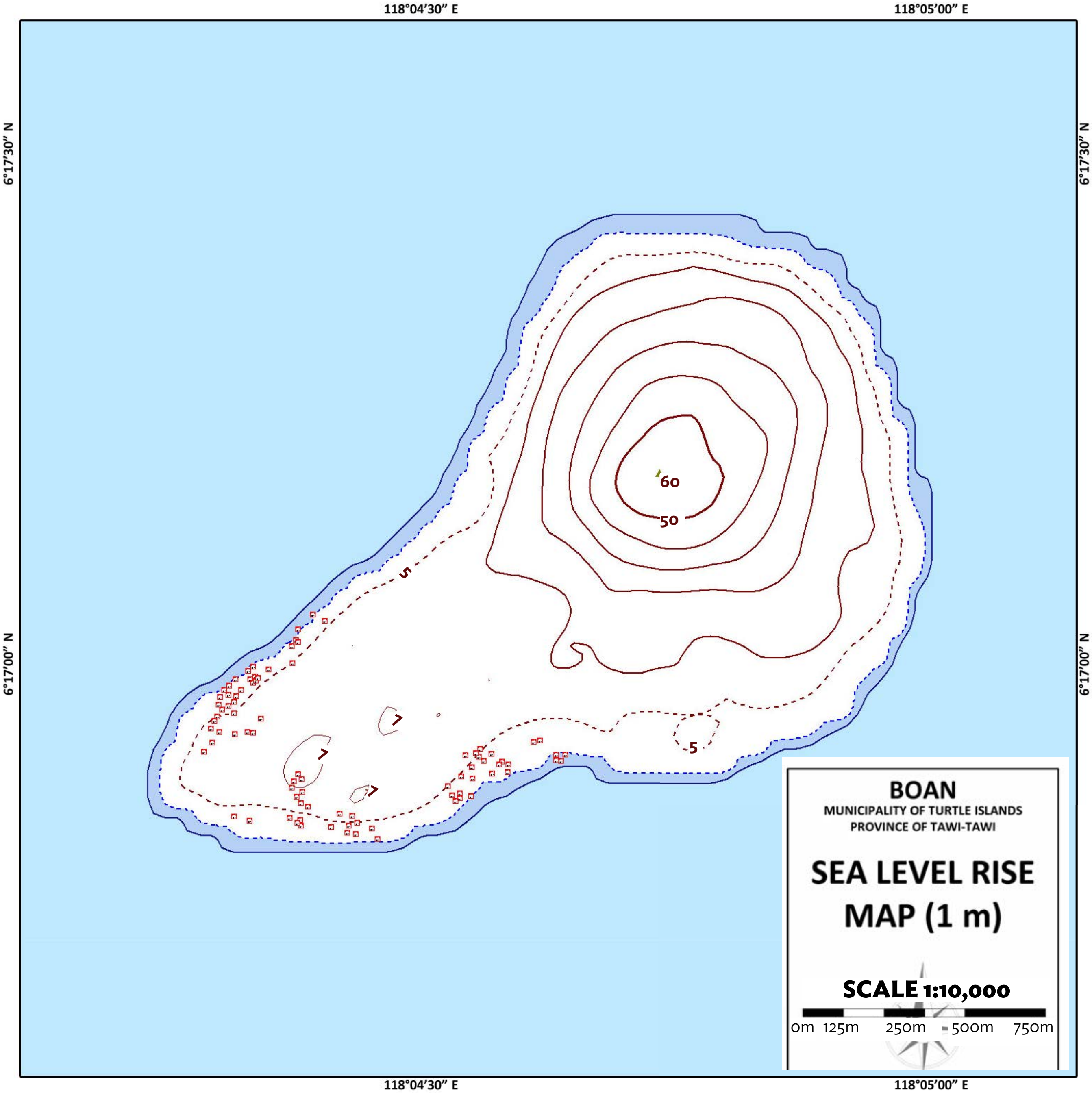
LEGEND

- contour line, intermediate
- contour line, major
- contour line, minor
- contour line, supplementary
- depression
- sea level rise
- shoreline
- spot evaluation
- structure

Figure 40. Population Exposure to SLR of 1.0 m in Boan



CONTOUR INTERVAL 10 M WITH SUPPLEMENTARY CONTOURS AT 5 M INTERVALS

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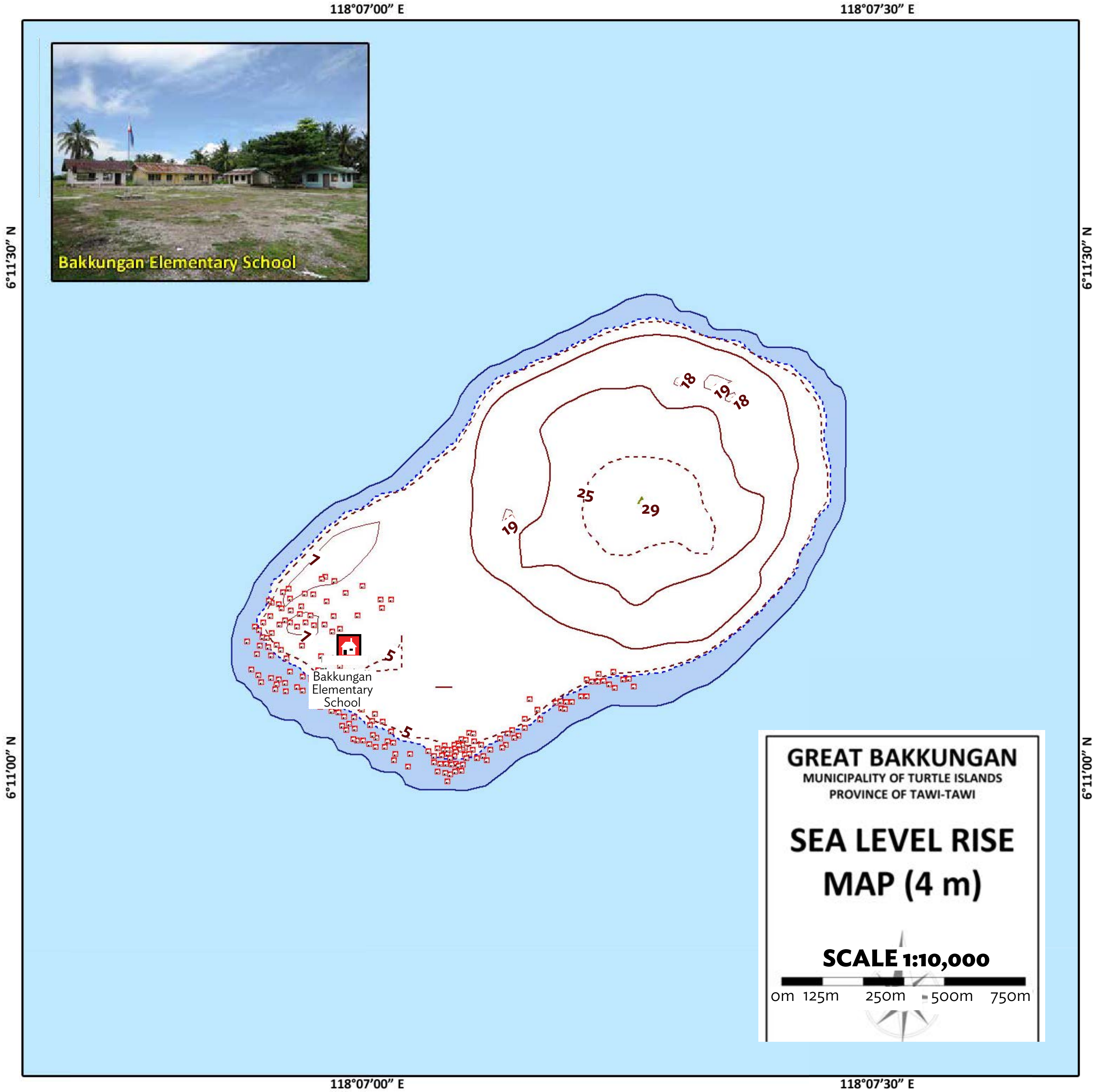
LEGEND

contour line, intermediate	contour line, major	contour line, minor
contour line, supplementary	depression	sea level rise
shoreline	spot evaluation	structure

Figure 41. Population Exposure to SLR of 1.0 m in Great Bakkungan



CONTOUR INTERVAL 10 M WITH SUPPLEMENTARY CONTOURS AT 5 M INTERVALS

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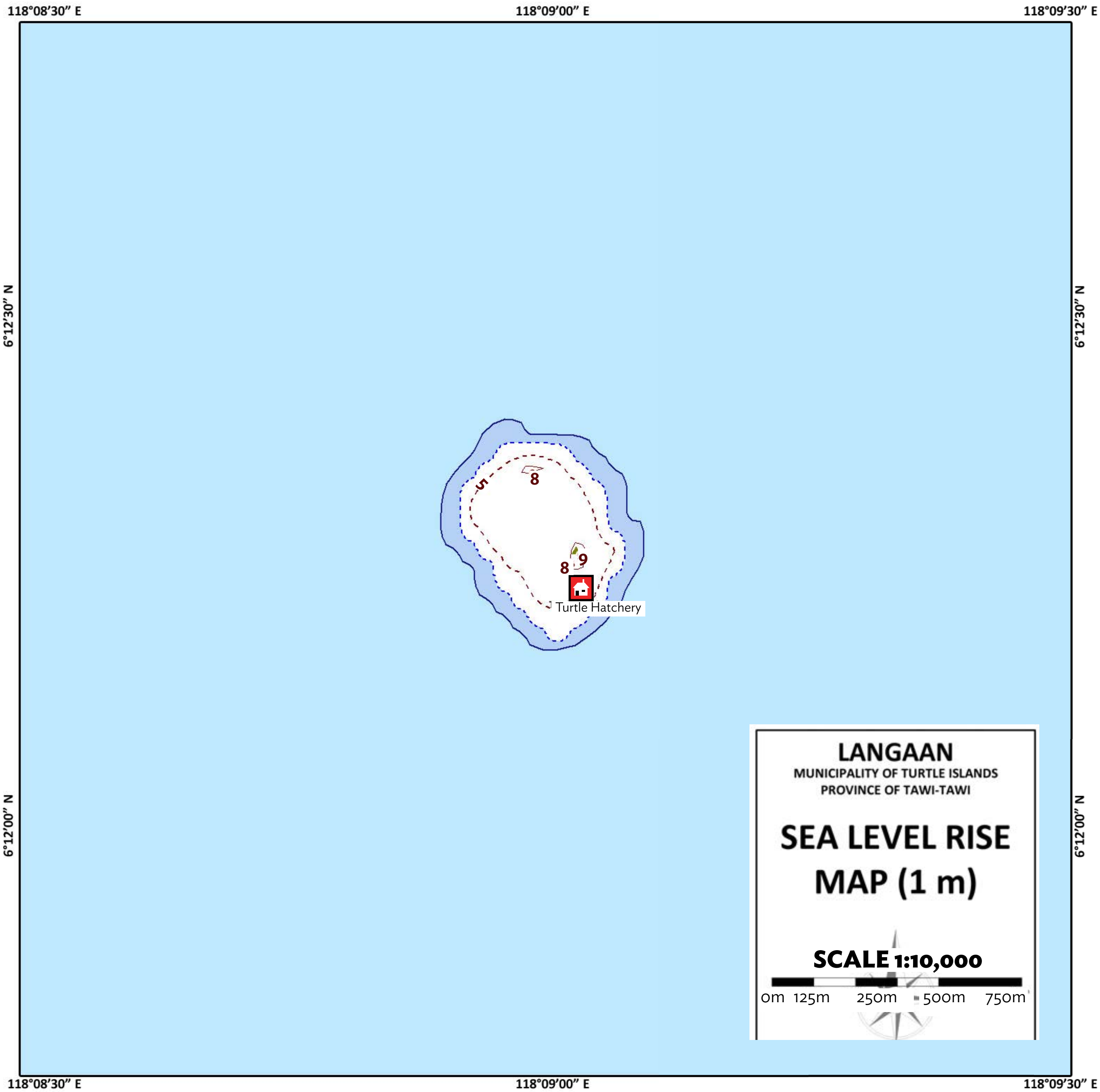
LEGEND

- contour line, intermediate
- contour line, major
- contour line, minor
- contour line, supplementary
- depression
- sea level rise
- shoreline
- spot evaluation
- structure

Figure 42. Population Exposure to SLR of 1.0 m in Langaan



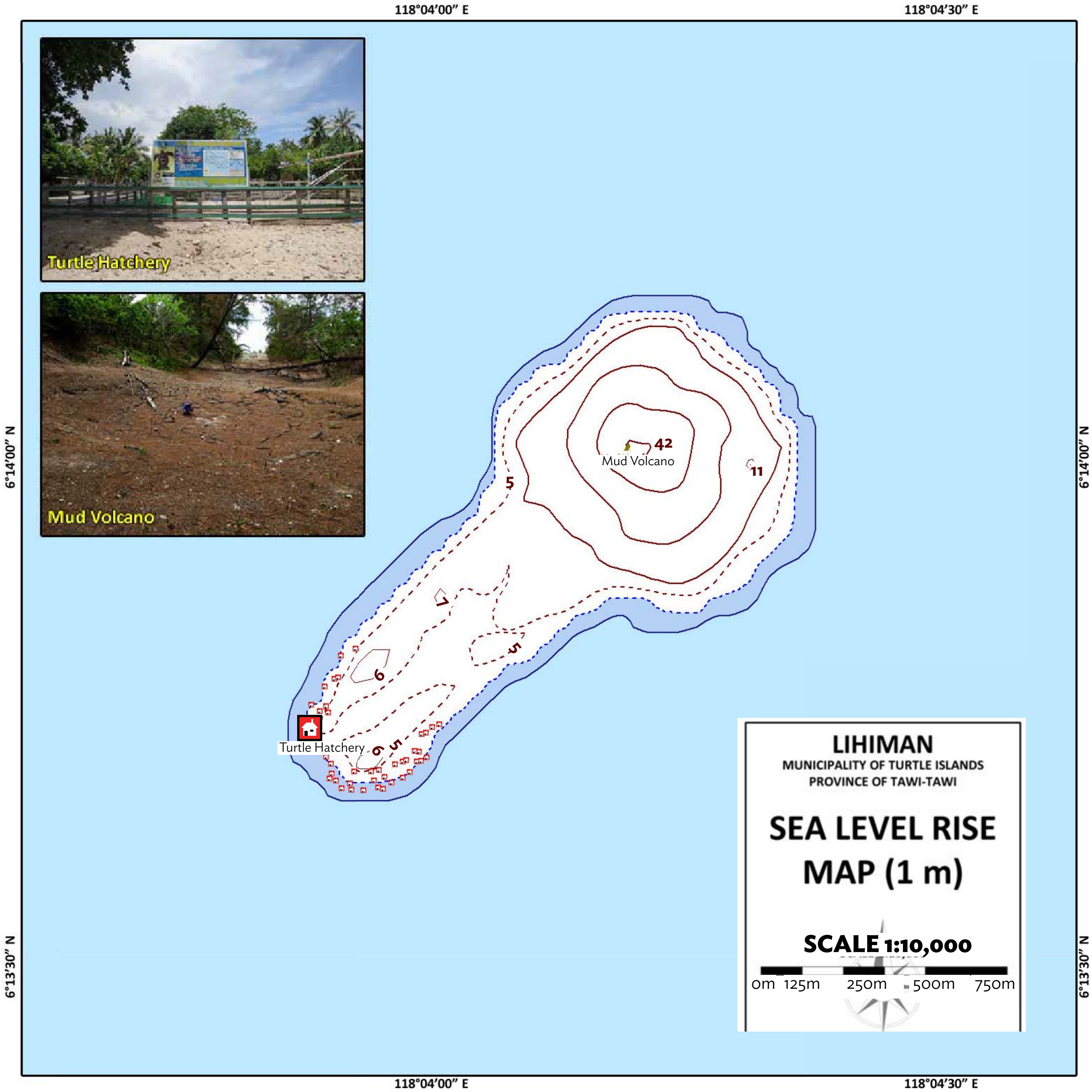
CONTOUR INTERVAL 10 M WITH SUPPLEMENTARY CONTOURS AT 5 M INTERVALS

UNIVERSAL TRANSVERSE MERCATOR PROJECTION DATUM: WORLD GEODETIC SYSTEM 1984
Source: ALOS Global Digital Surface Model © JAXA Digital Globe Satellite Imagery
Disclaimer: Administrative boundaries and spatial distribution of population are approximate **Date:** July 2016

LEGEND

- contour line, intermediate
- contour line, major
- contour line, minor
- contour line, supplementary
- depression
- sea level rise
- shoreline
- spot evaluation
- structure

Figure 43. Population Exposure to SLR of 1.0 m in Lihiman



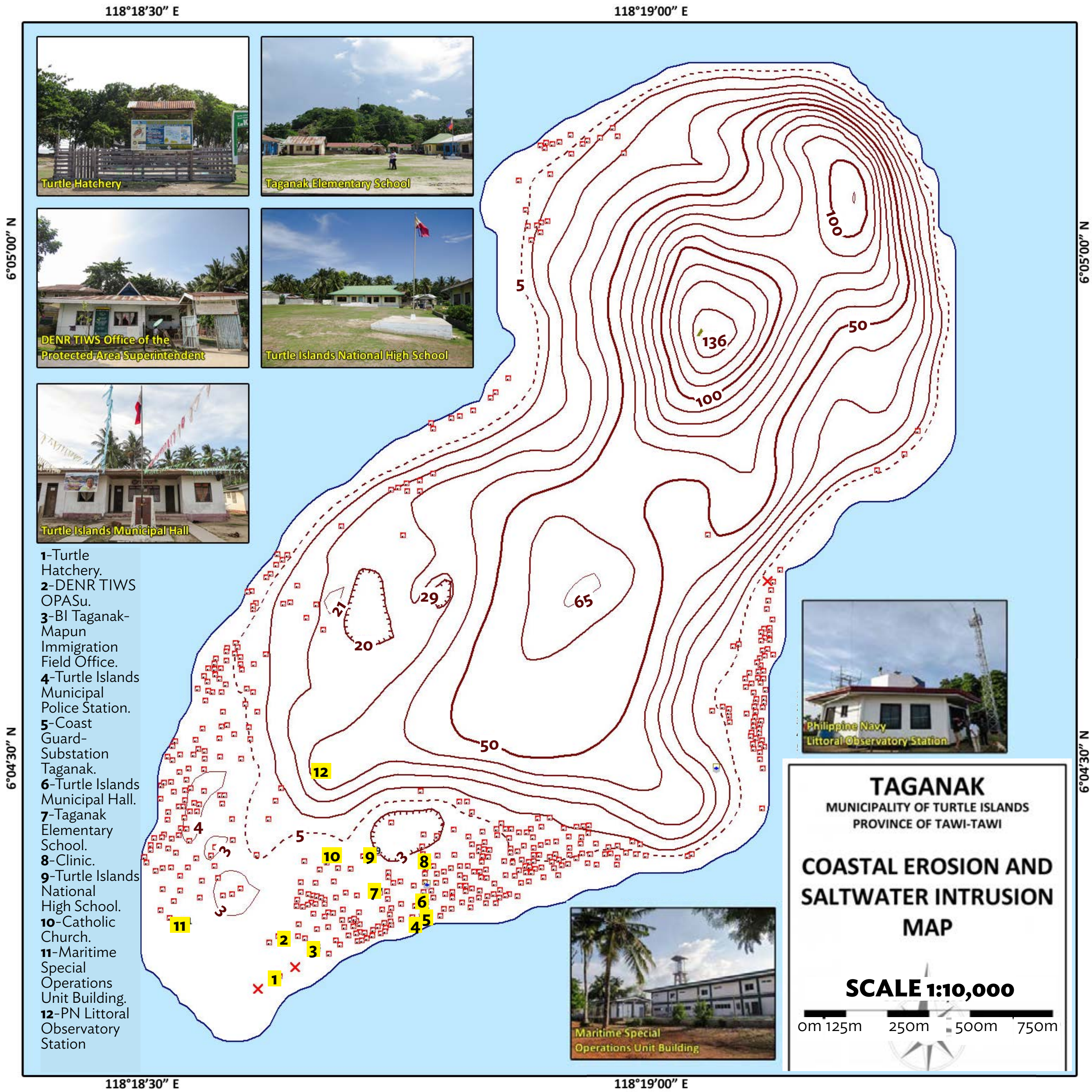
CONTOUR INTERVAL 10 M WITH SUPPLEMENTARY CONTOURS AT 5 M INTERVALS

UNIVERSAL TRANSVERSE MERCATOR PROJECTION DATUM: WORLD GEODETIC SYSTEM 1984
Source: ALOS Global Digital Surface Model © JAXA Digital Globe Satellite Imagery
Disclaimer: Administrative boundaries and spatial distribution of population are approximate **Date:** July 2016

LEGEND

- contour line, intermediate
- contour line, major
- contour line, minor
- contour line, supplementary
- depression
- sea level rise
- shoreline
- spot evaluation
- structure

Figure 44. Population Exposure to SLR of 1.0 m in Taganak



CONTOUR INTERVAL 10 M WITH SUPPLEMENTARY CONTOURS AT 5 M INTERVALS

UNIVERSAL TRANSVERSE MERCATOR PROJECTION DATUM: WORLD GEODETIC SYSTEM 1984
Source: ALOS Global Digital Surface Model © JAXA Digital Globe Satellite Imagery
Disclaimer: Administrative boundaries and spatial distribution of population are approximate **Date:** July 2016

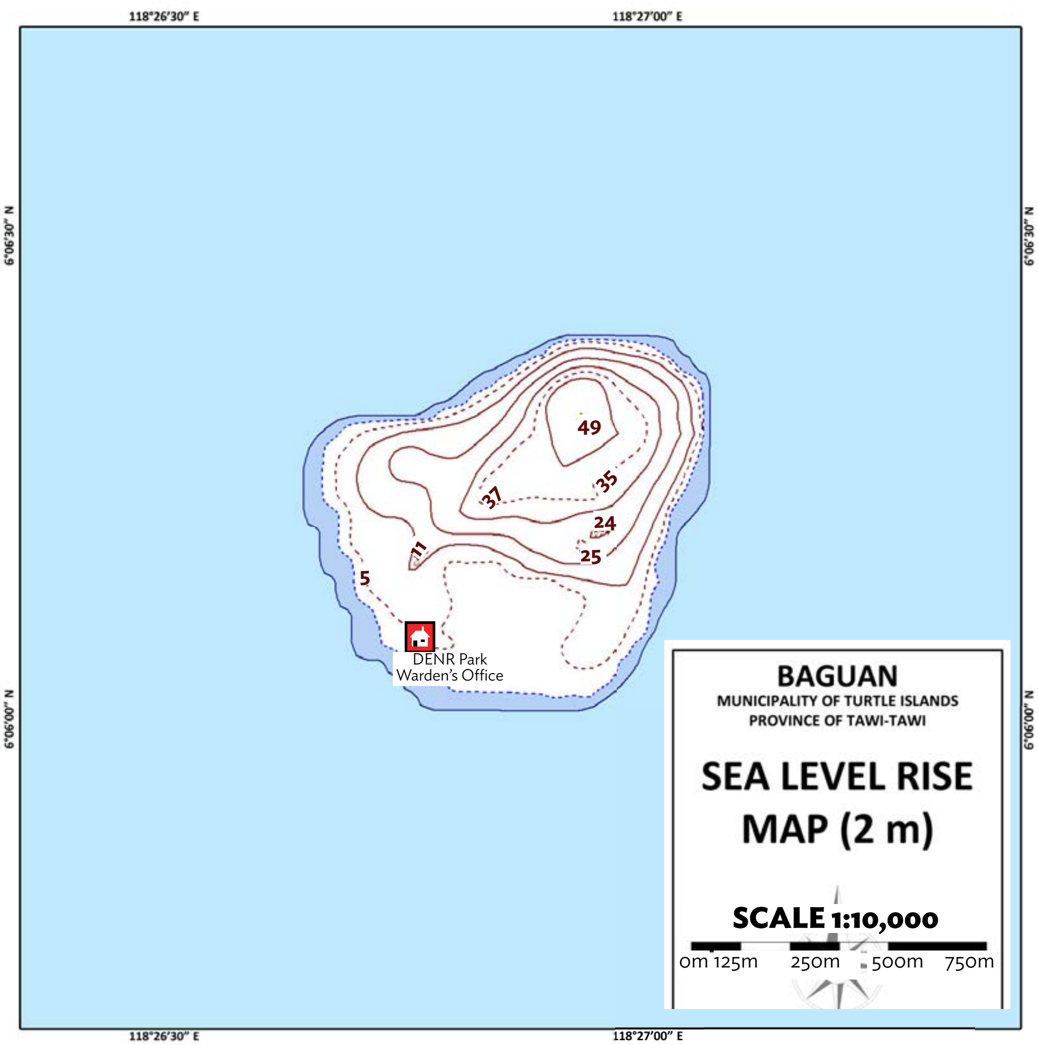
LEGEND

contour line, intermediate	contour line, major	contour line, minor
contour line, supplementary	depression	sea level rise
shoreline	spot evaluation	structure

2. Sea Level Rise of 2.0 m

Sea level rise maps at 2.0 m are presented in Figures 45-49. Around 14.4% of the total land area of the Turtle Islands will be inundated at a 2.0 m SLR, possibly affecting 13.1% (689) of the current population. In addition to the aforementioned structures, the Immigration Field Office and the Turtle Islands Municipal Hall in Taganak will also be submerged in water. Langaan and Lihiman are the only islands with 20% or more of their land area and population exposed to a 2.0 m SLR at 38.7% and 24.3%, respectively.

Figure 45. Population Exposure to SLR of 2.0 m in Baguan



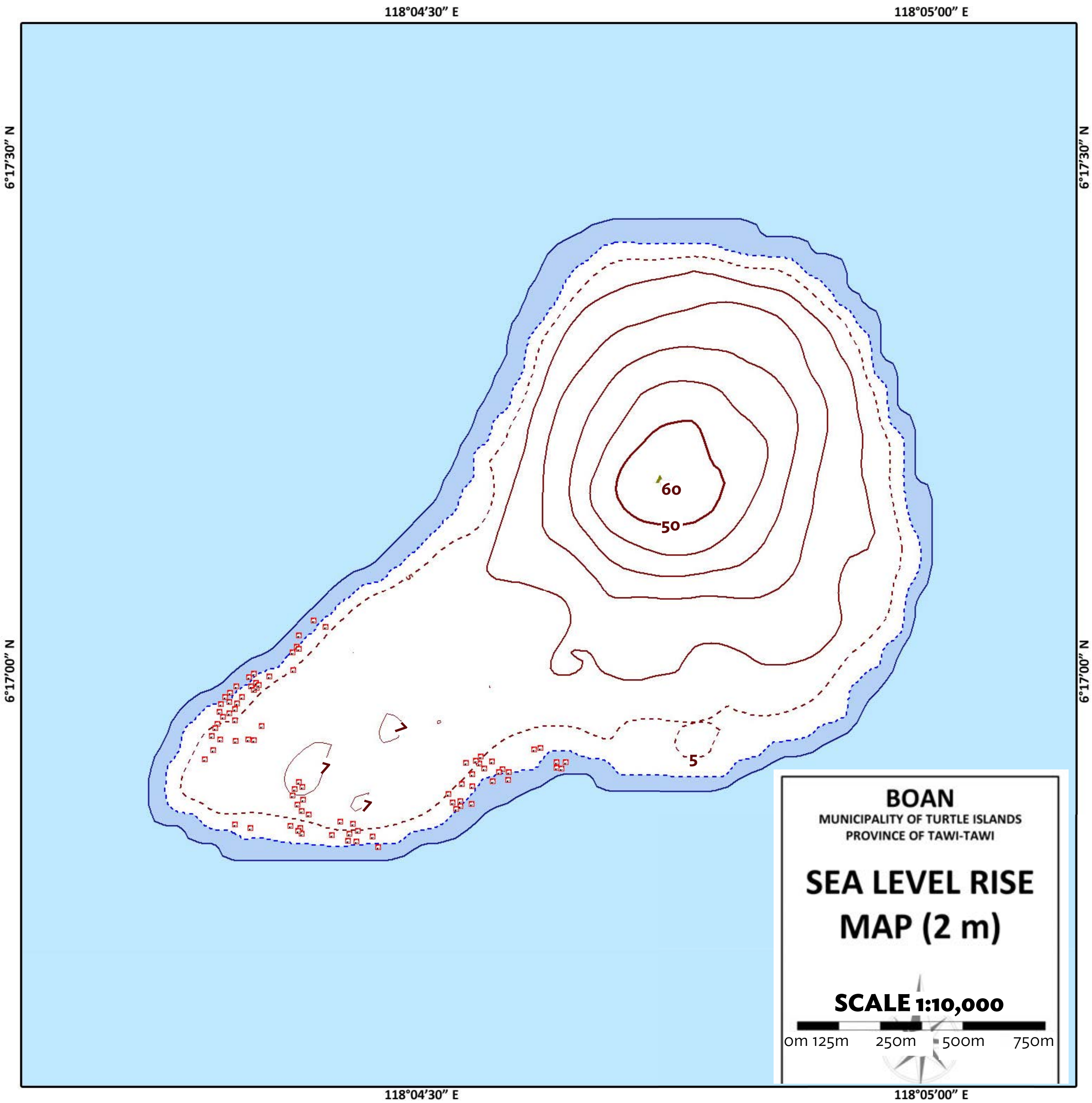
CONTOUR INTERVAL 10 M WITH SUPPLEMENTARY CONTOURS AT 5 M INTERVALS

UNIVERSAL TRANSVERSE MERCATOR PROJECTION DATUM: WORLD GEODETIC SYSTEM 1984
Source: ALOS Global Digital Surface Model © JAXA Digital Globe Satellite Imagery
Disclaimer: Administrative boundaries and spatial distribution of population are approximate **Date:** July 2016

LEGEND

- contour line, intermediate
- contour line, major
- contour line, minor
- contour line, supplementary
- depression
- sea level rise
- shoreline
- spot evaluation
- structure

Figure 46. Population Exposure to SLR of 2.0 m in Boan



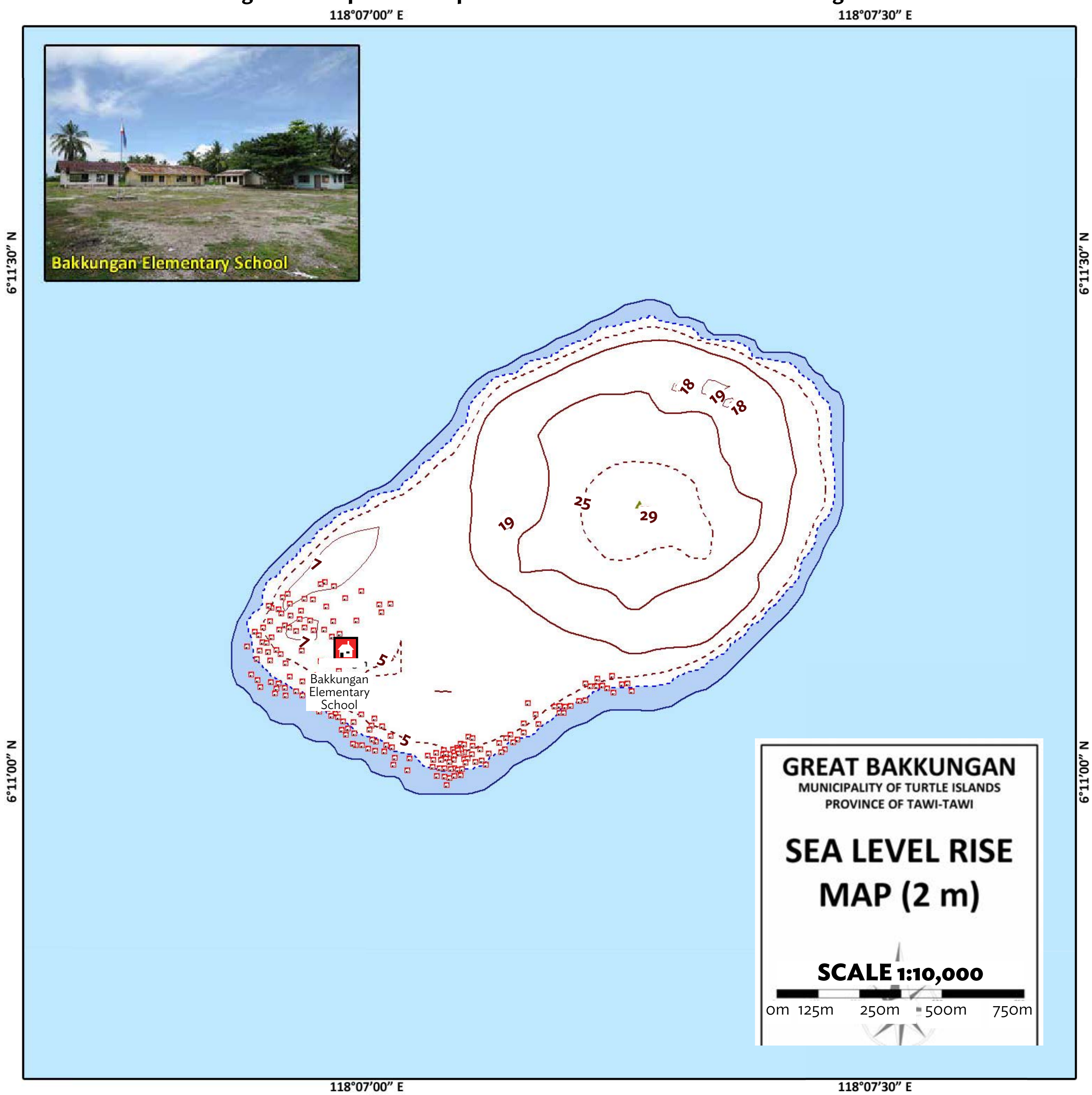
CONTOUR INTERVAL 10 M WITH SUPPLEMENTARY CONTOURS AT 5 M INTERVALS

UNIVERSAL TRANSVERSE MERCATOR PROJECTION DATUM: WORLD GEODETIC SYSTEM 1984
Source: ALOS Global Digital Surface Model © JAXA Digital Globe Satellite Imagery
Disclaimer: Administrative boundaries and spatial distribution of population are approximate **Date:** July 2016

LEGEND

- contour line, intermediate
- contour line, major
- contour line, minor
- contour line, supplementary
- depression
- sea level rise
- shoreline
- spot evaluation
- structure

Figure 47. Population Exposure to SLR of 2.0 m in Great Bakkungan



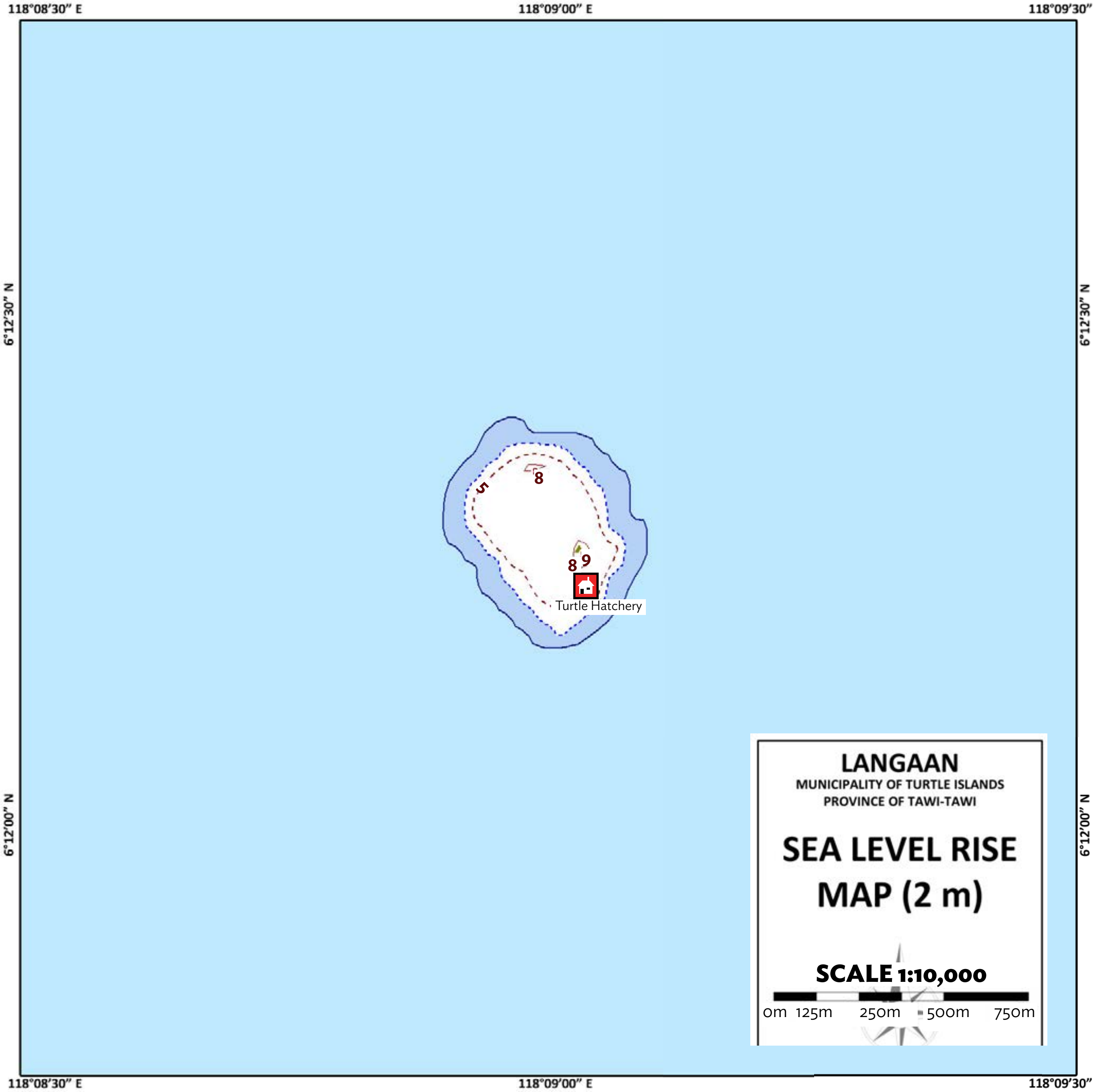
CONTOUR INTERVAL 10 M WITH SUPPLEMENTARY CONTOURS AT 5 M INTERVALS

UNIVERSAL TRANSVERSE MERCATOR PROJECTION DATUM: WORLD GEODETIC SYSTEM 1984
Source: ALOS Global Digital Surface Model © JAXA Digital Globe Satellite Imagery
Disclaimer: Administrative boundaries and spatial distribution of population are approximate **Date:** July 2016

LEGEND

- contour line, intermediate
- contour line, major
- contour line, minor
- contour line, supplementary
- depression
- sea level rise
- shoreline
- spot evaluation
- structure

Figure 48. Population Exposure to SLR of 2.0 m in Langaan



CONTOUR INTERVAL 10 M WITH SUPPLEMENTARY CONTOURS AT 5 M INTERVALS

UNIVERSAL TRANSVERSE MERCATOR PROJECTION DATUM: WORLD GEODETIC SYSTEM 1984

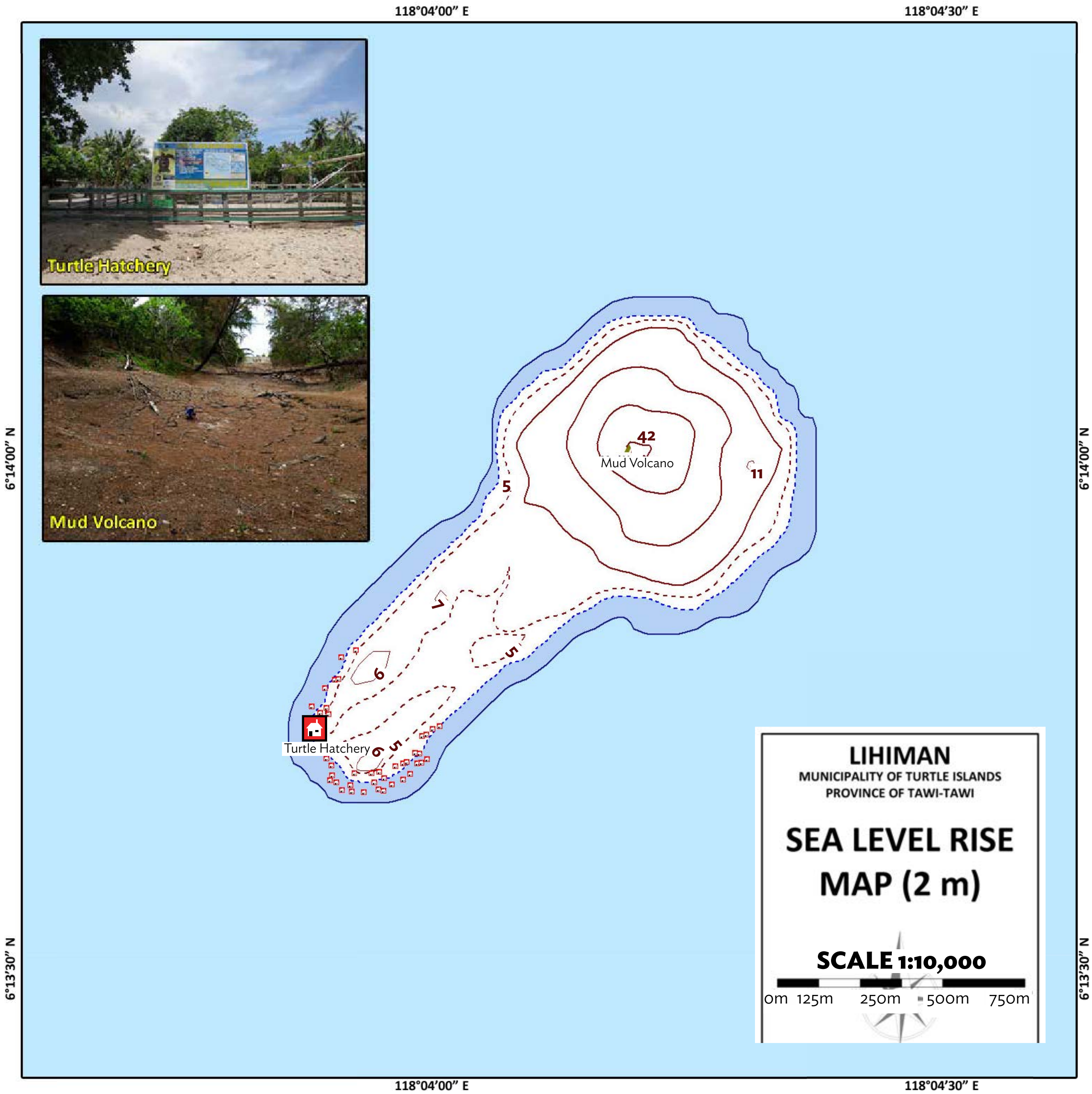
Source: ALOS Global Digital Surface Model © JAXA Digital Globe Satellite Imagery

Disclaimer: Administrative boundaries and spatial distribution of population are approximate **Date:** July 2016

LEGEND

- contour line, intermediate
- contour line, major
- contour line, minor
- contour line, supplementary
- depression
- sea level rise
- shoreline
- spot evaluation
- structure

Figure 49. Population Exposure to SLR of 2.0 m in Lihiman



CONTOUR INTERVAL 10 M WITH SUPPLEMENTARY CONTOURS AT 5 M INTERVALS

UNIVERSAL TRANSVERSE MERCATOR PROJECTION DATUM: WORLD GEODETIC SYSTEM 1984

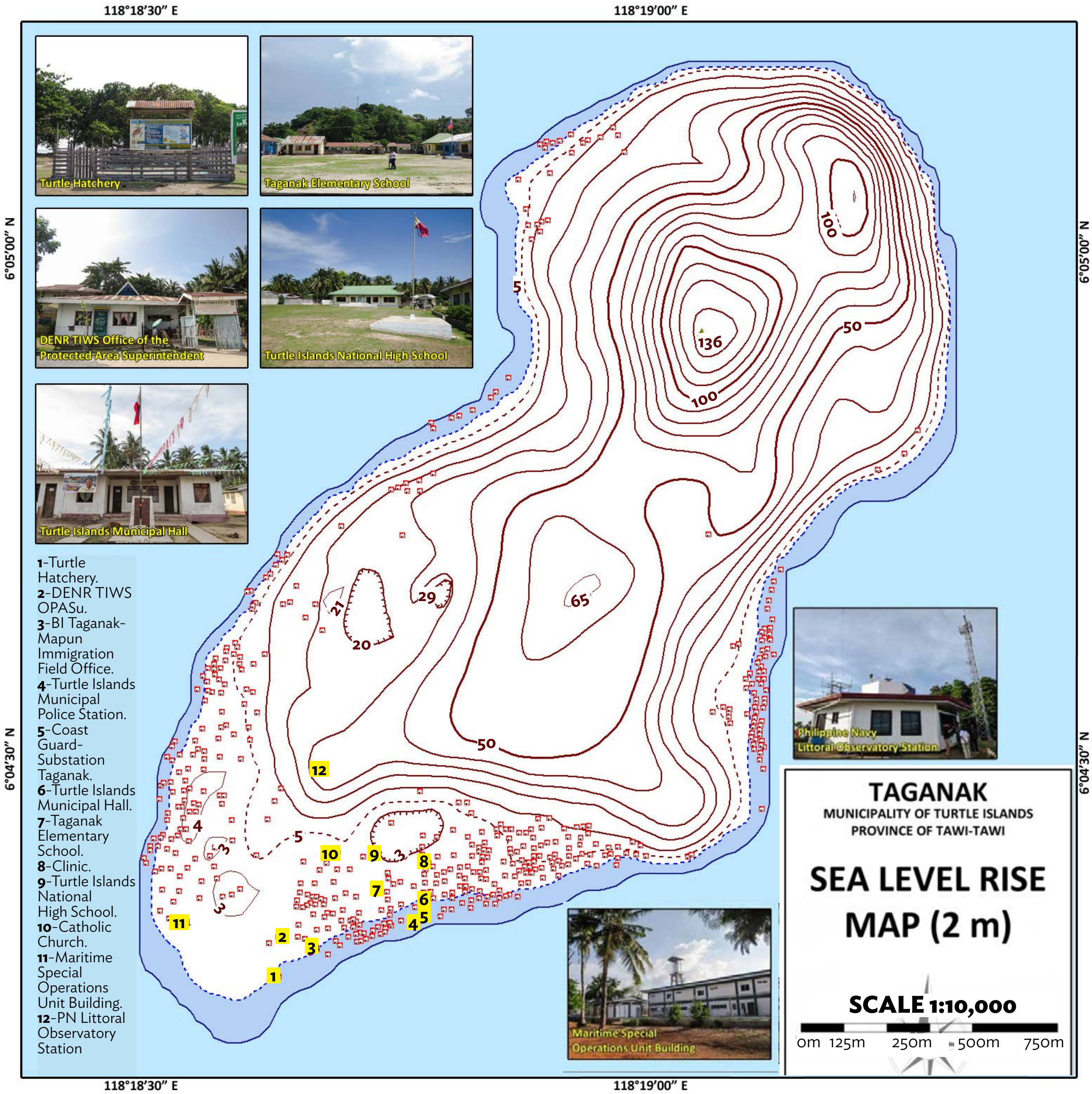
Source: ALOS Global Digital Surface Model © JAXA Digital Globe Satellite Imagery

Disclaimer: Administrative boundaries and spatial distribution of population are approximate **Date:** July 2016

LEGEND

- contour line, intermediate
- contour line, major
- contour line, minor
- contour line, supplementary
- depression
- sea level rise
- shoreline
- spot evaluation
- structure

Figure 50. Population Exposure to SLR of 2.0 m inTaganak



CONTOUR INTERVAL 10 M WITH SUPPLEMENTARY CONTOURS AT 5 M INTERVALS

UNIVERSAL TRANSVERSE MERCATOR PROJECTION DATUM: WORLD GEODETIC SYSTEM 1984
Source: ALOS Global Digital Surface Model © JAXA Digital Globe Satellite Imagery
Disclaimer: Administrative boundaries and spatial distribution of population are approximate **Date:** July 2016

LEGEND

- contour line, intermediate
- contour line, major
- contour line, minor
- contour line, supplementary
- depression
- sea level rise
- shoreline
- spot evaluation
- structure

3. Sea Level Rise of 4.0 m

Sea level rise maps at 4.0 m are depicted in Figures 51-56. At a 4.0 m SLR, 23.9% of the total land area of the Turtle Islands will be submerged in water, possibly affecting 22.2% (1,165) of the current population.More structures along the coastal plain of Taganak, including the MSOU Building, DENR TIWS Office of the Protected Area Supervisor (OPASu), Taganak Elementary School, and TINHS, will be inundated. All islands, except Greater Bakkungan, will have more than 20% their area and population exposed to a 4.0 m SLR.

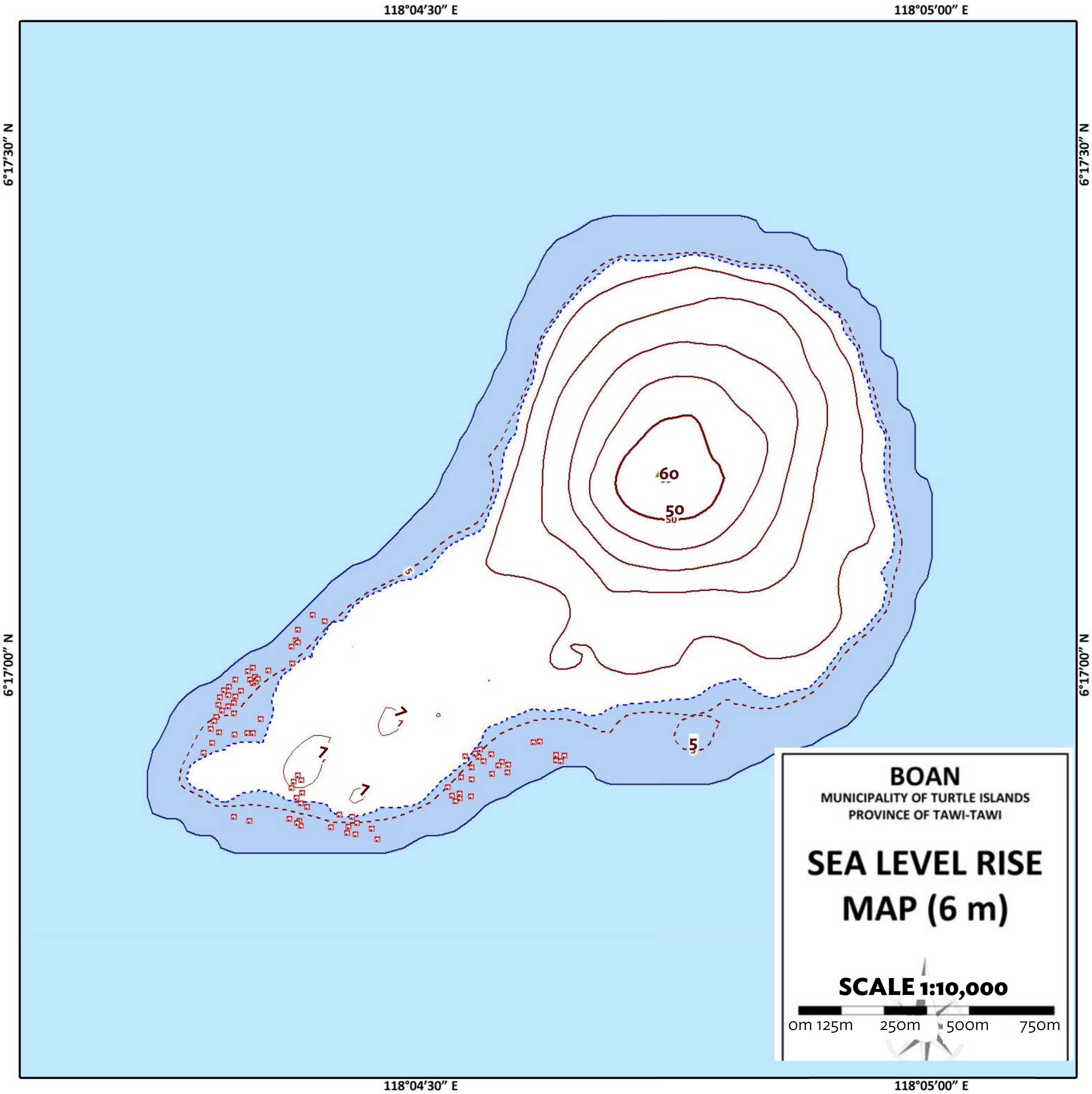
Figure 51. Population Exposure to SLR of 4.0 m in Baguan

CONTOUR INTERVAL 10 M WITH SUPPLEMENTARY CONTOURS AT 5 M INTERVALS

UNIVERSAL TRANSVERSE MERCATOR PROJECTION DATUM: WORLD GEODETIC SYSTEM 1984
Source: ALOS Global Digital Surface Model © JAXA Digital Globe Satellite Imagery
Disclaimer: Administrative boundaries and spatial distribution of population are approximate **Date:** July 2016

LEGEND contour line, intermediate; contour line, major; contour line, minor; contour line, supplementary; depression; sea level rise; shoreline; spot evaluation; structure

Figure 52. Population Exposure to SLR of 4.0 m in Boan



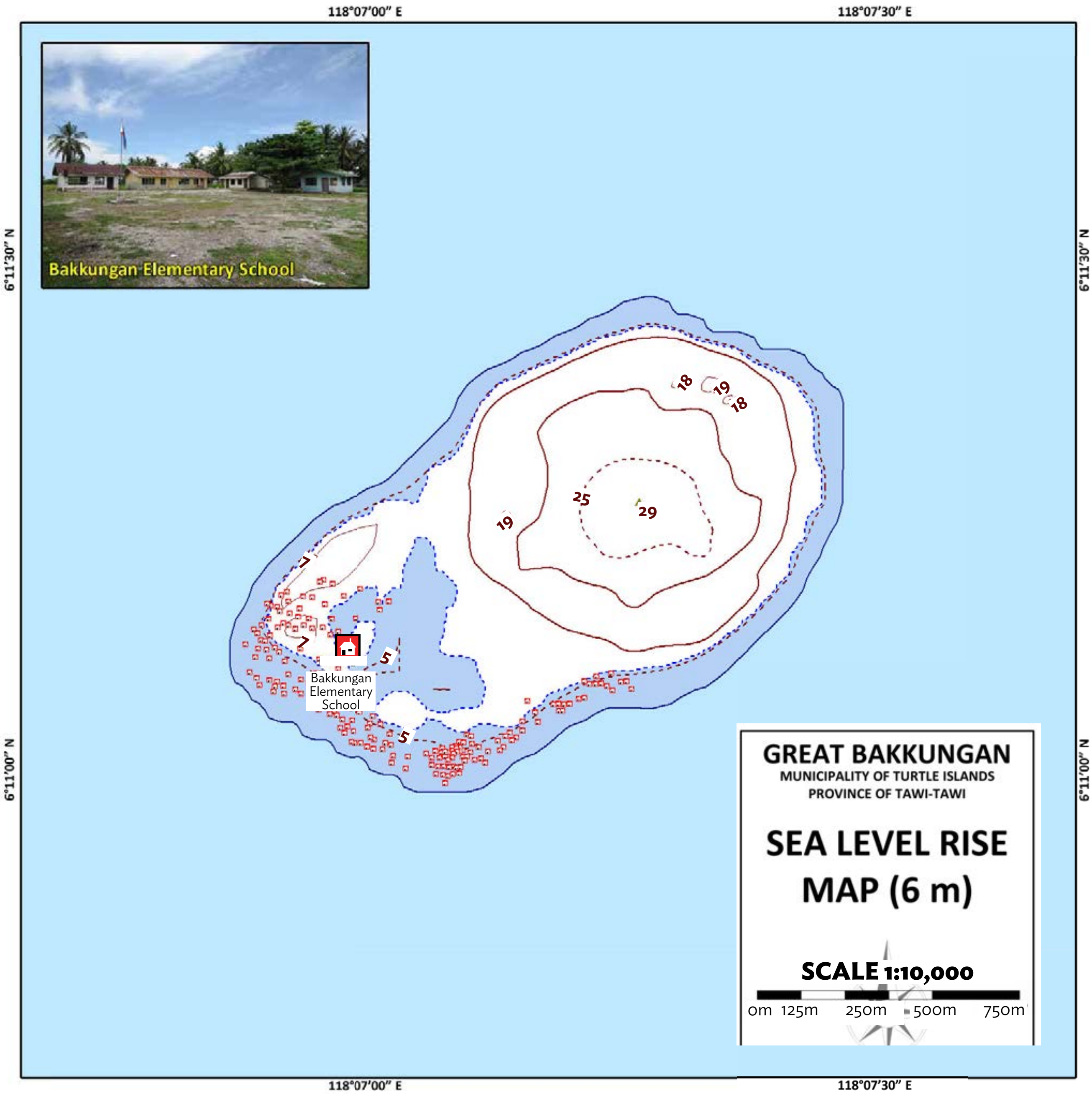
CONTOUR INTERVAL 10 M WITH SUPPLEMENTARY CONTOURS AT 5 M INTERVALS

UNIVERSAL TRANSVERSE MERCATOR PROJECTION DATUM: WORLD GEODETIC SYSTEM 1984
Source: ALOS Global Digital Surface Model © JAXA Digital Globe Satellite Imagery
Disclaimer: Administrative boundaries and spatial distribution of population are approximate **Date:** July 2016

LEGEND

- contour line, intermediate
- contour line, major
- contour line, minor
- contour line, supplementary
- depression
- sea level rise
- shoreline
- spot evaluation
- structure

Figure 53. Population Exposure to SLR of 4.0 m in Great Bakkungan



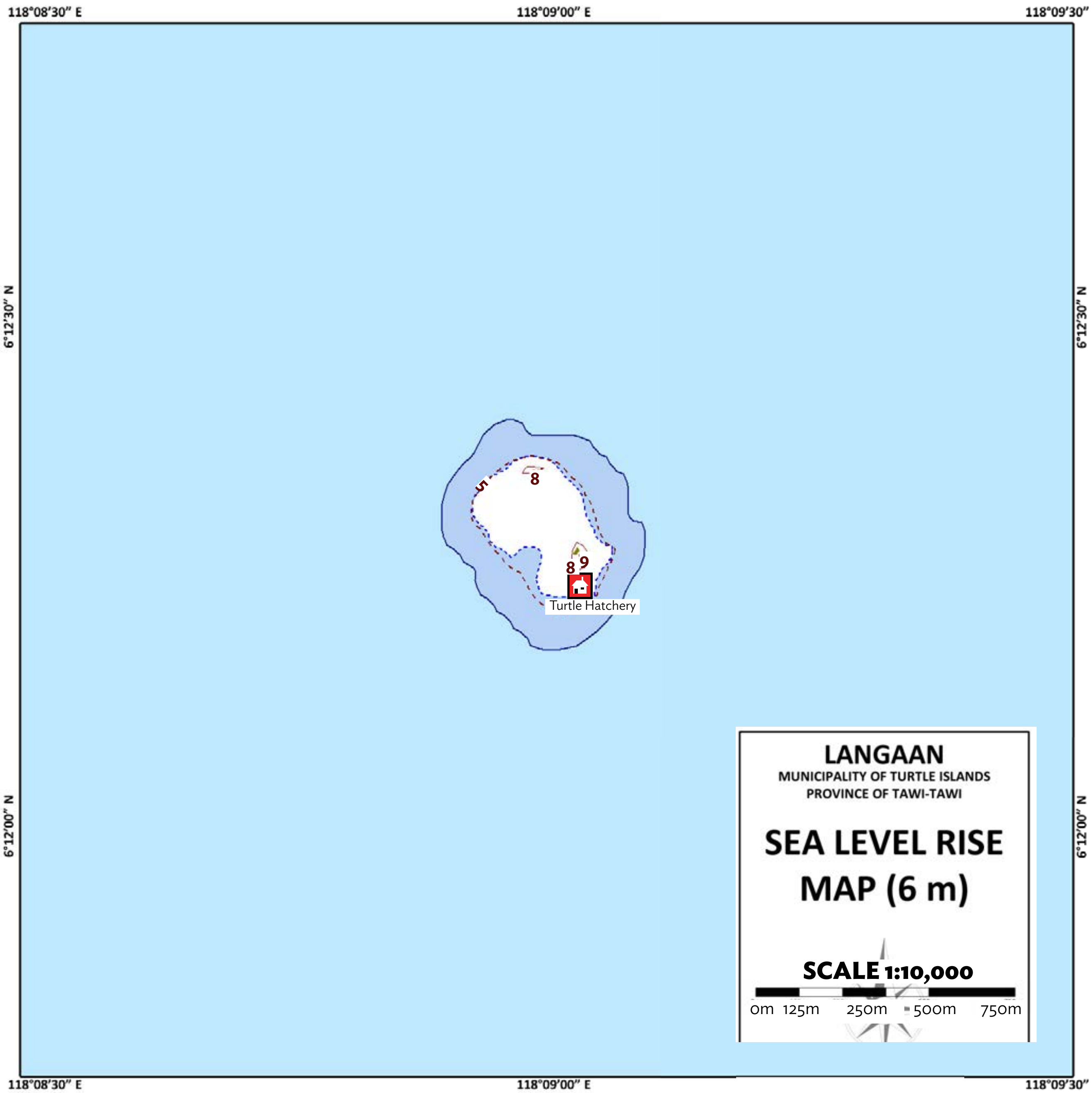
CONTOUR INTERVAL 10 M WITH SUPPLEMENTARY CONTOURS AT 5 M INTERVALS

UNIVERSAL TRANSVERSE MERCATOR PROJECTION DATUM: WORLD GEODETIC SYSTEM 1984
Source: ALOS Global Digital Surface Model © JAXA Digital Globe Satellite Imagery
Disclaimer: Administrative boundaries and spatial distribution of population are approximate **Date:** July 2016

LEGEND

- contour line, intermediate
- contour line, major
- contour line, minor
- contour line, supplementary
- depression
- sea level rise
- shoreline
- spot evaluation
- structure

Figure 54. Population Exposure to SLR of 4.0 m in Langaan



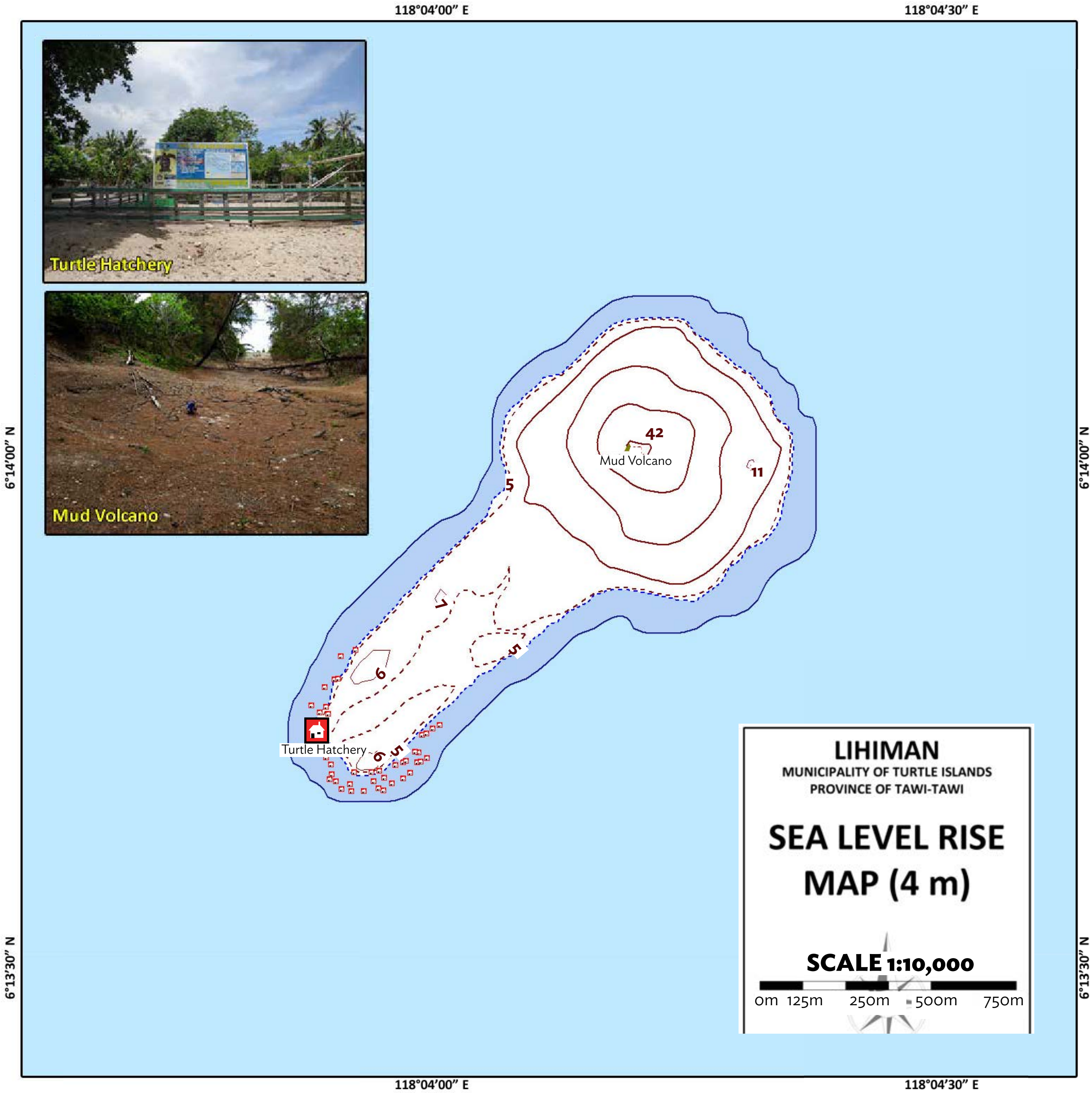
CONTOUR INTERVAL 10 M WITH SUPPLEMENTARY CONTOURS AT 5 M INTERVALS

UNIVERSAL TRANSVERSE MERCATOR PROJECTION DATUM: WORLD GEODETIC SYSTEM 1984
Source: ALOS Global Digital Surface Model © JAXA Digital Globe Satellite Imagery
Disclaimer: Administrative boundaries and spatial distribution of population are approximate **Date:** July 2016

LEGEND

- contour line, intermediate
- contour line, major
- contour line, minor
- contour line, supplementary
- depression
- sea level rise
- shoreline
- spot evaluation
- structure

Figure 55. Population Exposure to SLR of 4.0 m in Lihiman



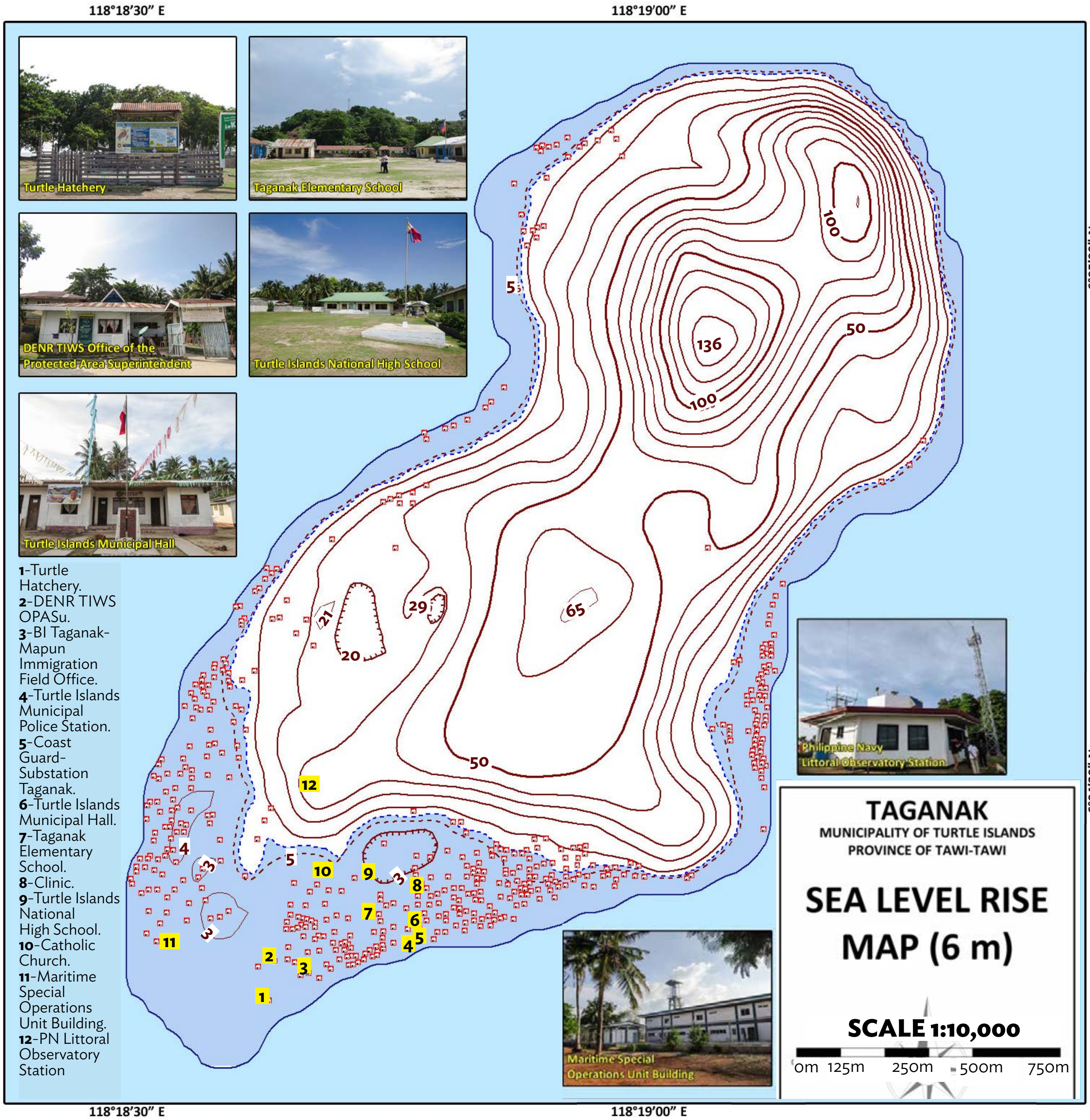
CONTOUR INTERVAL 10 M WITH SUPPLEMENTARY CONTOURS AT 5 M INTERVALS

UNIVERSAL TRANSVERSE MERCATOR PROJECTION DATUM: WORLD GEODETIC SYSTEM 1984
Source: ALOS Global Digital Surface Model © JAXA Digital Globe Satellite Imagery
Disclaimer: Administrative boundaries and spatial distribution of population are approximate **Date:** July 2016

LEGEND

- contour line, intermediate
- contour line, major
- contour line, minor
- contour line, supplementary
- depression
- sea level rise
- shoreline
- spot evaluation
- structure

Figure 56. Population Exposure to SLR of 4.0 m in Taganak



CONTOUR INTERVAL 10 M WITH SUPPLEMENTARY CONTOURS AT 5 M INTERVALS

UNIVERSAL TRANSVERSE MERCATOR PROJECTION DATUM: WORLD GEODETIC SYSTEM 1984

Source: ALOS Global Digital Surface Model © JAXA Digital Globe Satellite Imagery

Disclaimer: Administrative boundaries and spatial distribution of population are approximate **Date:** July 2016

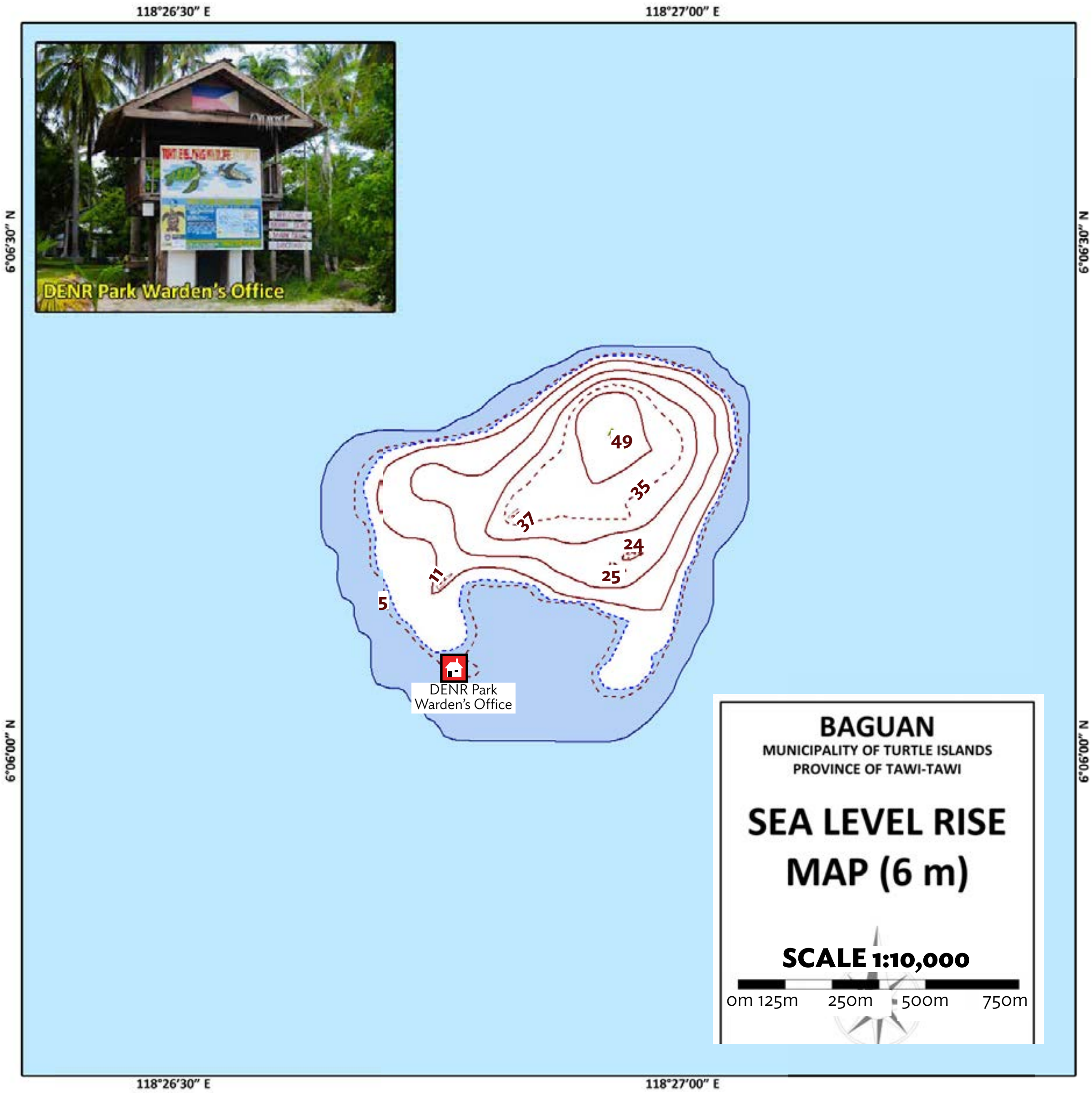
LEGEND

contour line, intermediate	contour line, major	contour line, minor
contour line, supplementary	depression	sea level rise
shoreline	spot evaluation	structure

4. Sea Level Rise of 6.0 m

Sea level rise maps at 6.0 m are shown in Figure 57-62. Around 35.2% of the total land area of the Turtle Islands will be inundated at a 6.0 m SLR, putting 32.3% (1,697) of the current population in danger at a 6.0 m SLR.

Figure 57. Population Exposure to SLR of 6.0 m in Baguan



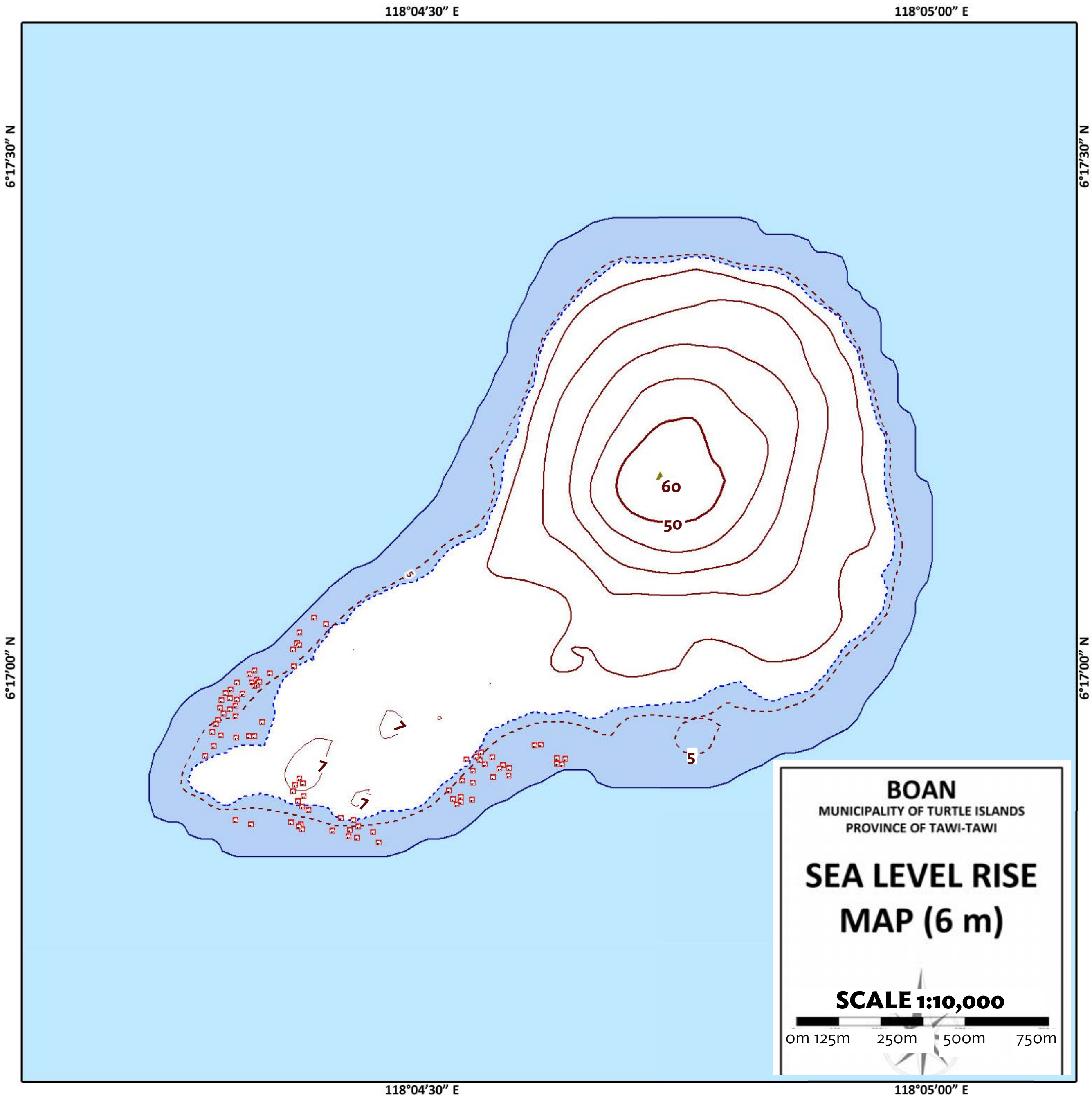
CONTOUR INTERVAL 10 M WITH SUPPLEMENTARY CONTOURS AT 5 M INTERVALS

UNIVERSAL TRANSVERSE MERCATOR PROJECTION DATUM: WORLD GEODETIC SYSTEM 1984
Source: ALOS Global Digital Surface Model © JAXA Digital Globe Satellite Imagery
Disclaimer: Administrative boundaries and spatial distribution of population are approximate **Date:** July 2016

LEGEND

- contour line, intermediate
- contour line, major
- contour line, minor
- contour line, supplementary
- depression
- sea level rise
- shoreline
- spot evaluation
- structure

Figure 58. Population Exposure to SLR of 6.0 m in Boan



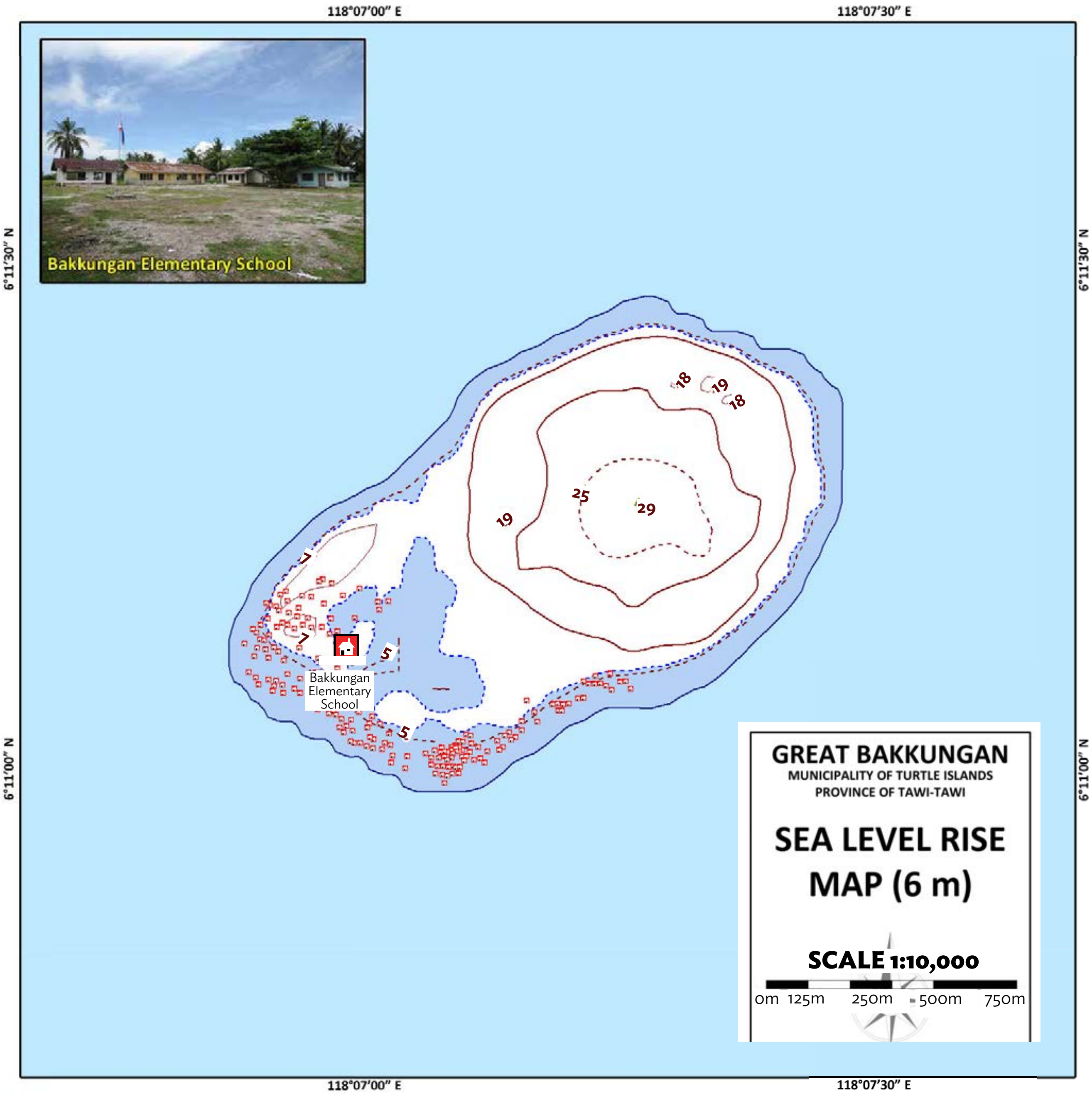
CONTOUR INTERVAL 10 M WITH SUPPLEMENTARY CONTOURS AT 5 M INTERVALS

UNIVERSAL TRANSVERSE MERCATOR PROJECTION DATUM: WORLD GEODETIC SYSTEM 1984
Source: ALOS Global Digital Surface Model © JAXA Digital Globe Satellite Imagery
Disclaimer: Administrative boundaries and spatial distribution of population are approximate **Date:** July 2016

LEGEND

- contour line, intermediate
- contour line, major
- contour line, minor
- contour line, supplementary
- depression
- sea level rise
- shoreline
- spot evaluation
- structure

Figure 59. Population Exposure to SLR of 6.0 m in Great Bakkungan



CONTOUR INTERVAL 10 M WITH SUPPLEMENTARY CONTOURS AT 5 M INTERVALS

UNIVERSAL TRANSVERSE MERCATOR PROJECTION DATUM: WORLD GEODETIC SYSTEM 1984

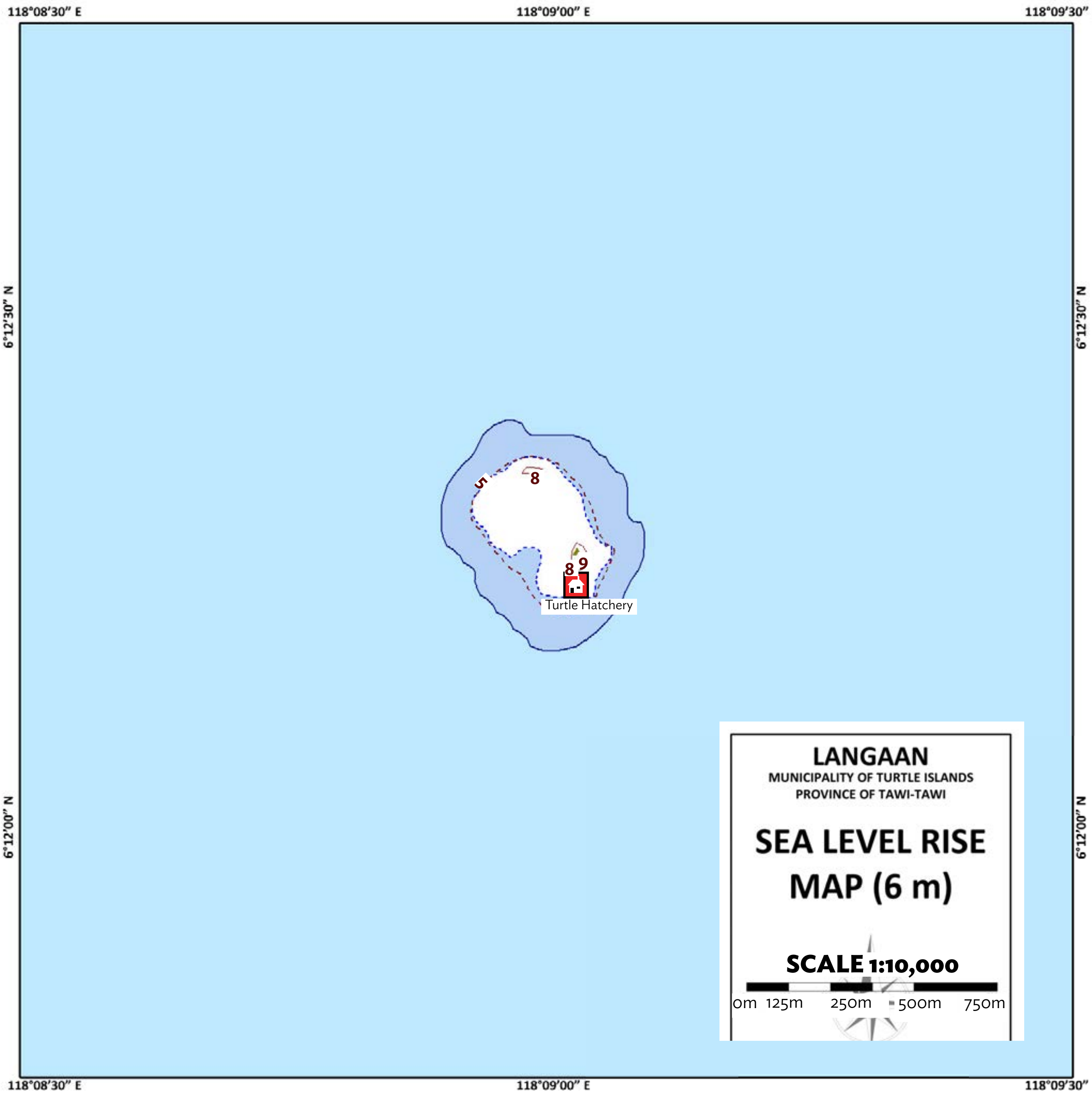
Source: ALOS Global Digital Surface Model © JAXA Digital Globe Satellite Imagery

Disclaimer: Administrative boundaries and spatial distribution of population are approximate **Date:** July 2016

LEGEND

- contour line, intermediate
- contour line, major
- contour line, minor
- contour line, supplementary
- depression
- sea level rise
- shoreline
- spot evaluation
- structure

Figure 60. Population Exposure to SLR of 6.0 m in Langaan



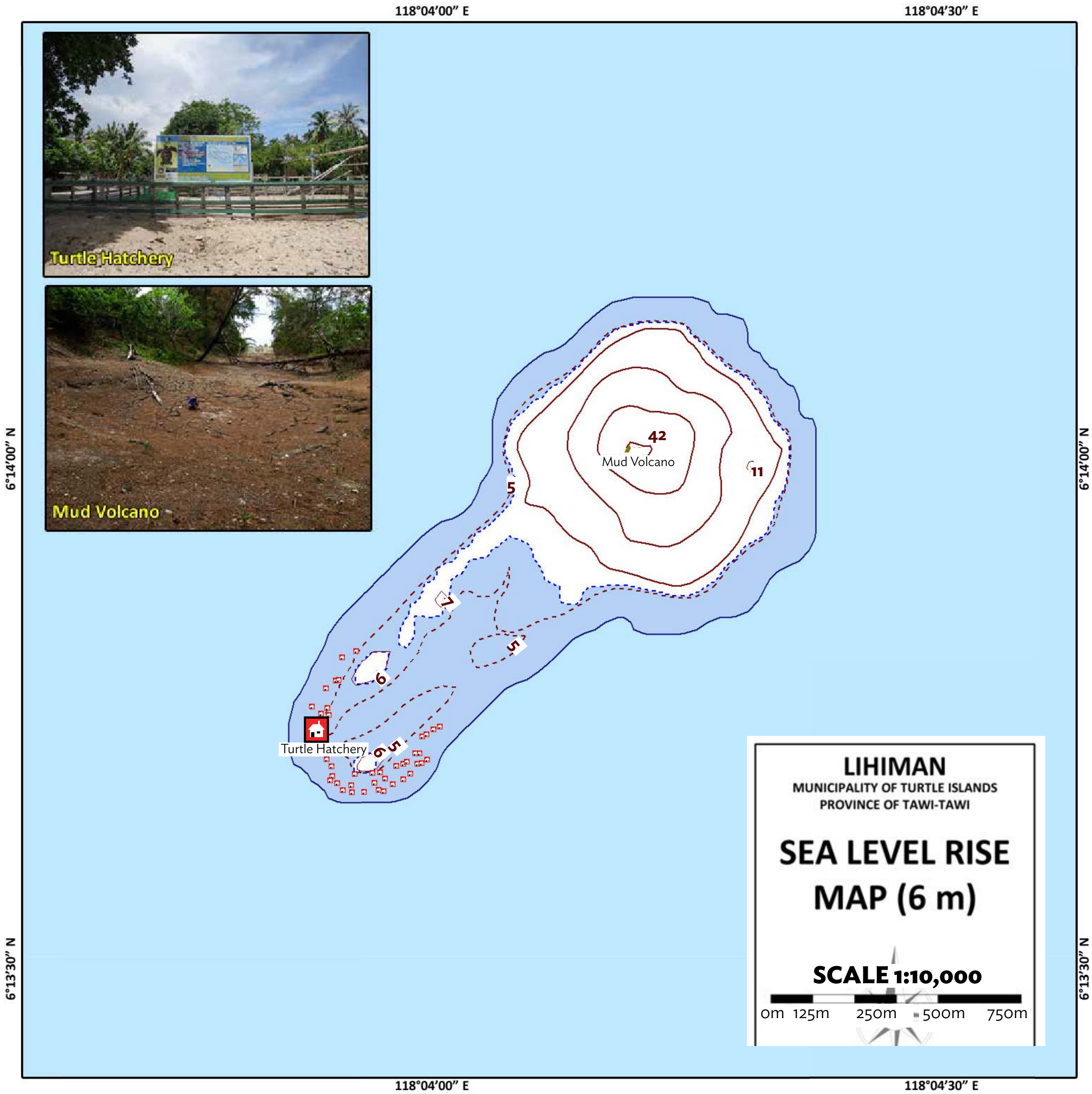
CONTOUR INTERVAL 10 M WITH SUPPLEMENTARY CONTOURS AT 5 M INTERVALS

UNIVERSAL TRANSVERSE MERCATOR PROJECTION DATUM: WORLD GEODETIC SYSTEM 1984
Source: ALOS Global Digital Surface Model © JAXA Digital Globe Satellite Imagery
Disclaimer: Administrative boundaries and spatial distribution of population are approximate **Date:** July 2016

LEGEND

- contour line, intermediate
- contour line, major
- contour line, minor
- contour line, supplementary
- depression
- sea level rise
- shoreline
- spot evaluation
- structure

Figure 61. Population Exposure to SLR of 6.0 m in Lihiman



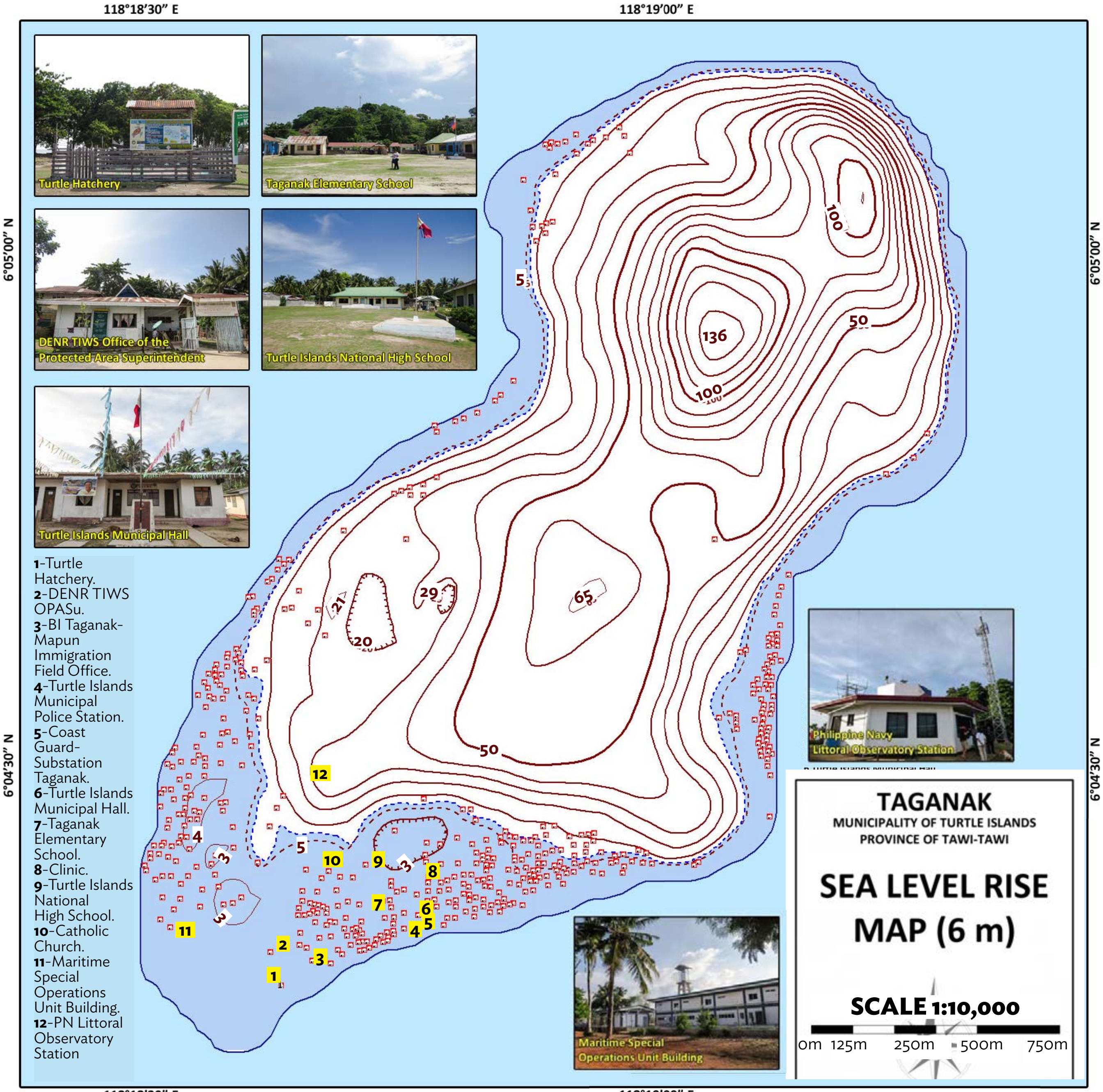
CONTOUR INTERVAL 10 M WITH SUPPLEMENTARY CONTOURS AT 5 M INTERVALS

UNIVERSAL TRANSVERSE MERCATOR PROJECTION DATUM: WORLD GEODETIC SYSTEM 1984
Source: ALOS Global Digital Surface Model © JAXA Digital Globe Satellite Imagery
Disclaimer: Administrative boundaries and spatial distribution of population are approximate **Date:** July 2016

LEGEND

contour line, intermediate	contour line, major	contour line, minor
contour line, supplementary	depression	sea level rise
shoreline	spot evaluation	structure

Figure 62. Population Exposure to SLR of 6.0 m in Taganak



CONTOUR INTERVAL 10 M WITH SUPPLEMENTARY CONTOURS AT 5 M INTERVALS

UNIVERSAL TRANSVERSE MERCATOR PROJECTION DATUM: WORLD GEODETIC SYSTEM 1984
Source: ALOS Global Digital Surface Model © JAXA Digital Globe Satellite Imagery
Disclaimer: Administrative boundaries and spatial distribution of population are approximate **Date:** July 2016

LEGEND

- contour line, intermediate
- contour line, major
- contour line, minor
- contour line, supplementary
- depression
- sea level rise
- shoreline
- spot evaluation
- structure

VIII. DISCUSSION AND CONCLUSIONS

A. Vulnerabilities and Capacities

From the survey and hazard mapping done for the risk and vulnerability assessment, it is noted that most of the human population will not be greatly affected by floods, landslides, earthquakes, and other nature-related hazards, except the most populous settlement areas of Taganak and Great Bakkungan.

Sea level rise will cause inundation and submergence of several coastal areas, both of which are slow progressing events, and before these could happen, the human population would probably have moved to other places. Extreme weather and climate events are the closest relatable experiences to climate change, which most people in the islands experience. With high vulnerabilities and low capacities (e.g., isolation, distance from centers of market and trades, and lack of basic health and medical services), the risks are high, particularly from floods and droughts caused by little rainfall combined with increasing temperature. As temperature increases and rainfall declines, freshwater availability will certainly be affected. Downstream impacts will include sanitation challenges and impacts to health. In addition, the degradation of marine ecosystems due to sea level rise and increasing water temperatures will especially affect fishers' livelihoods and capacity to earn.

A cause for alarm is the impact of current and potential climatic changes on the natural ecosystem and resources, particularly on turtles, which are the main concern of RETA 7813.In the survey of the islands, residents of Taganak and Lihiman islands noted that the turtle population in their islands is dwindling, and habitats and nesting grounds are in various stages of degradation.

These conditions are attributed to multiple stressors, both non-climatic and climate-related. The most significant are poaching and destruction of nesting grounds through sand quarrying and disturbances caused by trawl fishing, docking of boats, and other obstacles on the shore. The Philippines' Turtle Islands needs to emulate its counterparts in Sabah, Malaysia, where the islands are uninhabited, with only the concerned authorities, scientists, and workers staying there.

Although people living in the area are not well aware of the impact of climate stressors on the sea turtles, the increasing temperature, as shown in the projections, and sea level rise will have the biggest impacts. The rate of temperature increase far exceeds the abilities of most animals to adapt naturally to such dramatic environmental changes. These changes are projected to cause the extinction of many species over the next few decades. An increase in nesting beach temperatures will affect sea turtles greatly. Hotter sand from increasing temperatures results in decreased hatching rates or complete nest failure. Increased sand temperatures also affect hatchlings by altering natural sex ratios, with hotter temperatures producing more female hatchlings. Typically, the eggs in the lower, cooler, part of the nest produce male hatchlings, while the eggs in the upper, warmer, part of the nest produce female hatchlings. With increasing nest temperatures, scientists predict that there will be more female than male hatchlings, creating a significant threat to genetic diversity.

Warmer water temperatures are also likely to negatively impact on food resources for sea turtles and virtually all marine species. Sea turtles use ocean currents to travel and find prey. Warming ocean temperatures influence migratory species by altering currents and impacting the distribution and abundance of prey species. Warmer water temperatures also affect coral reefs—which are vital to the survival of species like the hawksbill—through bleaching. Increased warming of water temperature could cause defoliation of seagrass meadows, from which green turtles get seagrass, their main food.

A rise in sea level will contribute to the loss of beaches and sea turtle nesting habitats. Sea turtles have long-term memories of the sandy beaches where they hatch. They have the ability to return to the same sites years later to repeat their nesting rituals. Rising sea levels will lead to increased beach erosion, which will destroy their nesting grounds.

B. Adaptation

The susceptibility of the islands and the population to various hazards (like floods, landslides, earthquakes, increasing temperature, sea level rise, and changing rainfall patterns) have to be included in development, disaster reduction risk(DRR) and contingency, as well as environmental management plans (EMPs).

Specific adaptation measures have to be prepared in the context of disaster risk reduction and management (DRRM). The first step is the adoption of climate change sensitization processes. Efforts should be made to increase people's awareness of climate change risks. An island-wide vulnerability assessment needs to be conducted to determine specifically what the vulnerable systems are, where they are, and how many they are. Maps could be generated for this purpose, with inputs from the members of the community themselves (participatory approach). The information generated from this activity could be used for community situation analysis (e.g., determining other sources or ways of getting freshwater during very dry periods, such as rainfall water harvesting). LGU officials could use such information in decision-making, such as in prioritizing adaptation measures and management planning or the preparation of comprehensive development plans (CDPs), comprehensive land use plans (CLUPs), and DRR and contingency plans.

The results of the survey described in Section IV above revealed that people know what the problems are, and they rely on the LGU officials for help. It is about time that the people and their leaders gather as one community to discuss their problems and plan ways to solve them. For a successful conservation and protection program, the support of the locals is very important. For most of them, fishing is the most important activity and source of income. Some of them would resort to poaching turtle eggs just to augment their meager takehome pay if and when the opportunity presents itself.

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APPENDIX 1

SUMMARY OF PHYSICAL FEATURES OF THE SIX ISLANDS GROUP

Description	Topography	Land cover	Substrate	Groundwater	Coastal erosion
TAGANAK ISLAND					
With an area of 130 ha, Taganak is the biggest island in the group. Limited and narrow sandy beaches occur at the northern portion and predominantly rocky and coastal plain is covered by coralline sand. Coastal plain is covered by coralline sand. Sandy coastline rims the flatlands at the southern end, while shingles beaches made up of coralline rubbles are common in small coves. At the northern end, the coastline is generally rocky. The beach area is generally narrow and in most parts bounded by steep slopes of the volcanic hills. At the southern part of the island, the beach and backshore widen due to the presence of a wide coastal plain.	Topography varies from flat lands at the southern tip to hilly at the northern end with a low plateau-like feature at the southern end. The island has a higher relief ranging from 65 meters to 150 meters above sea level.	The dominant land cover is grass, which covers about 81 ha of the island's total land area. A short stretch of mangrove coastline is found in Bakkao, the western side of the island.	The substrate of Taganak is basalt, with coralline sand at the southern end. Soil cover of the hilly part is red clay derived from the volcanic bedrock. Observations in Taganak Island showed that island soil is dull red due to the presence of ferric oxide.	Groundwater is available both in the volcanic substrate as well as in the coralline san flatlands. Water in the volcanic rocks is available in the weathered portion. Water stored in the fractures of the basalt apparently recharges water along the coastal area.	Erosion scars are evident at the southern end of Limao-limao. Shore erosion at the western side of the southern end of Bakkao, on the other hand, has affected a number of houses along the shore. Bare slopes and landslide scarps indicate high rates of soil erosion. A layer of reddish silt is observed along the coast of Bakkao.

BOAN ISLAND					
The second largest island in the Turtle Islands Group with an area of 68 hectares, it is tadpole-shaped, elongated along the northeast-southwest direction.	The island has a low relief, with topography varying from flat to low hills at the northeastern end. Maximum elevation on the island is about 59 m.	A small mangrove patch is found along the northeastern shore. The land cover is dominantly agriculture in the wooded areas in the northern part of the island. The flat part is made up of coralline sand, coralline rubbles, and some sandstone boulders.	The substrate of the island is sandstone. Continued flow from mud activity built up the hill, though residents report that the outflow of mud has ceased for a number of years now.	The alluvial deposit makes up the aquifer of the shallow groundwater, which is essentially freshwater lens floating on seawater. The groundwater is directly recharged by rainfall.	The coastline is fairly regular with white sand beach rim at the elongated portion of the island. Sandy deposition area at the rounded northern part is very narrow. The sandy part of the coastline is now occupied by settlements. Shoreline retreat is evident in the toppled coconut trees at the eastern part. Scarp also rims this part of the island.
GREAT BAKKUNGAN					
This is the third largest island in the Turtle Islands Group, with an area of 48 ha and a more or less rounded northern portion. There are no reported present-day activities of the mud volcano in the Island.	Topography of the island is generally flat with a low hill at the northern end. Sandy beach surrounds the Island.	The hilly portion was built up by volcanic mud flow while the flatland is an accumulation of coralline sand and rubble. The highest elevation is 58 m. The vent of the mud volcano is reported to have shifted a number of times in the past. The mud volcano's activity is limited to quiet pulsating extrusion of pure gray mud accompanied by gas bubbling. Dark-colored streaks, which appear to be oil film, sometimes accompany the extruded mud. Gas was sampled in April 1998.			The northern coastline is dominated by a rocky shoreline, with the sandy beach limited to the southern part of the island. Settlements proliferate in the area fronted by the sand beach. Like in the other islands, shore erosion seems to be very active. Beach attrition has already affected a number of houses and the barangay hall.

BAGUAN					
The island is flat at the southern part while low hills characterize the northern part. Baguan is a 35 ha, bell-shaped island with a coastline of 1.7 km. The sandy flatland in the southern portion of Baguan makes up the largest part of the island. The flatland is 644 m wide at its broadest part with an average elevation of 3 m.	It has an expansive beach, flat at the southern part and a rolling to gently sloping hill in the north. It is volcanic in origin, later enlarged by the deposition of the coastal plain at the southern part. The volcanic part of the island is elevated, with a maximum elevation of about 40 m. The hill is moderately steep.	Agriculture is done in woody areas. There is a sizeable coconut plantation.	The southern coastline is regular and lined by about 1.6 km sandy beach, while the northern coastline on the other hand is irregular with 3 pocket beaches and headlines. Observations in Baguan Island showed that island soil is dull red due to the presence of ferric oxide. The source of the coralline beach sand is the surrounding fringing reefs. Areas of reef development generally provide locally derived beach materials which include various biogenic carbonate grains that reflect the composition of living biota adjacent to the beach.	Freshwater is present in the form of shallow groundwater.	Erosion and accretion are active, changing the island's outline over time. The composition of beach sediments is derived from the available material in nearby areas and reflects the nature of material brought in from the nearshore or alongshore sources. Transport of sand in the surf and intertidal zone accounts for a significant volume of immediate sand supply. Erosion of the coast itself, reworking and shoreward movement of beach and nearshore material are also important sources of sand.

LIHIMAN					
Lihiman has a smaller land area of about 30 ha.	The island has flat to undulating topography.	Dried mud at the top of the agoho trees rimming the crater shows the high pressure at which mud is vented. Due to the huge volume of material discharged, a drainage way has been carved on the northern hill slope leading to the sea.	The tail part of the island is fringed by a sandy beach while the head part is rimmed by a narrow shingle beach made up of gravel to boulder-size rocks.	Groundwater is present in the sandy flatland. Numerous shallow wells have been dug as source of water for the agricultural plots being cultivated by the residents.	Siltation at the northern shoreline is evident. Gray silt deposit, the same color as the mud coming from the mud volcano, is observed in the foreshore. Submarine mud has been observed offshore as indicated by the highly turbid water in the area.
LANGAAN					
Langaan is a sandy islet and one of the smaller Islands of the Turtle Islands Group with a land area of about 7 hectares and a coastline of about 458 m.	It has a flat and smooth coastline surrounded by sandy beach constituting the topography of the Island.	Dense beach vegetation is observed at the western side.	The island is rimmed with wide sandy beach and backshore.	Shallow groundwater is available.	Shoreline retreat has been observed at the western side of the island while accretion is noted at the northeastern side.

APPENDIX 2

BIOLOGICAL FEATURES OF THE TURTLE ISLANDS

A. Flora

1. Terrestrial Flora

The coastline of Baguan Island is fringed with *Terminalla catappa* and *Cocos nucifera.* Common species found are P*andanus tectorinus* and *Barringtoni aasiatica.* Species of *Callophyllum inophyllum, Erythrina indica, Caryota cumingii, Saccharum spotaneom, Calamus mollis, Ficus* sp., *Vitex trifolia, and Livistona rottundifolia* can be observed landward.

2. Marine Flora

There are 50 seaweed species in the area representing 32% of the 158 macrobenthic seaweeds identified from 18 coastal provinces in the country (Fortes, 1991). Of the 50 species identified, 23 species belong to Chlorophyta (green algae), 4 species to Phaeophyta (brown algae), and 23 species to Rhodophyta (red algae). In terms of diversity, Baguan Island is significantly richer than the other islands since it has 47 species of seaweeds; Langaan and Taganak has only 25 and 20 species, respectively.

B. Fauna

1. Terrestrial Fauna

Terrestrial Reptiles. An endangered reptile present in the protected area is the monitor lizard *(Varanussalvator).* This is a natural predator of marine turtle eggs and hatchlings, especially in Baguan Island. Two species of lizard *(Gecko gecko)* and (*Mabuya* spp.) have also been identified.

Birds. There are 12 species of birds in the Turtle Islands. In Taganak, the most common are A*plonis p. panayensis* (Asian glossy starling), *halcyon chloris collaris woodi* (white-collared kingfisher), *streptopelia semitorquata* (red-eyed pigeon), and S*terna fuscata nubilosa* (sooty tern). In Baguan the most common species include *Nectarinia jugularis woodi* (yellow-bellied sunbird), *Halycon chloris collaris, Anthreptes malacensis cagayensis* (plain-throated sunbird), *Aplonis p. panayensis* (Asian glossy starling), *Treton v. vernans* (pink-necked green pigeon), *Ducfula p. picheringii* (mountain imperial pigeon), *Sterna fuscata, nubilosa, Haliacetus leucogaster,* and *Pachycepalla cenerea homereyi.* Ducks and chicken have also been introduced to the islands.

Of the 12 species of birds identified, two species *(Aplonis p. panayensis)* and *Treton v. vernans* are endemic throughout the Philippine archipelago, one species *(Nectarinia jugularis woodi)* is endemic in the Sulu Archipelago, while another species *(Sterna fuscata nubilos)* is endemic in Cagayan de Tawi-Tawi (Mapun).

Mammals. Black rats *(Rattus rattus)* and fruit insect bats are the only mammals found in all the islands. Introduced mammal species include cattle, goats, dogs, and cats.

2. Marine Fauna

The Turtle Islands supports a diverse population of marine fauna (corals and fishes) as well as two species of endangered marine turtles. The Turtle Islands exhibits the highest diversity in terms of marine communities among all NIPAS sites in the country.

Marine Reptiles. Two species of endangered marine turtles are found in Turtle Islands. Of the country's remaining marine turtle resources, 80% is found in the area. The islands are regarded as the only major nesting ground (with more than 1,000 nesters annually) of the green turtle *(Chelonia mydas)* in the ASEAN region. There are only 10 remaining nesting sites sites worldwide. The hawksbill *(Eretmochelys imbricata)* also occurs but with a low density nesting in contrast to the green turtle. Worldwide, marine turtle populations have critically declined; hence, the CITES-IUCN has declared all species of marine turtles endangered.

Benthos and associated fishes. The information on benthos relates to the habitat structure and their relationship to the fish assemblages. The surrounding waters of Turtle Islands have fringing reefs, which experience appreciable influence of terrigenous runoff from Sabah. Nevertheless, the coral communities have a relatively fair coverage (25-50%),except for the Langaan Island transect, which has less than 20% cover. Most coral growth forms are non-*Acropora* branched forms that are indicative of relatively calm conditions in the reef slope. These branched forms are also well adapted to site runoffs. Taganak and Baguan Islands show a high coral diversity of 24-27 genera. This diversity in coral genera and high live coral cover of branched benthic life forms contribute to the high fish species diversity in the Turtle Islands.

These assemblages are mainly dominated by the families of *Pomacentridae* and *Labridae* (coral reef fishes). *Pormacentrus molunensis* (damselfish) is the most common fish species in the Turtle Islands, except for Langaan Island, were *Pomacentrus vaiuli* (princess damsel) and *Pomacentrus alexanderaes* (Alexander's damsel) are most common. The most common labrid species is *Thalasso malunare* (moon wrasse). Overall, there are around 80 coral genera observed and 361 fish species recorded during the Sitangkai-Turtle Islands Survey.

Bottom coral cover is generally presented as predominantly sand with patches of corals, algae-covered corals and rocks, submerged sand in shallow waters, seagrass areas, and sand areas containing rubbles, particularly along areas close to the coastline. Some studies using satellite imagery[15] traced siltation/sedimentation from Sabah, Malaysia, raising some concerns about the extent of areas under stress that might be harmful to the marine environment, particularly the coral reef ecosystems.

[15] "Baseline mapping of the Philippine-Sabah Turtle Islands using spot satellite imagery" by Abigail Ramos, WWF, accessed on 04 July 2017 from http://www.isprs.org/proceedings/XXXIII/congress/part7/180_XXXIII-part7s.pdf

APPENDIX 3

TOPOGRAPHIC MAPS

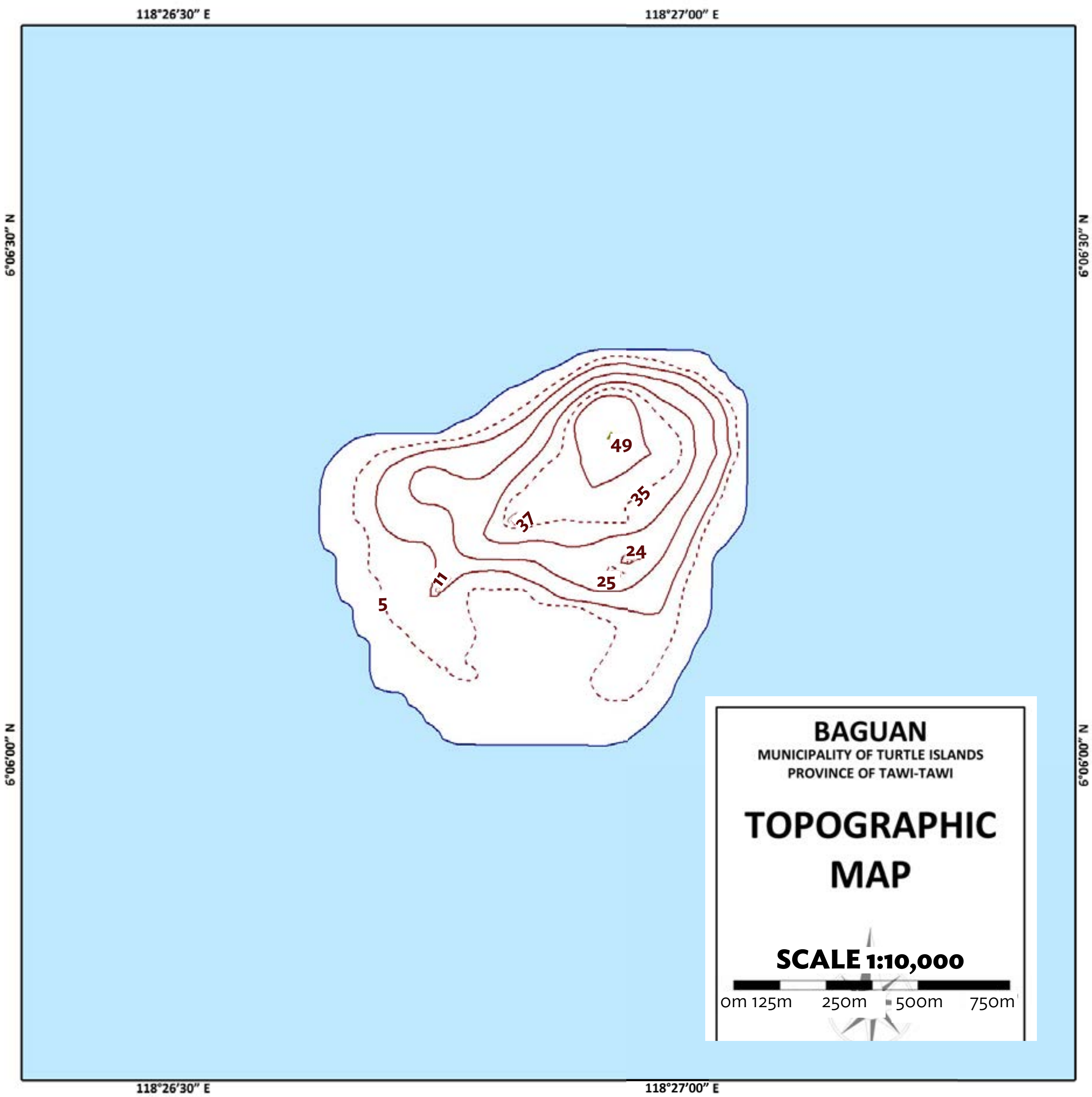


Figure 63. Topographic Map of Baguan

Figure 64. Topographic Map of Boan

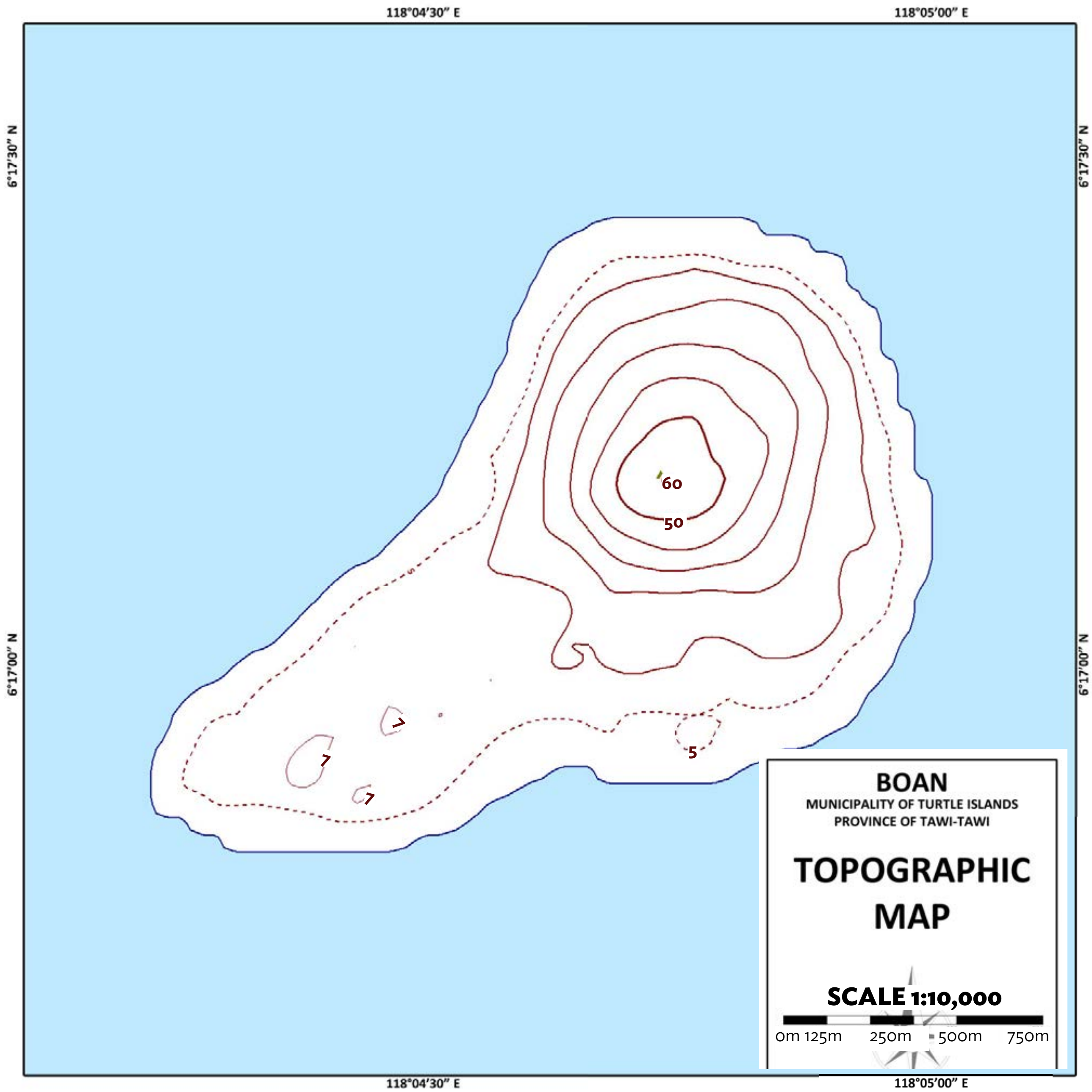


Figure 65. Topographic Map of Great Bakkungan

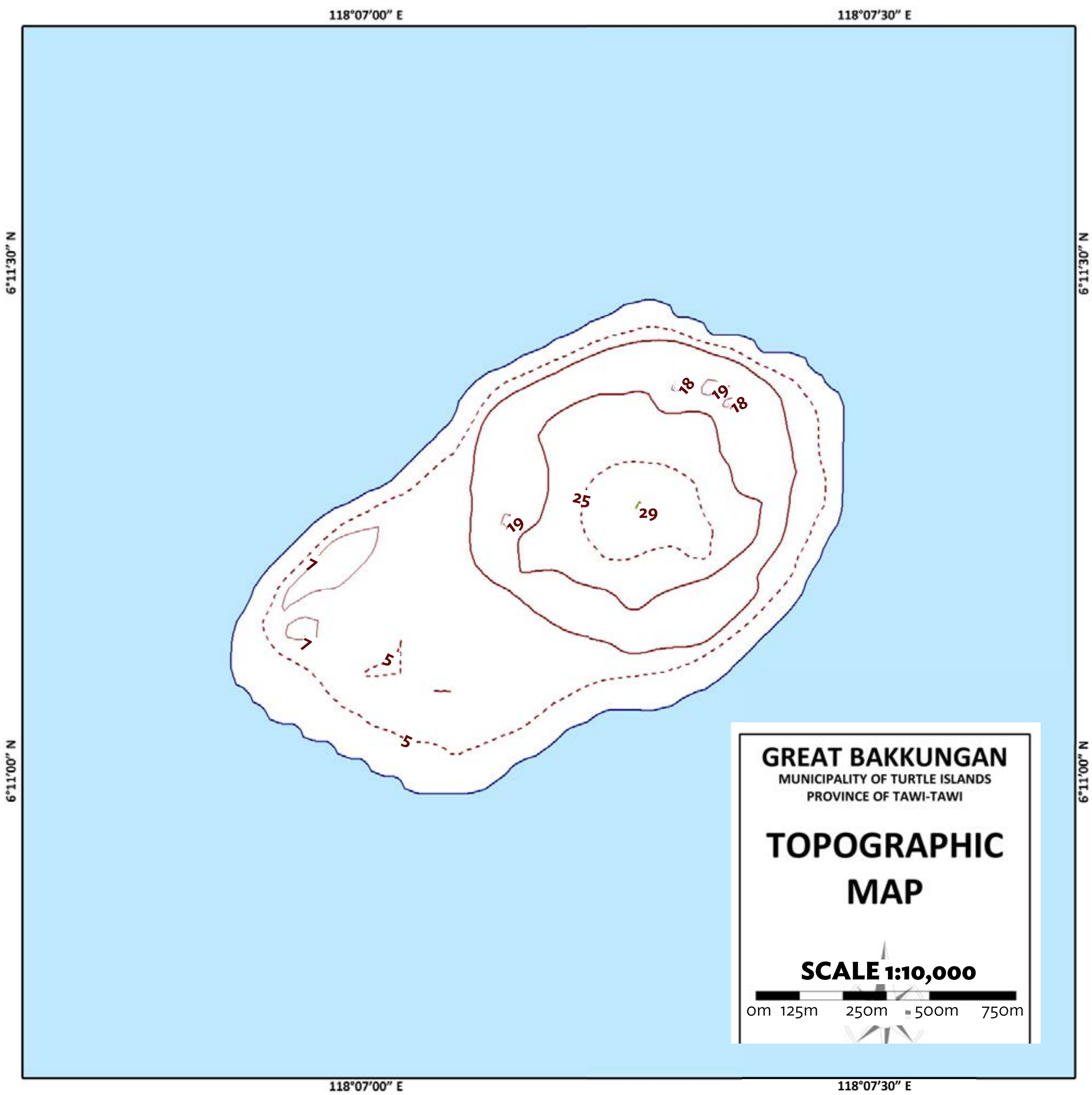


Figure 66. Topographic Map of Langaan

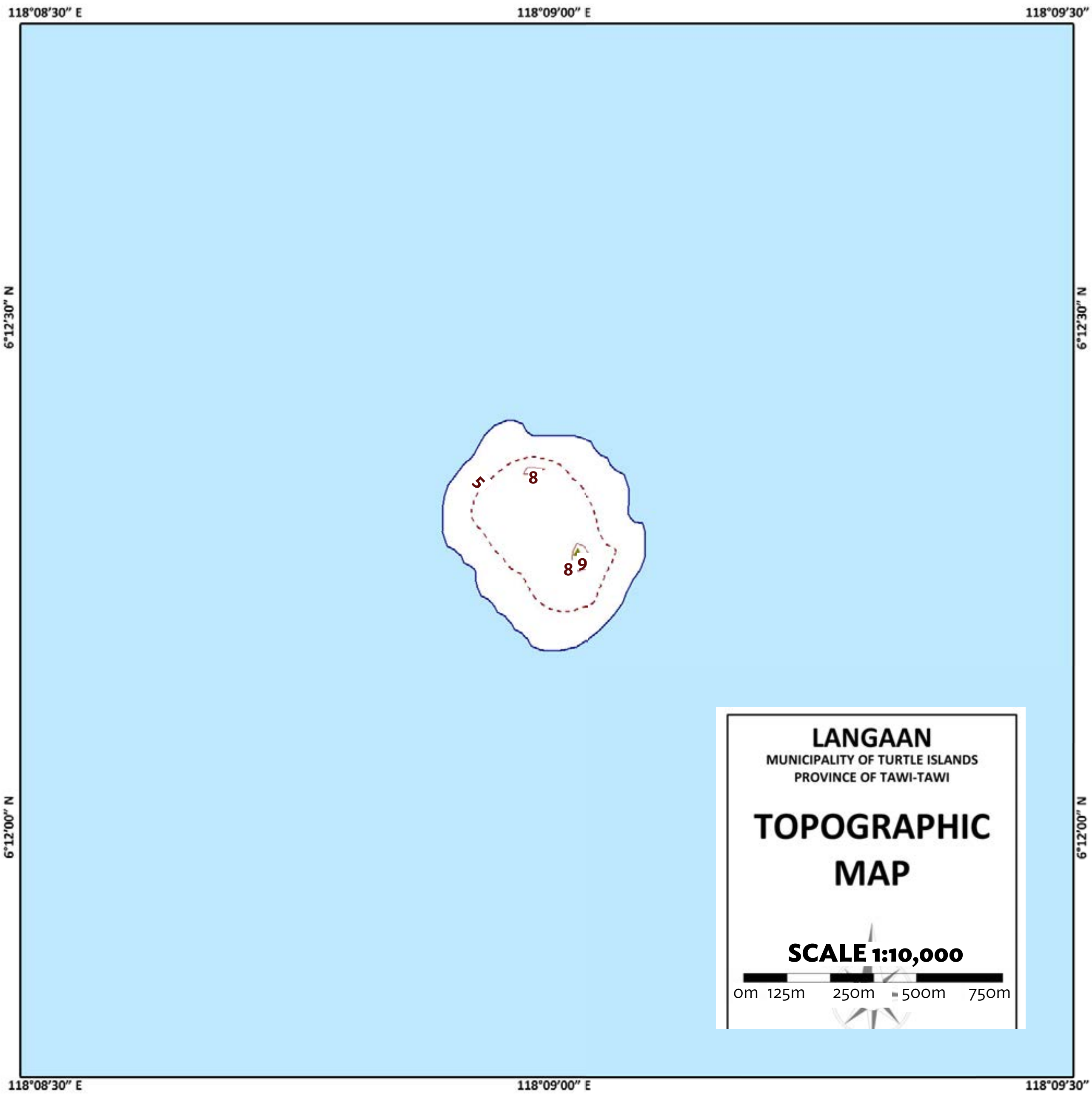


Figure 67. Topographic Map of Lihiman

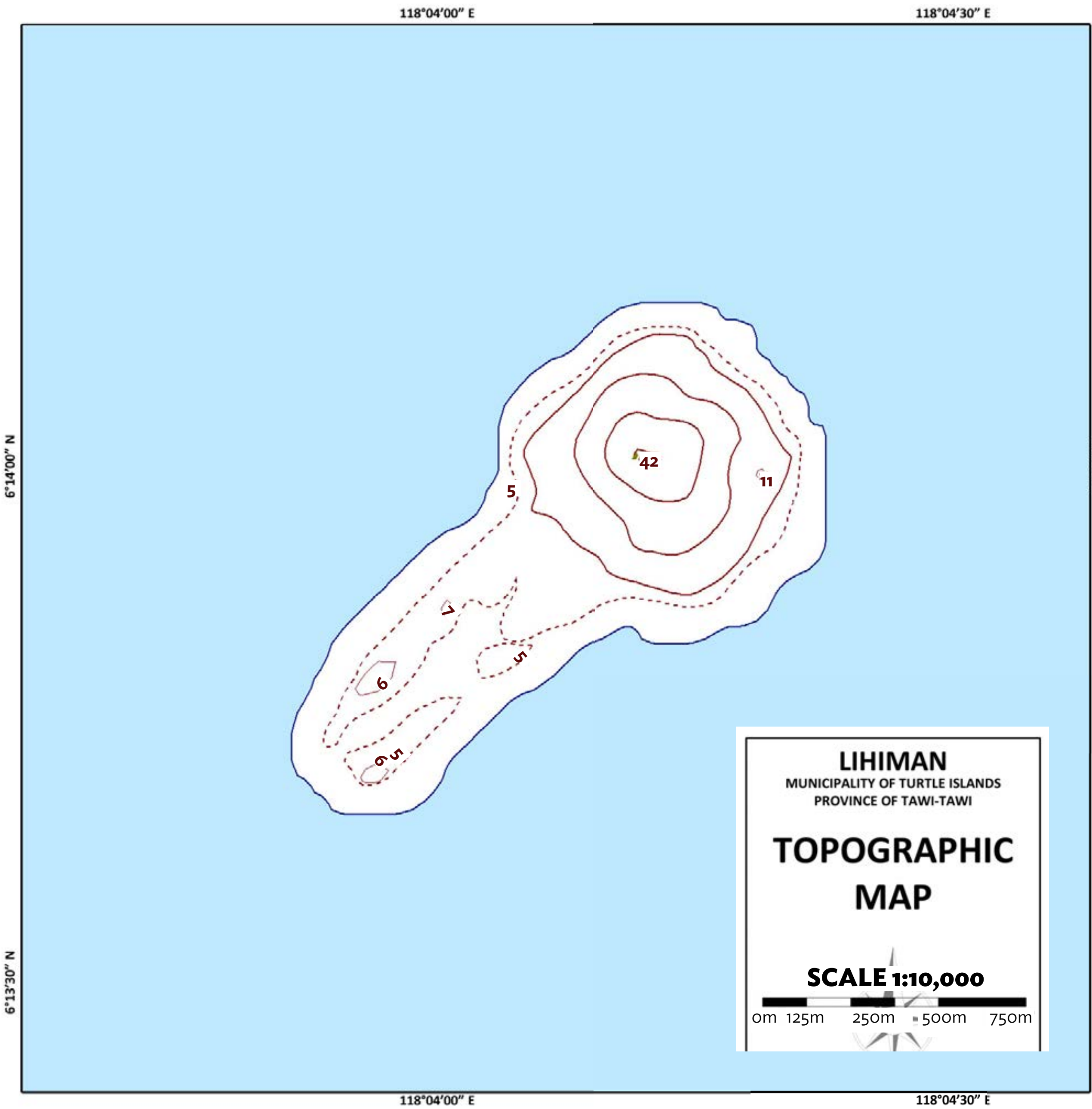
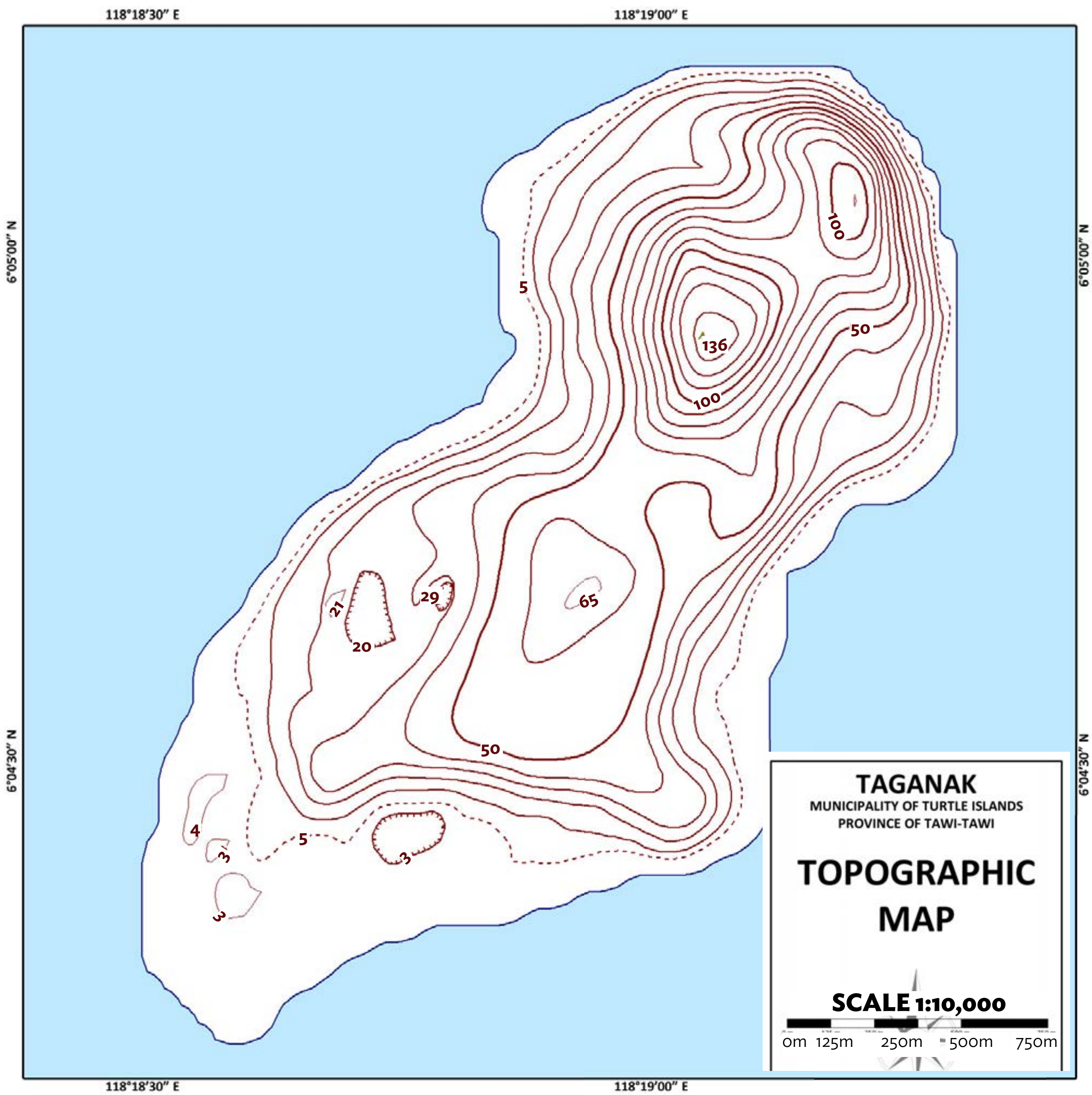


Figure 68. Topographic Map of Taganak



TURTLE ISLANDS WILDLIFE SANCTUARY
CLIMATE RISK AND VULNERABILITY ASSESSMENT

Climate change exacerbates natural hazards. Therefore, it cannot be dissociated or delinked from disaster risk. This study included the assessment of natural disaster risks, including earthquakes and soil liquefaction, in addition to typhoons, floods, rain-induced landslides, storm surges, and sea level rise. This assessment profile will serve as a basis to formulate proposed Climate Change Adaptation (CCA) and Disaster Risk Reduction Management (DRRM) measures for the areas surveyed in Turtle Islands, Palawan.