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# CLIMATE CHANGE VULNERABILITY ASSESSMENT OF LABUTTA TOWNSHIP AYEYAWADY REGION, MYANMAR, 2016-2050

## SCENARIOS FOR RESILIENCE BUILDING

STUDY CONDUCTED BY



IN COLLABORATION WITH



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#### NOTES ON THE STUDY

UN-Habitat and UN-Environment conducted the study as implementing partners of the Myanmar Climate Change Alliance Programme (MCCA). MCCA is an initiative of the Ministry of Natural Resources and Environmental Conservation (MoNREC), i.e. Environmental Conservation Department (ECD). MCCA is funded the European Union through the Global Climate Change Alliance (GCCA). GCCA is a flagship initiative of the European Union helping the world's most vulnerable countries to respond to climate change. GCCA is a major climate initiative that since 2007 has funded 72 projects of national, regional and worldwide scope in Africa, Asia, the Caribbean and the Pacific. [www.gcca.eu](http://www.gcca.eu) #GCCAPlus

MoNREC/ECD facilitated the cooperation with key national departments, i.e. the General Administration Department (GAD) of the Ministry of Home Affairs, for local consultations; the Department of Population (Ministry of Labour, Immigration and Population), which provided disaggregated 2014 Census data; the Department of Meteorology and Hydrology (DMH) of the Ministry of Transport and Communication (MTC), which provided all necessary data for the downscaled climate change projections.

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**CLIMATE CHANGE VULNERABILITY  
ASSESSMENT OF LABUTTA TOWNSHIP  
AYEYAWADY REGION, MYANMAR,  
2016-2050**

SCENARIOS FOR RESILIENCE BUILDING

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## EXECUTIVE SUMMARY

This assessment analyzes the vulnerability of the ecological, infrastructure and socio-economic conditions of Labutta in relation to the present and projected climatic conditions. It concludes that vulnerabilities in Labutta are currently high and that changes in climate will require decision-makers in Labutta Township to plan for increased coastal flooding, warmer temperatures, more frequent extreme heat days, greater amounts of rain within a shorter monsoon season, salinization of water sources and agricultural land, and erratic rainfall patterns during other seasons. Based on these findings, required actions for building resilience over the mid to long-term are in the Annex 1.

In 2016 the Myanmar Climate Change Alliance, comprised of UN-Habitat, UN-Environment and the Ministry of Natural Resources and Environmental Conservation, in collaboration with WWF and Columbia University conducted a detailed climate change vulnerability assessment of Labutta Township. Labutta is located at the southern tip of the Ayeyawady Delta Area region in Myanmar and is home to around 315,000 people. Characterized by a deltaic environment, it has a predominantly flat topography, and suffered greatly in terms of damage and lives lost from Cyclone Nargis in 2008. Labutta is still struggling to recover from its effects, especially in rice production.

The study analyses current vulnerabilities, and by projecting changes in climate, anticipates further vulnerabilities in the future up to 2050. On this basis, it proposes scenarios that describe potential impact of climate change, and issues recommendations for adaptation to avoid the worst case future scenario. It also describes the expected outcomes and results, and prioritized activities that communities identified during the course of the assessment.

The study projects changes in climate for the township, to a 25-kilometre spatial resolution. Projections show an increase in temperatures by as much as 2.3°C in 2050, with up to 17 more hot days per year. Rainfall patterns are also projected to change, with a possible increase in rainfall during a shorter rainy season, meaning more frequent heavy rainfall events. Strong winds and cyclones are also expected to increase, because of higher temperatures, more evaporation and a greater



Figure 1. Water collection chores. Most of Labutta access to water is from open unprotected surface water ©MCCA



In current conditions, the study demonstrates, Labutta Township is insufficiently resilient to the present climate conditions, and its vulnerability will increase greatly because of the projected future changes in climate if no adaptation actions are taken.

moisture level in the atmosphere. Finally, salinity is also a critical challenge. Labutta has two salt lines: A permanent salt line, below which the land and groundwater is saline, and a seasonal salt line, in which land and groundwater is saline in the dry season. These salt lines are moving north and east, affecting a greater number of people. The assessment projects up to approximately 40 centimetres of sea-level rise by 2050, which will increase the area of salt infiltration, and cause more frequent and more intense inundations and floods.

The assessment shows that decision-makers in Labutta Township will need to plan for increased coastal flooding, warmer temperatures, more frequent extreme heat days, greater amounts of rain within a shorter monsoon season, and unknown rainfall changes during other seasons.

In current conditions, the study demonstrates, Labutta Township is insufficiently resilient to the present climate conditions, and its vulnerability will increase greatly because of the projected future changes in climate if no adaptation actions are taken. This is mainly due to the current socio-economic; infrastructure and ecological system conditions, and the expected impact of climate change on these systems. In particular:

1. Labutta's economy is not diversified and up to 72 per cent of people depend on highly climate-sensitive agriculture and fisheries for their livelihoods, which on average provide incomes well below the minimum wage, while people have little training in other trades and professions. Agriculture is affected by salinity, higher average temperatures, heat waves, floods, inundation, and strong rains. As most people do not have alternative livelihoods or technical or vocational skills, migration is high, especially among young men, who are more than twice as likely to migrate than women. Climate change projections indicate that these impacts will worsen by 2050; incomes will at

best stagnate and may well decline, and in this case increased migration is highly likely.

2. Labutta has a deltaic ecosystem, which though naturally highly productive and resilient, is rapidly degrading. There was a 64 per cent reduction in mangrove coverage area between 1978 and 2011, mainly due to land conversion for agro-industry and cutting for domestic fuel use. Mangrove ecosystems provide multiple critical services: protecting people from waves, providing habitats for fish, regulating erosion and salt infiltration, and providing construction materials and fuel-wood for cooking. With the current trends – and the further effects of climate change on flora and fauna – mangroves could be entirely lost by 2019. This will increase the sensitivity of communities to the adverse climatic effects.
3. Infrastructure in Labutta is not adapted to strong winds and floods, and unable to withstand the effects of tropical storms and cyclones, and is further at risk from projected changes in the future. Housing and basic service infrastructure primarily uses non-resistant local materials; in some areas, up to 97 per cent of houses use local materials, while the network of disaster resilient life-line buildings, such as cyclone shelters, only cater for 10 per cent of the total population. Schools, health facilities and other public buildings are also not adapted to withstand severe climatic events. A network of waterways provides

mobility for people in Labutta and sustains commerce and connectivity to Pyinsalu, in the south, to Labutta Town in the north and from east to west. However, the combined effect of up to 41 centimetres of sea-level rise and heavy rains means that waterways may become impassable with high tides, storm surges and waves, and main roads may be inundated. Lack of effective connectivity is a severe obstacle for development and may represent a hazard for people. Drinking water in Labutta relies overwhelmingly on uncovered, rain-fed sources; around 80 per cent of people depend on such facilities for their drinking water. The shorter monsoon season, greater evaporation and salinity require improvements to rainwater harvesting and water storage to allow people to continue living in this area.

The interplay of these underlying vulnerabilities with ongoing and future changes in the climate will, if not urgently addressed, leave the people of Labutta more vulnerable to disasters. The effects will be seen through more frequent loss of lives and assets, lower incomes that will drive poverty, increased migration, poorer outcomes for women and a challenging public health situation. Housing and basic service conditions will also worsen, driven by changes in the climate and degraded ecosystems. Overall, without adaptation measures, climate change will be a barrier to socio-economic development as Labutta is not resilient at present.





## THE ASSESSMENT PRESENTS THREE POSSIBLE FUTURE SCENARIOS FOR THE YEAR 2050:

- A. The business as usual scenario, in which authorities and communities do not recognize the urgent need to address different aspects of vulnerability. Therefore, changes in climate have an exponential effect on the three systems analysed in this report; socio-economic, infrastructure, ecological and ultimately affect people's life, livelihoods, health, and safety by 2050. In this scenario, insufficient planning capacities and governance, negate mid to long-term planning. Decisions are taken to respond to short-term needs; such as allowing cutting mangroves without replanting; constructing infrastructure where inundation may occur; or failing to construct houses with storm-resistant techniques, but with long-term negative consequences. Under this scenario, livelihoods, infrastructure and environmental conditions will not allow people to improve living conditions in the township. In addition, projected changes in the climate will interact with and exacerbate the existing vulnerabilities and as they do, new, unforeseen vulnerabilities may also emerge.
- B. The resilience is built to maintain current living standards scenario, in which the township and communities recognize the urgent need to take

action, but also recognize investment, time, economic, technical and skill constraints. In this scenario, an adaptation plan is adopted, and activities that can be implemented without large investment are consistently undertaken, such as the protection of the environment; the strengthening of economic associations to create a more resilient livelihood and income; the integration of measures for strong winds in housing and schools; the improvement of water-harvesting, among others. Under this scenario, decisions on land-use and town-planning would need to take into account current and projected climate risks, to prevent hazardous situations, such as infrastructure being constructed near flood-prone areas and the need to clean drainage infrastructure inter alia. In this scenario, the township and communities are able to plan their adaptation needs considering climate constraints, and communicate them to the districts, states and regions, NGOs and development partners. This scenario is the minimum required to prevent increased vulnerability, and to enable continued development.

- C. Resilience is built that enables economic and social development despite changes in climate by 2050, considering the different vulnerabilities of both men and women, in which effective, strategic planning, resources, coordination, and

time is assigned not only to maintain basic safety conditions, but to achieve development goals. Based on this assessment, the first of its kind in Labutta, planning work that follows is strategic, and guides the township planning, the budget request to the district and other authorities. It requests investment from national authorities and international partners, to achieve three main results: 1) A healthy ecosystem is maintained and enhanced, to protect and provide for people; 2) A diversified, inclusive and resilient economy, to enhance the economic conditions of the township; 3) A resilient infrastructure and connectivity, that protects and enables people. In this scenario, efforts are sustained in an inclusive manner over a long period of time, and by a number of actors, but particularly the local and national government.

To make the findings of this report actionable, a climate change resilience action plan should be developed and adopted at the township level. To this end, the assessment mobilized communities to identify expected adaptation outcomes and results, and priority potential activities to pre-empt Scenario A from materializing and instead promote a more resilient Labutta by, at the very least, achieving the conditions of scenario B, and working towards scenario C. The results of these consultations are included in this report, and they should be used as a basis to initiate adaptation in Labutta township (Annex 1)

# 1

## PURPOSE OF THE REPORT

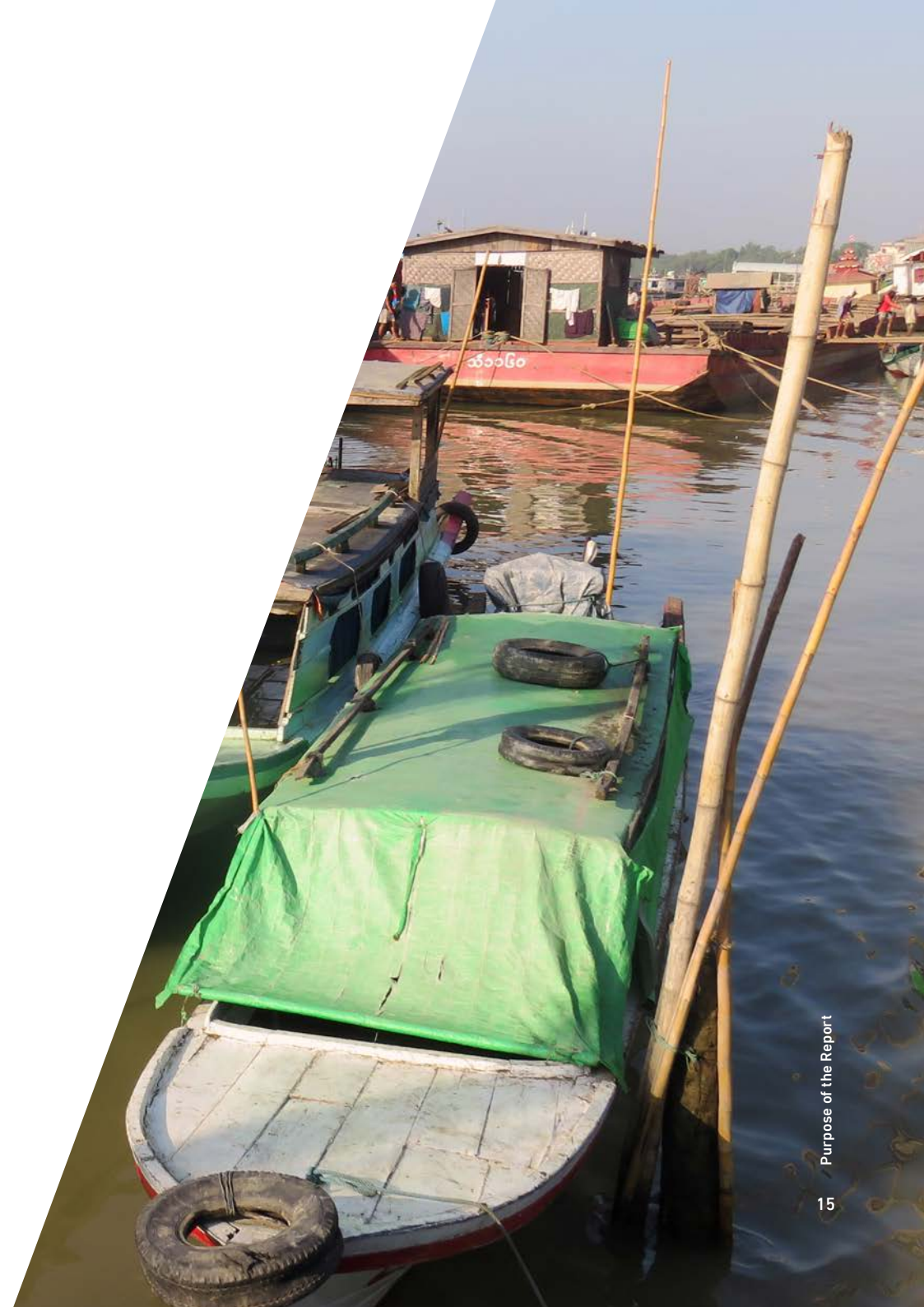
The purpose of this report is to help the Township's authorities to understand the risks related to climate change, plan accordingly, and direct investments to build resilience in the short to long-term, with 2050 time horizon.

To do that, the study analyses current township vulnerabilities as concerns governance, ecosystem, infrastructure and socio-economic conditions and, by projecting changes in climate in the township, it anticipates further vulnerabilities in the future up to 2050. On this basis, the report envisions future scenarios for the Township affected by climate change, the projections of which are downscaled at local level.

Finally, it provides recommendations for building resilience in order to avoid the

worst-case future scenario, the 'Business As Usual'. The report also includes the results of the planning exercise conducted with the communities and the authorities to prepare a local resilience and adaptation plan, with expected outcomes and results for resilience building, and prioritized activities that communities identified during the course of the assessment.

The report draws on information that is readily available – such as disaggregated Census Data – or easy to obtain through desk review and consultations. The indicators chosen for the vulnerability index are simple and mostly from Census 2014: the report therefore is also a baseline that can be updated on a regular basis, as part of the resilience building action.



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## 1.1 BACKGROUND

Myanmar is one of the most vulnerable countries in the world to the negative effects of natural hazards. Many of its 51.4 million people<sup>1</sup> and productive assets - in terms of land, ecosystems and infrastructure - are concentrated in the Ayeyawady Delta and the Dry Zone Area, which are also the two physio-geographic regions most exposed to recurrent cyclones and tropical-storms, storm-surges and floods; and droughts and heat waves respectively. People and assets are highly exposed to hazards, while low socio-economic outcomes because of high dependence on climate-sensitive sectors such as agriculture and limited access to infrastructure reduce people's ability to withstand and recover from shocks.

Rapid on-set disasters caused by cyclones and floods that have immediate and devastating consequences affect the delta and the dry zone. Other slow on-set phenomena such as ground water salinization in the delta due to sea-level rise, or the reduction of agricultural productivity due to higher temperatures and changing rainfall patterns in the monsoon season in the dry-zone also have significant effects on the society and economy of Myanmar.

In 2012, the Department of Meteorology and Hydrology (DMH) of the Ministry of Transport and Communication (MTC) confirmed changes had been observed in the climate over the last sixty years including an increase in mean temperatures, highly variable rainfall patterns, increased dry spells, a shorter monsoon season (from about 144 days in 1988 to the current estimated 125); as well as stronger tropical storms, cyclones and floods, which occur with more frequent return periods and in unexpected locations. The latest projections<sup>2</sup> prepared in 2016 confirm the confidence in further changes, which will result in increased vulnerability.

Although Myanmar is transitioning its economy towards the tertiary sector and manufacturing, and generates revenues from the energy produced and sold to other countries, it still depends heavily on largely rain-fed agriculture for between 34 and 37 per cent of its GDP, and employment for between 70 and 80 per cent of the workforce. In this sense, the capacity of the country to attain its ambitious



development objectives by 2030 may be affected unless it urgently adapts to the present and future changes in climate.

There is strong evidence that climate change is affecting Myanmar; high confidence that changes will continue to impact the country over the next decades; and that unless urgent action is taken at national, regional and local levels people will suffer disproportionately.

To support Myanmar to address these issues, in 2013 the European Union funded The Myanmar Climate Change Alliance (MCCA) Programme, implemented by the United Nations Human Settlements Programme (UN-Habitat) and United Nations Environment under the Ministry of Natural Resources and Environmental Conservation (MoNREC) and its Environmental Conservation Department. Its main goal is to mainstream climate change in the political, institutional and development agenda of the country. To achieve this, it aims to increase institutional, policy and technical capacities to address climate change. The MCCA has three results:

1. The government, civil society and the private sector in Myanmar are more aware of the implications of climate change.
2. The government has the capacity and support needed to integrate climate change considerations in policies, strategies, plans and operations.
3. The lessons drawn on climate change from State and local level activities influence policy-making and are communicated to relevant decision-makers in the relevant sectors.

In 2015, to achieve its third result, in 2015 MCCA in agreement with several national and local stakeholders selected one township in the dry zone; Pakokku in Magway Region and one in the delta area, Labutta in the Ayeyawady Region to assess vulnerabilities and, based on the assessment's findings, launch a Township Climate Change Adaptation Programme to help communities adapt to the negative effects of climate change in the short, medium and long-term.

The present assessment report is part of this work and will inspire the development of a vulnerability assessment method to be replicated in other townships of Myanmar.

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1 Myanmar Initial National Communication to the UNFCCC (2012), pp.54-97  
2 Myanmar National Adaptation Programme of Action (2012) pp26-35



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## 1.2 OBJECTIVES OF THE ASSESSMENT

The main objective of this assessment is to inform the Labutta Township, as well as the district, regional and national authorities, as well as development partners, of the expected consequences of climate change and, on this basis, to help them to plan and act to adapt to climate change. It provides important information to understand vulnerabilities now and in the future and is therefore a tool for community and the townships to plan ahead, build resilience, and mitigate the negative impact of climate change

Specifically, the assessment delivers the following benefits to stakeholders at different levels:

1. Increased understanding of the underlying causes of vulnerability vis-à-vis the negative effects of natural hazards, and the effects of the changing climate over the short, medium and long-term;
2. Increased awareness of the sources and location of vulnerabilities for people and assets in the township;
3. Increased understanding of how the ecological; socio-economic and infrastructure systems interact to sustain life in the township, and how climate change may affect them;
4. Spatial dynamics of vulnerability in the present and in the future identified;
5. Short to long-term scenarios of development defined;
6. Based on the above, increased capacity to plan and implement adaptive pathways for the township, which are spatially relevant, and guide the correct allocation of resources.



Figure 2. Young women in the Labutta area working for daily wages, at about 1500MMK/day (US\$1.20) Sukun/UN-MCCA/2016

The vulnerability assessment illustrates how climate change will heighten risks and exacerbate already sizeable challenges. Labutta township is characterised by a poverty rate above the national average, and social development indicators such as tertiary education that are well below those in the rest of Myanmar, and an economy dependent on climate-sensitive sectors. Environmental challenges hamper development, because of man-made degradation, exposure to extreme natural events, and incipient effects of climate change.

Most notably, mangrove coverage has rapidly declined because of household scale cutting and some clearance for agriculture and agro-industry; even though mangroves provide innumerable vital services, including habitats for fish and protection from storms and waves. Also, the topography of the township makes spatial interaction difficult: travel from some coastal areas to Labutta town can take 8 hours by boat, and is only passable in favourable weather conditions, limiting the ability of coastal communities to travel and trade.

At national level, there is increasing data and understanding of the observed impacts of climate change and projections on the expected changes<sup>3,4,5</sup> and initial analyses on the risks and vulnerability to climate change in sectors such as agriculture<sup>6</sup> and the natural environment<sup>7</sup>. However, there is very little information on the expected effects of climate change on the ground. Several valuable studies exist, especially those conducted in Labutta after Cyclone Nargis, relating to vulnerability to disasters, but these do not project changes in climate. Most

importantly, no studies analyse the interplay of infrastructure, the environment and socio-economic development to sustain livelihoods and social development in the township and how climate change is going to affect this interplay.

The vulnerability assessment covers this gap by:

1. Delivering an accurate account of the development profile in Labutta relating to the physical and natural environment, administrative and demographic features, infrastructure and socio-economic conditions.
2. Overlaying present and projected climate hazards onto Labutta's eco-system, socio-economic, infrastructure and spatial conditions, to understand the current and future impacts of extreme natural events, as well as changing in temperatures, rainfall patterns, sea-level rise.
3. Designing scenarios for 2050 that may occur based on the level of adaptation actions taken.

The result of this is to present a comprehensive analysis of the present situation and future development that comprehensively considers climate change. This will be beneficial to planners at the state/region and national level who will be able to use the findings of the report to make more informed, strategic planning decisions.

This analysis supports a strategic approach over the long-term that will identify objectives for climate resilient development, and design actions that best use the resources available to achieve them<sup>8</sup>.

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3 Myanmar Initial National Communication to the UNFCCC (2012), pp.54-97  
4 Myanmar National Adaptation Programme of Action (2012) pp26-35  
5 Germanwatch (2015) Global Climate Risk Index 2015  
6 JICA (2013) Data Collection Survey on Agriculture Sector in The Republic of the Union of Myanmar  
7 WWF (2016) Natural Connections: How Natural Capital Supports Myanmar's People and Economy  
8 This is informed by UN-Habitat (2014) Planning for Climate Change, A Strategic, Values—based Approach for Urban Planners





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## 1.3 PRINCIPLES & METHODOLOGY

Five overarching principles guide the assessment:

1. **Simplicity, to ensure ease of replication in other townships**
2. **Measurability and availability of data, to ensure ease of update and replication**
3. **Inclusiveness, to ensure participation of communities**
4. **Comprehensiveness, to ensure relevance of the findings**
5. **Spatial relevance, to guide actual adaptation interventions**

To respect these principles, the assessment uses the following:

- Open-source or widely available software, such as Q-GIS, which reduced costs and enables national replication.
- Data available at either national or local level, is easily obtained upon written request. The assessment does not use satellite imagery. Although this creates limitations in developing flood modelling, for example, it enhances the replication potential of this work.
- Data from the Census 2014, disaggregated at village-tract and urban ward level, as a key source of information. In addition to being a vast source of information and insight, future census' will provide actual monitoring of changes in the structure of the townships, which can be reanalysed in the future. Census data can also be easily accessed for each township.
- Involving communities throughout the whole township through simple questionnaires, community focus groups and participatory mapping.
- Studying the three main systems that define the township; ecological, socio-economic, and infrastructure. Climate change causes impacts on all three of these systems in Labutta. A simple analysis of extreme natural hazards does not help to understand the extent to which the township will need to adapt. Hence, the assessment is designed to analyse system-wide issues and the interaction between systems.

- Identification of the current and future spatial structure of the township, which is essential to support planning and direct interventions for adaptation and to understand how changes in one part of the township or the region may affect others.
- Equal participation of men and women and, where possible, using gender-disaggregated data.
- Engagement of the national government and the township throughout the process, to ensure ownership of the results and replication.

## PROCESS

The vulnerability assessment uses an iterative process, in close consultation with the national and township authorities. The assessment involves national and township level technical meetings; local community participatory workshops; surveys with village administrators; a desk review of studies; creation of datasets based on available geo-referenced data.

## METHODOLOGY AND TECHNIQUES

The methodology works as follows:

1. It establishes a basis for analysis by describing the context and key socio-economic, ecological and infrastructure features and the spatial structure of the township. This generates insights on the current situation and sources of vulnerability. A vulnerability index is presented, which gives an account of the most vulnerable locations in the township;
2. It analyses, through both data analysis and community risk mapping, the exposure of people and assets to recurrent natural hazards and their potential for rapid and slow on-set disaster;
3. It overlays downscaled projections of climate change for the township on the current conditions analysed in the assessment and studies how these new climatic conditions will affect people and assets in the township;
4. It defines future scenarios that may materialize without adaptive action and contrasts them with potential adaptive pathways, which inform adaptation planning.

## Box 1. Climate Modeling Methods

The NASA NEX-GDDP dataset includes downscaled projections (0.25 degrees, 25km resolution) from the 21 models and scenarios for which daily scenarios were produced and distributed under the Coupled Model Intercomparison Project Phase 5 (CMIP5). The CMIP5 GCM simulations were developed in support of the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC AR5). The NEX-GDDP dataset includes downscaled projections from the 21 models and scenarios for which daily scenarios were produced and distributed under CMIP5. Each of the climate projections includes daily maximum temperature, minimum temperature, and precipitation for the periods from 1950 through 2100. The spatial resolution of the dataset is 0.25 degrees (approximately 25 km x 25 km). Two time slices were developed to represent 30-year averages – 2020s (2011-2040) and 2050s (2041-2070). Temperature change factors reflect changes in seasonal and annual averages of daily mean temperature in reference to the base period. Precipitation change factors reflect percent changes in total seasonal and annual precipitation in reference to the base period. All change factors are relative to the 1980-2005 base period.

Horton, R., De Mel, M., Peters, D., Lesk, C., Bartlett, R., Helsing, H., Bader, D., Capizzi, P., Martin, S. and Rosenzweig, C. 2017. *Assessing Climate Risk in Myanmar: Technical Report*. New York, NY, USA: Center for Climate Systems Research at Columbia University, WWF-US and WWF-Myanmar.

There is no one size fits all approach to understanding the additional vulnerability that will occur because of climate change, or to identifying the adaptation measures that follow from it. Instead, the assessment combines several methods and tools that best fit the requirements of the location being studied<sup>9</sup>.

#### TO GENERATE A COMPREHENSIVE ACCOUNT OF THE TOWNSHIP VULNERABILITY, THE FOLLOWING KEY METHODS/TOOLS WERE APPLIED:

##### Vulnerability Index

The assessment defines vulnerability as a function of exposure, sensitivity, and adaptive capacity<sup>10</sup>. However, because there are no direct indicators of adaptive capacity, and to maintain the principle of simplicity, the vulnerability index does not attempt to measure adaptive capacity. Nine simple indicators define the sensitivity of each system analysed in this report (ecological, socio-economic and infrastructure systems), eight of which are data available in the census. The total score is multiplied by the intensity of natural hazards, as measured through historic data and community consultations. This results in an indication of the level of risk<sup>11</sup> for each village tract/urban ward.



Focus groups with village members in Labutta. The assessment team from UN-Habitat, UN Environment and ECD is pictured.

**Purpose of the method:** To provide an overview of the most vulnerable locations to current natural hazards and climatic conditions. Because there is no single way to establish comprehensive indices of vulnerability, this tool is used in connection with others to provide in-depth analysis.

##### Downscaled climate models

The assessment studies historic trends and downscales projections for the township, mostly based on data provided by the Department of Meteorology and Hydrology (DMH) for the relevant weather stations. Temperature and precipitation projections use the NASA Earth Exchange Global Daily Downscaled Projections (NEX-GDDP) dataset released in 2015 (NASA, 2015), creating two scenarios, low and

high, corresponding to two Representative Control Pathways (RCPs) of global greenhouse gas emissions developed by the Intergovernmental Panel on Climate Change (IPCC), RCP 4.5 and 8.5 (Box 1). Sea level rise projections were developed using model outputs from the CMIP5 GCMs to create a range of possible future rise across multiple RCPs, along with other data sources and methods that account for land-based ice loss and changes in land water storage.

**Purpose of the method:** To provide evidence of the historic climatic trends and projected changes at the township level; enabling the accurate analysis of current and future vulnerabilities in several systems, and supporting tailored design of adaptive pathways for the future.



### Spatial Analysis

The spatial and territorial analysis uses matrix of functions (MoF) to assess the relations amongst villages and urban wards in the township. To do that, the MoF describes which services and functions are available in each ward and the village tract of the township and what is the hierarchy and importance of these settlements one to another, where functions are missing and, importantly, how balanced the spatial development of the township is. Applied to climate change, it increases understanding of how the current spatial structure of the township enables or inhibits the resilience of the area to the changes in climate. The MoF is developed by collecting data with a simple questionnaire to determine where services are available. Key functions are listed, processed and mapped through GIS. Technical annexes are available on request.

Purpose of the method: To support national, regional and local government decision-making by setting out a spatial vision and strategy specific to a particular region with a view to maximising the benefits from investments and bringing about more balanced territorial development patterns. In this context, it provides the township, regional and national authorities the evidence to intervene in specific areas but with the aim of generating climate change resilience for the whole township.

### Socio-economic system analysis

The analysis utilizes quantitative and qualitative surveys. The quantitative analysis draws on several sources: the census, sector specific data gathered at the national and local level (such as Myanmar agriculture at-a-glance data, and locally sourced planning data), and data gathered for the MoF. It also uses data from the township planning department to calculate output per capita, and make estimations of income, factoring in the relatively high number of economically inactive people. This assessment also generates qualitative information through consultations that makes it both participatory and values-based. The community focus groups were held with

clusters of villages throughout the township, resulting in an even geographical spread of consultations. The consultations increased the participation of women, by involving a gender expert who conducted parallel, female-only consultations.

Purpose of the method: To provide understanding of the main sources of livelihoods, productive sectors, and social conditions that enable development, such as the education level and productive sectors, among others. This increases understanding of how dependency on single sources of livelihood may affect the overall resilience of the township when new climatic features affect that specific source of livelihood. Through this, the assessment unveils to what extent livelihoods and productive sectors in the township are resilient to the current and future climatic conditions.

### Eco-system service analysis

Four types of ecosystem services and functions – the mechanisms essential to nature, and the benefits nature provides to people – are analysed: provisioning, regulating, cultural and supporting, to find which services are most used by the township and how climate change is affecting the quality and availability of these services. The assessment, through both local consultations and desk review, analyses their availability and quality in the township and their role to sustain life.

Purpose of the method: To analyse how the township depends on services provided by the environment. Some services play multiple functions. For instance, mangroves have a regulating value, as they protect people from storm-surges; but they also function as provisioning service, by creating a habitat for fish feeding and breeding. They also play an important supporting function by controlling erosion and soil quality. They have, in some cases, cultural value, as they define eco-systems and landscapes. Defining to what extent the eco-system is vulnerable, and how much climate change will affect it, is key to understanding the resilience capacity of the township, and the required adaptation actions. Thorough understanding of the



Members of the MCCA Technical Working Group validate the methodology of the study and preliminary findings in Nay Pyi Taw, October 2016

ecosystem services provided in each township also enables the understanding of which ecosystem-based adaptation approaches can be proposed as adaptation measures.

#### Infrastructure and connectivity system analysis

Data gathering for the Infrastructure analysis was conducted through a mix of local surveys, census data, and analysis of datasets in a GIS environment. It reflects both the conditions of the built environment and its spatial distribution. The analysis provides a description of the predominant construction techniques and materials, which are key to understanding the vulnerability of critical assets such as housing, schools, and health posts to natural hazards, especially of heightened intensity resulting from climate change related droughts, cyclones, and floods. Importantly, it analyses the architectural features and the overall safety of the units through their sanitation facilities and water harvesting capacities, for example. It also analyses the distribution and access through roads and waterways, which provides insight on how isolation and distance contribute to vulnerability in many areas, and how climate change exacerbates this. Finally, it provides an analysis of the distribution of key safety infrastructure, such as cyclone shelter availability and whether this is strategically located.

Purpose of the method: To provide a spatial analysis of the sensitivity of the built environment and the connectivity to natural hazards and climatic conditions. These are important features that enable or inhibit the resilience of communities, development, as well as very basic safety from adverse natural hazards.

#### Future vulnerability scenarios in GIS environment

Key features of the ecological, socio-economic and infrastructure systems are contrasted with the projected climatic changes for the township. A coefficient for climate change for each projected change is assigned and multiplied against a given feature, such as crops. For instance, a coefficient expressed as a percentage was assigned for increase in temperature and multiplied the type of crops, soil and irrigation systems in a given location. Literature suggests that a 1°C increase may result in between 10 and 50 per cent reduction in rice yields. The multiplied effect of the increased temperature on the known crops is illustrated in a GIS environment. The maps show a reduction in the amount of people that will be able to derive a living from agriculture as a result of the changes.

Purpose of the method: To build scenarios that show how given new climatic features will have a practical impact on infrastructure, agriculture, and the economy adaptive planning. It is extremely important to understand that these are not forecasts, and they are based on three key assumptions: first, that no adaptive measures will be taken (business as usual); second, that literature and experience in the different sectors are accurate in predicting what may happen to a sector, in relation to a new climatic feature. Finally, all projections are themselves built on future emission scenarios; the RCP 4.5 and 8.5. Extreme scenarios are used in this report, to ensure that planning considers the worst-case scenarios.

#### Local participatory risk mapping

Maps designed through consultation with communities and local administrators assess, the most exposed locations, where disasters occurred or recurrently affect people, infrastructure, and crops. This ground truthing work, mixed with the analysis of recorded historic data, gives the assessment depth and accuracy.



Women-only focus-group is conducted to ensure gender perspectives are duly captured in the study, May 2016, Labutta

### Disaggregated census data, 2014

Disaggregated data at urban ward and village tract level through several tables related to education, demography, disabilities, and construction, among others, informs all aspects of the assessment, as it provides geographically relevant socio-economic and infrastructure information.

### Integrating gender considerations

The assessment presents socio-economic information that reflects gender-disaggregated data, where available, and female-only consultations. This means that the assessment furthers the understanding of female and male sources of income and differing household roles and responsibilities, and the different perspectives of men and women. The assessment integrates gender considerations throughout the sections of this report.

## LIMITATIONS OF THE ASSESSMENT

Climate change is a complex phenomenon that intersects many aspects of society, the economy, and the environment. The assessment follows the principle of simplicity as much as possible, but nevertheless its development required diverse expertise; so, this assessment is not a rapid tool, but requires thorough analysis and critical thinking.

In technical terms, only the GIS and spatial representation of issues require advanced technical skills. These are available in Myanmar, but more training and capacity-building on the spatial analysis are needed, as well as on the scenario building.

The study also limits the use of flood modelling and the digital elevation models. Following the principle of replicability, the assessment team used existing satellite imagery and did not purchase it. As a result, the digital elevation models constructed did not offer sufficient resolution as to propose detailed flood-prone areas. This can be remedied during the adaptation process with more detailed studies.

The assessment team had access to a large number of datasets, inventories and data, and most of these were contrasted with the reality on the ground. However, some of the agriculture, forestry, and ecological data and information (species types, biodiversity) was sometimes outdated or not verified. Findings take this into account.

9 UNEP (2013) PROVIA Guidance on Assessing Vulnerability, Impacts and Adaptation to Climate Change, p.52

10 Where  $[Vulnerability V = (Exposure E + Sensitivity S) - Adaptive Capacity A]$

11 Where  $Hazard H \times vulnerability V = Risk R$

# 2

## TOWNSHIP PROFILE

Labutta Township is in the heart of Ayeyawady delta. The township is characterized by a flat, low-lying topography typical of a river basin outlet, except for some low hills in the north of the township. The mangrove forests and the surrounding ecosystem are in an increasingly fragile state due to direct impacts of economic development and land use change, including decades of deforestation.

Labutta's demographic and socio-economic characteristics make the township vulnerable to shocks, even more so because of climate change. In particular, migration trends, low economic outputs, non diversified livelihoods sources and lack of vocational training education,

make Labutta insufficiently resilient and dependent on climate-sensitive sources of income. In addition, social trends show an unequal access to economic opportunities for women.

Labutta town hosts both the Labutta Township administration and the Labutta District, which is one of the six districts that form the Ayeyawady Region. The Ayeyawady Region regional government is located in Patheingyi. The ability of the Township administration to integrate climate change into planning, and invest resources to mitigate its impact, will determine the future scenarios and the development of the township and its inhabitants.



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## 2.1. PHYSICAL AND ENVIRONMENTAL OVERVIEW

Myanmar can be divided into five physiographic regions: the northern mountains, the western ranges, the eastern plateau, the central basin and lowlands, and finally the coastal plains<sup>12</sup>, which includes the Ayeyawady Delta. Labutta is located 254 kilometres to the southwest of Yangon by road, in the heart of the delta. It is connected to both Yangon and Patheingyi, the capital of the Ayeyawady Region, 125 kilometres away by a paved road and river transportation.

Myanmar's three main river systems are the Ayeyawady, the Thanlwin, and the Sittang Rivers<sup>13</sup>. The longest river, the Ayeyawady, is nearly 2,170 kilometres (1,348 miles) long, flowing from the foothills of the Himalayas through the country and into the Gulf of Martaban. The Ayeyawady River and its tributaries are the principal drainage system in Myanmar, collecting around 66 per cent of surface water and ultimately flowing into the Andaman Sea.

In the deltaic areas formed by the Ayeyawady and Sittang Rivers, the landscape is flat, disrupted only by the Bago Mountains located between the larger Ayeyawady Valley and the smaller Sittang Valley. These deltaic lower portions of the Ayeyawady and Sittang Valleys cover a level and low-lying delta-plain of some 31,000 km<sup>2</sup>, which is prone to flooding. Labutta Township is in the heart of this drainage, framed by the main stem of the Ayeyawady River to the east and Patheingyi to the west and characterised by a flat, low-lying topography typical of a river basin outlet, except for some low hills in the north of the township.

Due to its location at the outlet of such a large water body, the Ayeyawady Delta collects sediments and nutrients that support a highly productive surrounding ecosystem that in turn provides numerous ecosystem services – benefits that nature provides to people – that support livelihoods and the larger economy of the entire township. The most important of these are nutrient rich soils that support paddy rice farming, aquaculture, and mangrove forests that themselves



Figure 3. Participatory mapping exercise in Labutta ©Capizzi/UN-MCCA/2016

For every hectare of mangrove cleared, nearby coastal fisheries can lose 480 kg of fish per year.

provide many critical services to the township. These include habitat for biodiversity, wood fuel for cooking, sediment trapping to support land stability and limit coastal erosion and protect coral reefs from sediments, and defences against strong coastal storms and cyclones. Mangrove forests in the region are particularly diverse, with an estimated 30 species of trees found in the Delta,<sup>14</sup> which in turn support a rich diversity of fresh and saltwater fisheries and shellfish that are an important protein source and livelihood to the local population. One estimate highlights the importance of mangroves for fishery production: for every hectare of mangrove cleared, nearby coastal fisheries can lose 480 kg of fish per year.<sup>15</sup>

Figure 4. The Location of Labutta in Myanmar

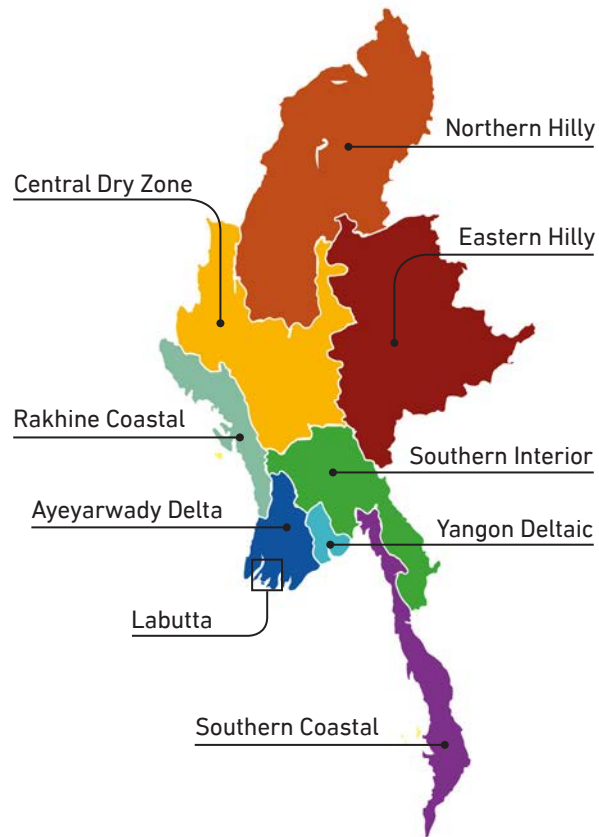


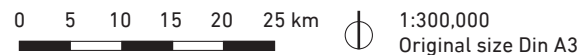
Figure 5. The Mangrove forest in Labutta ©MCCA/2017

These forests and the surrounding ecosystem are in an increasingly fragile state due to direct impacts of economic development and land use change, including decades of deforestation that has destroyed more than 60 per cent of mangroves in the delta<sup>16</sup>. This has in turn significantly degraded the ecosystem's ability to provide ecosystem services, including fisheries and coastal defences against extreme storms, evidenced by the high death toll in deforested areas from Cyclone Nargis. This is a major contributor to the overall climate risk in the township (see Section 3).

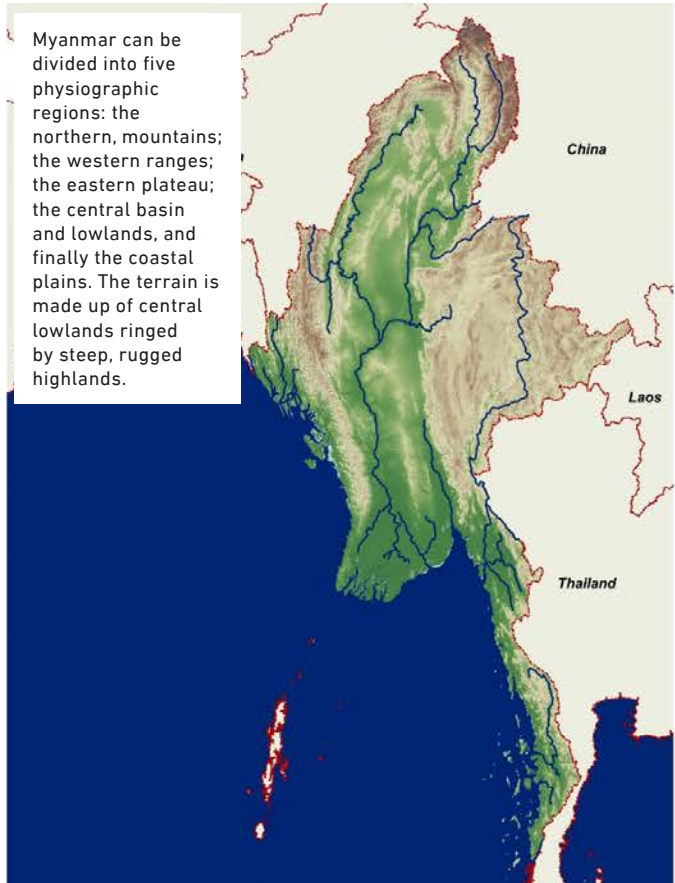
- 12 The Geology of Burma (Myanmar): An Annotated Bibliography of Burma's Geology, Geography and Earth Science. R. Lee Hadden, Topographic Engineering Center US Army Corps of Engineers. September 2008
- 13 The Geology of Burma (Myanmar): An Annotated Bibliography of Burma's Geology, Geography and Earth Science. R. Lee Hadden, Topographic Engineering Center US Army Corps of Engineers. September 2008
- 14 Aung, T. T; Mochida, Y; Maung Than, M (2013) Prediction of recovery pathways of cyclone-disturbed mangroves in the maga delta of Myanmar
- 15 Driel, W.F. van & T.A. Nauta, 2014. Vulnerability and Resilience Assessment of the Ayeyarwady Delta in Myanmar. Full assessment phase. Delta Alliance report no. 10. Bay of Bengal Large Marine Ecosystem (BOBLME) Project, Global Water Partnership (GWP) and Delta Alliance, Delft-Wageningen, The Netherlands
- 16 Webb et al. (2015) Deforestation in the Ayeyarwady Delta and the conservation implications of an internationally-engaged Myanmar



Labutta Township is located in the heart of the Ayeyawady delta, formed by the Ayeyawady and Sittang rivers, where the landscape is characterised by a flat topography typical of a river basin ecosystem, except for some low hills in the north of the township.



Digital Elevation Model (DEM) of Myanmar



Type of settlements

- Sub-village

Main communication routes

- Major road
- Secondary road
- Streams
- Water canals



Disclaimer: The designations employed and the presentation of material on this map do not imply the expression of any opinion whatsoever on the part of the Secretariat of the United Nations concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries.

Data Source: MINU, FAO, WWF, UN HABITAT

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## 2.2. DEMOGRAPHIC OVERVIEW

In 2014, Myanmar conducted its Population and Housing Census, the first national census in 30 years<sup>17</sup>. The data gathered for the census is disaggregated to the township level, giving local officials and experts – including the MCCA team – a substantial amount of new information that will enable more informed planning and decision making.

Labutta is one of 33 townships and sub-townships in the Ayeyawady Region. In this section and throughout the report, 'Labutta Township' includes data for Labutta and Pyinsalu sub-township, unless otherwise stated. According to the census, the population of Labutta is 229,929 and with 85,289 people in Pyinsalu, giving a total population for the township of 315,218.

The share of population residing in urban areas in the Ayeyawady Region declined by 2.4 per cent between 1973 and 2014, while at the Union level there has been a 5.3 percent increase in urban population<sup>18</sup>. Only 14 per cent of the population of Ayeyawady Region is urbanized, while urbanisation at the national level is 30 per cent. Labutta Township is even less urbanised; only 33,403 people (10.6 per cent of the township's population), are considered to be living in the urban area, of which almost all, 31,174, live in Labutta Town, with the rest in Pyinsalu.

The population density in Ayeyawady Region has increased from 118 inhabitants per km<sup>2</sup> in 1973 and 142 in 1983, to 176.5 persons per square kilometre in 2014. Currently it is the third most densely populated state or region in the country, surpassed only by Yangon Region and Mandalay Region. In Labutta Township there is a significant difference between the population density in rural areas (145 inhabitants per km<sup>2</sup>) and in the two urban areas, where Labutta town has 3,175 inhabitants per km<sup>2</sup> and Pyinsalu 472 inhabitants per km<sup>2</sup>.

Labutta's demographic and socio-economic characteristics reveal a number of issues that make the township vulnerable to shocks, regardless of any impacts of climate change or climate-related hazards, and are likely to exacerbate the impacts of climate change in the future.

The population pyramid, which is sex disaggregated and shows the number of people in each age category, tells us that there is an unusual age distribution; with a sharp decline in the number of people in 15-19 and 20-24 age groups with an increase to the 25-29 age group. Thereafter, the distribution returns to normal. There are a couple of causes of this; high levels of net outward migration of young people to seek work or education, and because children were disproportionately affected by Nargis. Indeed, there is evidence of a gendered aspect to outward migration; 73 per cent of outward migrants from Labutta in 2014 were male. The impacts of this are analysed further in section 4.3 of this report. Just under 38 per cent of the population of the township is under the age of 18; a relatively high proportion of youth residents. 14 per cent of households in Labutta are headed by women, slightly below the national average of 15.1 per cent<sup>19</sup>.

Figure 6. Demographic pyramid of Labutta (Census, 2014)

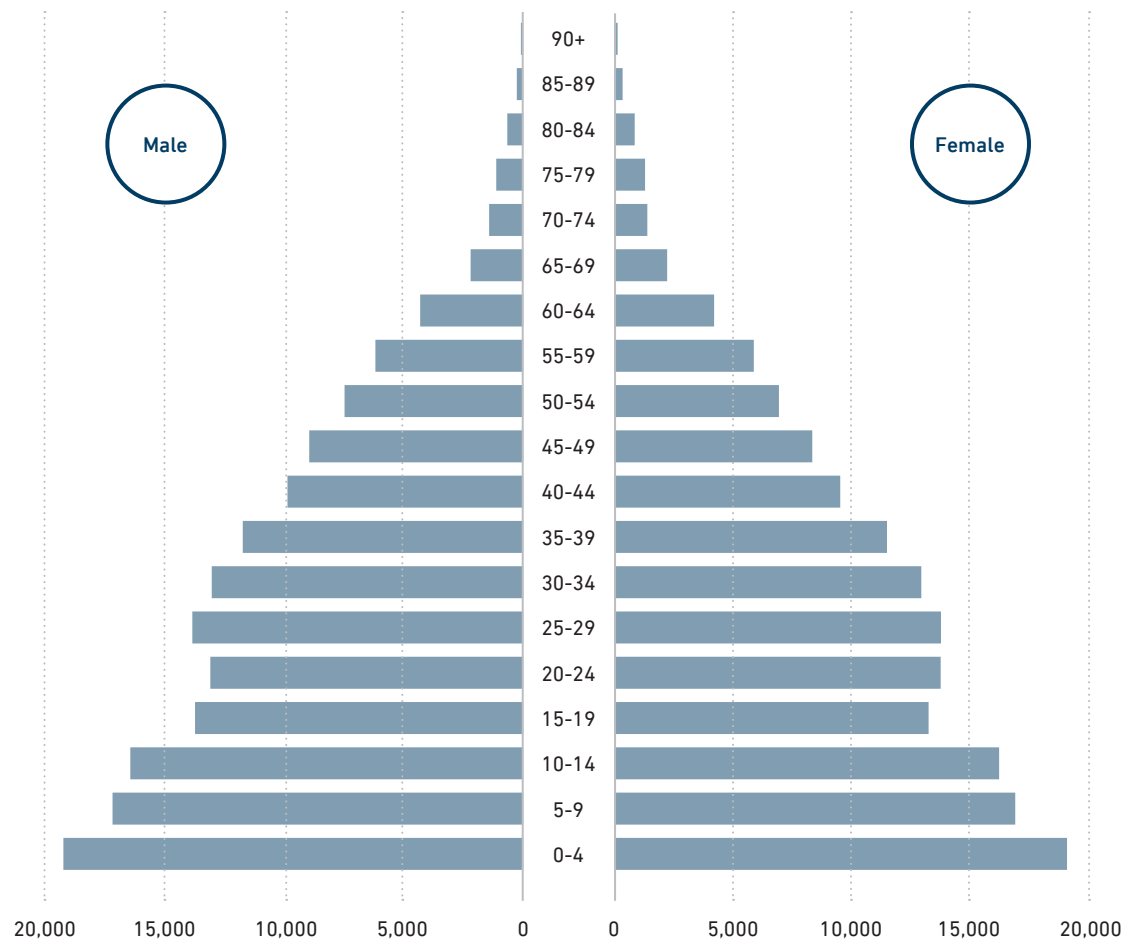
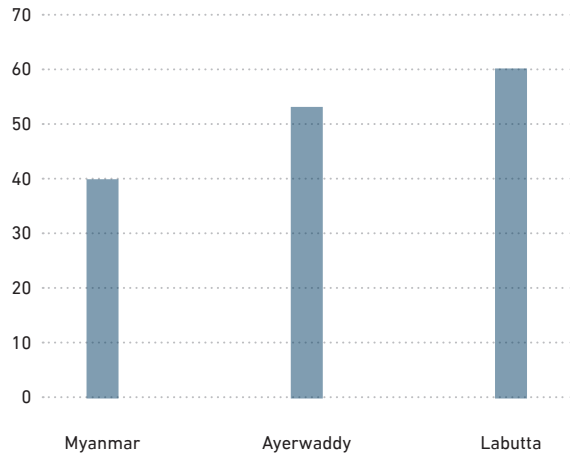


Figure 7.  
 Infant Mortality per 1,000 Live Births (Census, 2014)

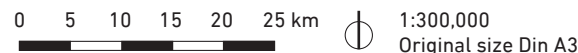
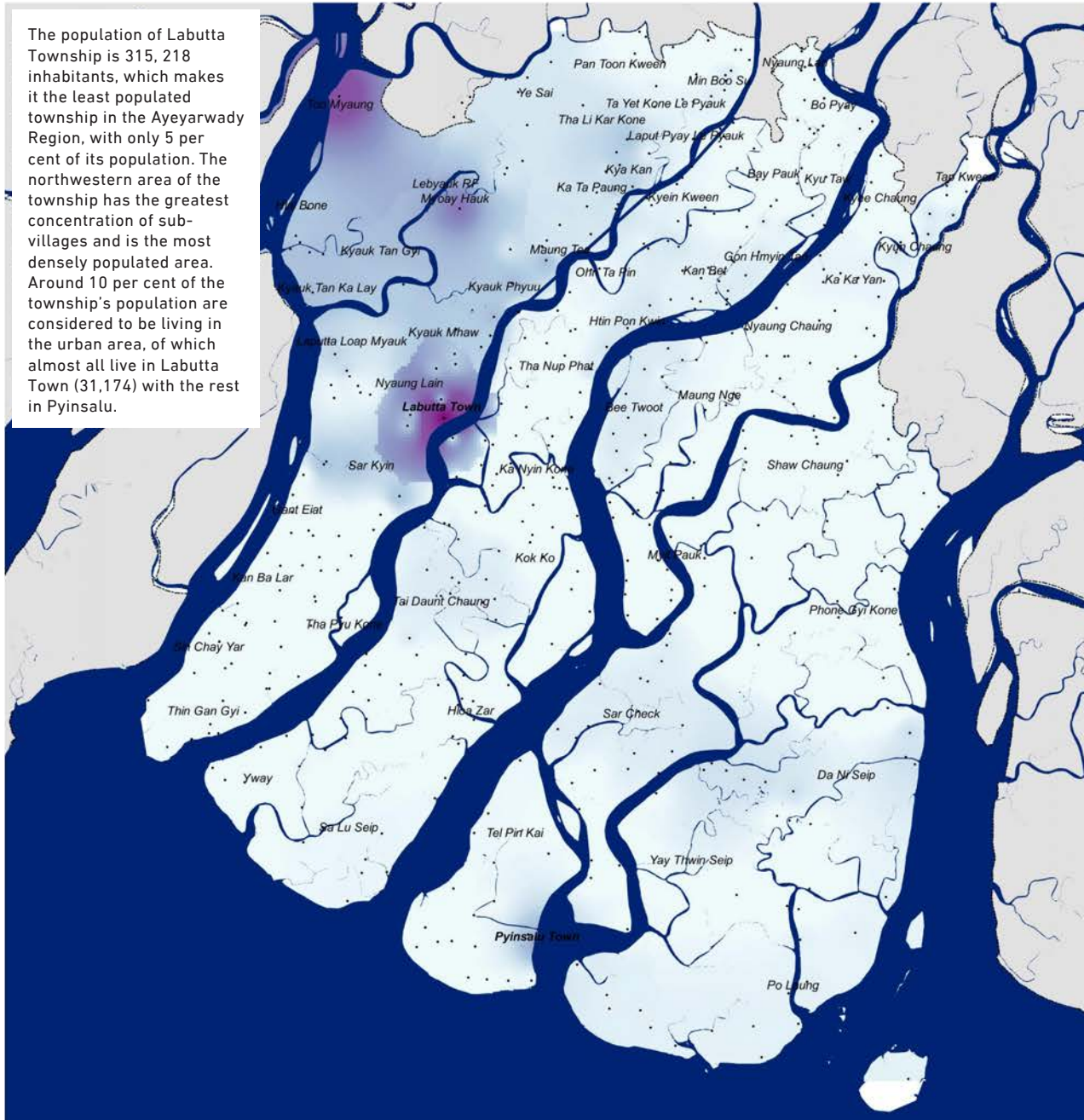


The census data also shows the infant mortality rate in recent years to be very high in Labutta; higher than both in the remainder of the Ayeyawady Region and in Myanmar. In 2013–2014 the infant mortality rate was around 60 per 1,000 live births, higher than the average for the Ayeyawady Region (53) and far higher than the national rate, which is 40 per 1,000 live births<sup>17</sup>. This signals a lack of health care facilities, post-natal care and nutritional problems, and is a subject to which the report will return later.



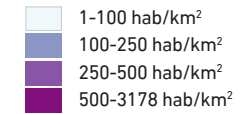
17 The Ministry of Immigration and Population of the Republic of the Union of Myanmar, The 2014 Population and Housing Census, The Union Report (Census Report Vol. II), Nay Pyi Taw, (May) 2015  
 18 UNFPA Census Thematic Report on Migration and Urbanization, 2016.  
 19 Ibid, Census 2014  
 20 World Bank (2015) data series. Available here - <http://data.worldbank.org/indicator/SP.DYN.IMRT.IN> - accessed 11-8-2016

The population of Labutta Township is 315, 218 inhabitants, which makes it the least populated township in the Ayeyarwady Region, with only 5 per cent of its population. The northwestern area of the township has the greatest concentration of sub-villages and is the most densely populated area. Around 10 per cent of the township's population are considered to be living in the urban area, of which almost all live in Labutta Town (31,174) with the rest in Pyinsalu.



Population density

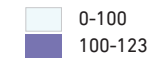
The spatial distribution of the population density shows the northwestern areas are the most densely populated. There is a significant difference between the population density in rural areas (145 hab/km<sup>2</sup> on average), and in urban areas, Labutta town (3,175 hab/km<sup>2</sup>) and Pyinsalu (472hab/km<sup>2</sup>).



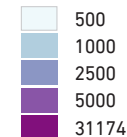
Distribution of population by sex

The northern areas of the township have a more equal sex ratio, while in central and southern areas the ratio is less equal, with the male population being higher. Tei Pin Klaing village tract has the most unequal sex ratio; 60 per cent of its inhabitants are men.

Sex ratio



Population (num inhabitants)

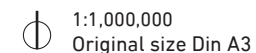


Type of settlements

- Sub-village

Main communication routes

- Water canal



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## 2.3. ADMINISTRATION AND GOVERNANCE OVERVIEW

Labutta town hosts both the Labutta Township administration and the Labutta District, which is one of the six districts that form the Ayeyawady Region. The Ayeyawady Region regional government is located in Pathein.

Pathein is considered a regional centre by the National Spatial Development Framework (NSDF), which is embedded into the National Transport Development Plan<sup>21</sup>. This type of centre is a strategic node of transportation, interconnecting roads and waterways. Pathein is host to a cluster of commercial and transportation activities, on which Labutta partly depends.

Under the NSDF typologies, Labutta is a town with concentrations of population predominantly engaged in agrarian activities. The district and township level administrative functions are provided here and health, education, social and community services, as shown in the spatial structure below in map LBT 09. 75 village tracts and 10 urban wards are included under the administrative boundaries of Labutta, which has a total area of 2,491 square kilometres.

Township governance in Myanmar remains largely related to regional and national programmes. However, although a municipal body does not exist, there is a township administration that works through 1) local branch offices of union level sectoral ministries that implement national programmes in a deconcentrated manner; 2) the General Administration Department (GAD) of the Ministry of Home Affairs (MoHA), which coordinates government activity in the township, including the activities of the other local branch offices of the ministries 3) a township development or management committee; an administrative entity which oversees the township.

Strong local governance is a pre-condition for building resilience and adapting to climate change.



Figure 9. Data gathering with the General Administration Department, the Township Development Committee, ECD and MCCA team in Labutta Township ©MCCA 2015

Heads of the local branches work under supervision lines at the district level, the regional/state level, and the union level, from which they also receive their work programmes, plans, and budgets<sup>22</sup>.

Lists of requirements at local level (village tracts) are collected and planning officers aggregate the needs into plans, for further discussion with the district level and the various sectors. However, this approach lacks the strategic focus required to address climate change effectively.

At the time of writing, this governance arrangement implies that the General Administration Department coordinates actions aligned with the policies and programmes of line ministries. The assessment was not able to clarify

how needs assessed at local level are captured at regional and national level, and vice-versa. This is a major area for further analysis and possibly reform.

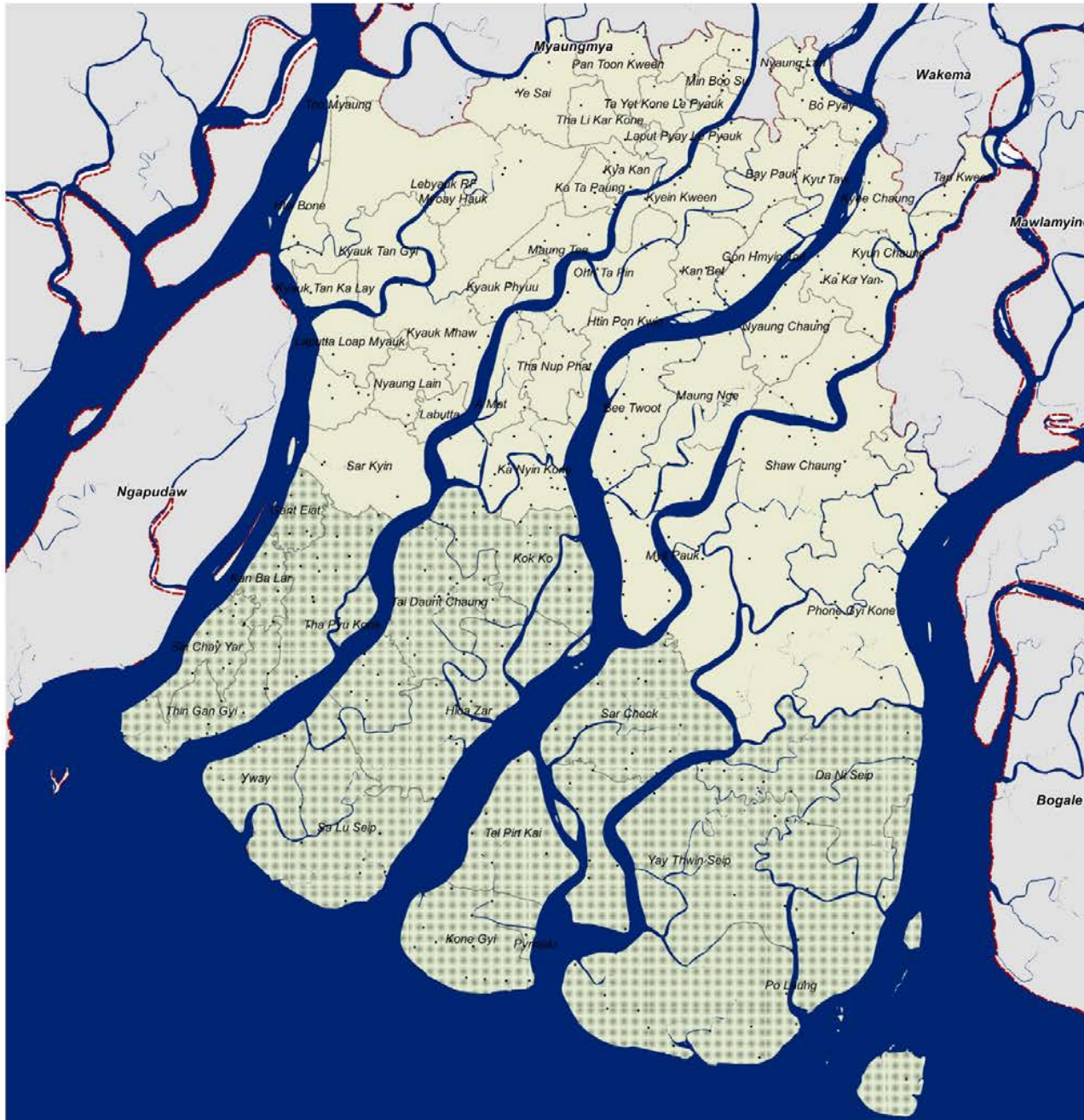
Municipal governance capacities are considered essential pre-conditions to ensure effective long-term adaptation to climate change, as it enables programming and budgeting across sectors, over the mid to long-term. The findings of this report highlight the need for cross-sectoral and mid to long-term planning, if resilience is to be built. Because of this, the present governance system at local level must be considered a factor of potential vulnerability. For instance, the list of needs collected at village tract level in the planning processes do not ensure that adaptive actions are taken

in a cross-sectoral and strategic manner over the necessary timespan. Resilience requires that, for instance, actions in the infrastructure and in the environment are coordinated and mutually sustaining. In June 2016, the Township Environmental Conservation and Climate Change Committees were officially established. However, their formation and terms of reference were not entirely defined at the time of writing, and it remains to be seen how these committees will function in practice within the township governance structure highlighted above.

21 The Ministry of Transport of the Republic of the Union of Myanmar, The Survey Program for the National Transport Development Plan in the Republic of the Union of Myanmar, Final Report, Nay Pyi Taw, Sept. 2014.

22 UN-Habitat, Rapid Urban Diagnostic Myanmar, 2016

# 2016 | Administrative boundaries



0 5 10 15 20 25 km  
 1:300,000  
 Original size Din A3

## Labutta township in Ayeyawady region



**Type of settlement**

- Sub-village
- Village tract
- ▨ Sub-township
- ▤ Township
- ▥ Region

**Main communication routes**

- Water canal

0 100 200 km  
 1:2,625,000  
 Original size Din A3

**LBT03**

Disclaimer: The designations employed and the presentation of material on this map do not imply the expression of any opinion whatsoever on the part of the Secretariat of the United Nations concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries.

Data Source: MIMU





အထည်ပစ္စည်းရေစေ့စွဲ  
**Win**  
ဆပ်ပြာမှန်

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# 3

## VULNERABILITY ANALYSIS AND RISK PROFILE

This chapter describes the current vulnerabilities of the township against the dominant natural hazards, and the current associated levels of risks, mapped spatially.

Labutta is exposed to several climatic hazards, such as cyclones, which may kill people and destruct infrastructure and is vulnerable to the effects of long-term climatic processes, such as salinization and a shorter monsoon season, which increase risks of water shortages, and reduction in agricultural productivity.

The current conditions of its socio-economic, infrastructure and ecological systems make Labutta very vulnerable to these climatic features. High risks are generalized in the Township, but coastal areas – as shown in

the maps – present higher comparative risks given the local socio-economic, infrastructure & transport, and ecological conditions, while areas where agriculture is concentrated will also face serious challenges.

Both public and private infrastructure is largely non-resistant to strong-winds and cyclones with 95 percent in non-durable material), and life-line network of buildings is insufficient. Transport is based on waterways, which are easily interrupted by climatic events, isolating parts of the town. Economy is non-diversified, with highly climatic-sensitive type of agriculture. Amongst other eco-system services, mangrove forests play an essential role, but are critically endangered and without sustainable management they may be entirely lost in the coming decade.



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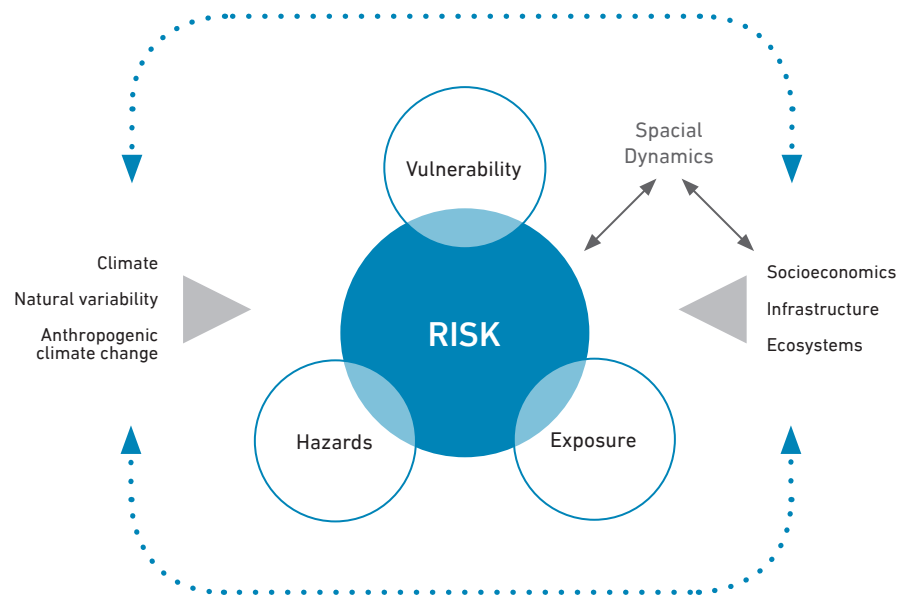
## 3.1. DEFINING VULNERABILITY & RESILIENCE IN THE CONTEXT OF LABUTTA

Vulnerability and resilience are multi-semantic notions. In this report, their use is based on the following definitions or sources

This assessment uses a tailored definition of vulnerability informed by the IPCC 3rd/4th and 5th Assessment Reports, that refers to the interaction of hazards, exposures, sensitivities and adaptive capacities of people, communities and settlements to predict the level of risk they may potentially incur. This is informed by definitions outlined in the Intergovernmental Panel on Climate Change 3rd/4th and 5th Assessment Reports. The tailored approach has several benefits; firstly, this assessment focuses on ecosystems, their vulnerability, and their potential to support people to adapt to climate change. Secondly, the assessment focuses on the spatial dynamic of vulnerability; understanding how impact and vulnerability in one location will affect people in other locations. Finally, the definition used here recognises that the pre-existing, underlying vulnerabilities in socio-economic, infrastructure and ecosystems, interact with climate change and climate related hazards to enhance risk and vulnerability. In calculating the vulnerability index in Section 3.5, the IPCC 3rd/4th Assessment Framework definition has been used, to keep the index calculations simple. The broader overall framework is captured in Figure 10,.

There is no univocal definition of resilience, or urban resilience and an open global debate on how to measure it exists. This report refers to resilience according to UN-Habitat and UN Environment, and also broadly to the notion in use in major resilience expert entities, such as Arup. When mentioning resilience, this report refers to the ability of systems regulating natural, built environment and socio-economic dynamics to withstand and to recover from any plausible hazards, including both chronic stressors (for instance deforestation) and acute shocks (for instance a cyclone). The report also recognizes that in complex systems, such as those studied by this assessment, there is no single equilibrium to be sought and restored after a shock. There are multiple, co-existing equilibriums, and both human settlement and ecological systems change continuously. This report analyzes prevailing conditions of the environment, the infrastructure and the social and economic systems, as well as the governance and population circumstance to understand how these enable, or negate, resilience in the Township. For or a review of urban resilience trends see UN-Habitat, 2017. Trends in Urban Resilience, 2017 (Retrieved at <https://unhabitat.org/books/trends-in-urban-resilience-2017/>). For further analysis, see: Arup, 2014. Facing up to the future: the City Resilience Index. (Retrieved at [http://www.arup.com/city\\_resilience\\_index](http://www.arup.com/city_resilience_index)).

Figure 10. Overall Vulnerability Framework



## 3.2 CLIMATIC FEATURES, NATURAL HAZARDS AND OBSERVED IMPACTS

- Stronger storms, winds and unusually heavy rainfall puts at risk houses, schools and health posts and affects people's mobility and access to basic services and destroys agriculture crops
- Exposure to storm surges and erosion, resulting from the change in the hydrodynamics of the river and the sea-level rise, render communities landless and is higher in deforested areas along the coast and water canals
- A shorter monsoon season and higher temperatures gives less time to collect rain water and faster evaporation, with resulting water shortages for agriculture and drinking water
- Sea water infiltration increases salinization, with impact on impacting nutrient cycling in soil and lowers rice and other crops' yields

Labutta faces a number direct impacts resulting from both climate hazards and long term climate change. While some of these are observed in a number of areas across Myanmar, others are specific to, or are more pronounced, in Labutta. In many cases, climate features that have been observed in the past are projected to continue their present trajectory – and become more severe – in the future. This is discussed further in sections 3.3 and 3.4, below. This means that hazards and their observed impacts, as highlighted by community members, are likely to also become more serious in the future, without adaptation measures.

According to communities consulted in this assessment, persistent increases in temperatures, including the number of extreme hot days, has a number of serious impacts; there is an increased number of deaths among livestock, as families often have no access to shelter for their animals. Excess heat also affects human health, especially among the young, elderly and vulnerable. It also results in declining productivity; communities reported that periods of excess heat mean that people don't tend to fields or seek casual work as often. The latter disproportionately affects daily wage labourers. However, perhaps most significantly, heat waves seriously impact people's access to drinking water. 79 per cent<sup>22</sup> of people in Labutta rely on water from uncovered sources; pools, ponds or lakes. More hot days, and particularly more clear-sky days, that are associated with the late onset and early retreat of the monsoon, result in greater levels of evaporation. This means that drinking water availability has declined. In consultations with communities, the availability of drinking water was a challenge that was repeated throughout all geographic areas of the township.



Figure 11. During Nargis, numerous casualties were provoked by storm-surges, high waves that inundated the coastal areas and killed people. Deforestation and poor siting increase this risk. Lay Yin Kwin village © MCCA

Cyclones also cause serious and devastating impacts. In terms of loss of life, economic loss and damage to land, no township in Myanmar suffered the impact of Cyclone Nargis in 2008 as much as Labutta. Further information about the impact of Cyclone Nargis can be found in Box 2. However, while the severity of Nargis may have been unprecedented, cyclones and storms are common during the monsoon season, and frequently cause disruption for people in Labutta. For example, they make transport from the coastal area, around Pyinsalu, to the main town of Labutta almost impossible as people rely on small boats that cannot safely pass the waterways. Both cyclones and heavy rains mean that houses are

often damaged, resulting in a financial burden of repairs. 73 per cent of houses in Labutta are constructed from traditional materials, with a further 12 per cent made from wood. Only 2 per cent are constructed using bricks or concrete<sup>23</sup>. This means that winds of around 60-80kph or more, coupled with heavy rains, are likely to damage houses.

People in Labutta also reported that observed changes in rainfall – late onset and early withdrawal of the monsoon, which concentrates the same or more rainfall in a shorter rainy season – has resulted in some flooding impacts. These have been seen in Labutta town where

there has been some damage to houses and infrastructure, and in agricultural areas, where floods have caused damage to and total losses of crops. Heavy rainfall and localised flooding also hampers access for people in villages in the central and northern areas of the township, as they rely on small, unsealed roads, which can become impassable.

As a result of sea-level rise, combined with a loss of mangrove and other forest, saline intrusion is now a serious problem in Labutta. As shown in Map LBT04, there are broadly three levels of salinity at present in the township. In the saline area, close to the coast, it is not possible to grow rice or other crops, as these areas experience year-round salinity. In these areas, there is also the additional pressure of salinity on drinking water in addition to the evaporation, described above. The central area of the township experiences seasonal salinity; in the dry season this area is saline, and as a result farmers are unable to grow a second (dry season) rice crop. This area also has experienced some problems of salty drinking water. Finally, the northern area of the township has not, so far, been affected by salinity. However, in recent years, the 'salt lines' have been moving north-eastward, affecting a larger land area and greater number of people.

23 Ministry of Immigration and Population (2015) The 2014 Myanmar Population and Housing Census, Ayeyawady Region, Labutta Township, Table J-2  
 24 Ministry of Immigration and Population (2015) The 2014 Myanmar Population and Housing Census, Ayeyawady Region, Labutta Township, Table i-4b

## Box 2. Cyclone Nargis

Cyclone Nargis was a Category 4 cyclone that first made landfall in Labutta Township on the 2nd of May 2008, with wind speeds of at least 200 kilometres per hour, heavy rain and a 3.6 metre (12-foot) storm surge. At least 140,000 people were killed in Myanmar, with as many as 80,000 of those fatalities in Labutta. At least 37 townships were damaged by Nargis, with 2.4 million people thought to be severely affected out of the total population of 7.35 million living in these areas.

As the Post Nargis Joint Assessment noted in July 2008, “The disaster caused widespread destruction to homes and critical infrastructure, including roads, jetties, water and sanitation systems, fuel supplies and electricity. A large number of water supplies were contaminated and food stocks damaged or destroyed. The winds tore down trees and power lines, while the accompanying storm surge submerged countless villages”.



Dala Township after Nargis  
©UN-Habitat

The World Bank estimated that the storm surge flooded 600,000 hectares of agricultural land and that 50 per cent of livestock was killed in the affected area. The total losses that resulted from Nargis were equivalent to about 2.7 of GDP in 2008, while the recovery requirement over three years was estimated at the time to be \$1 billion.

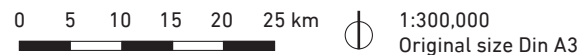
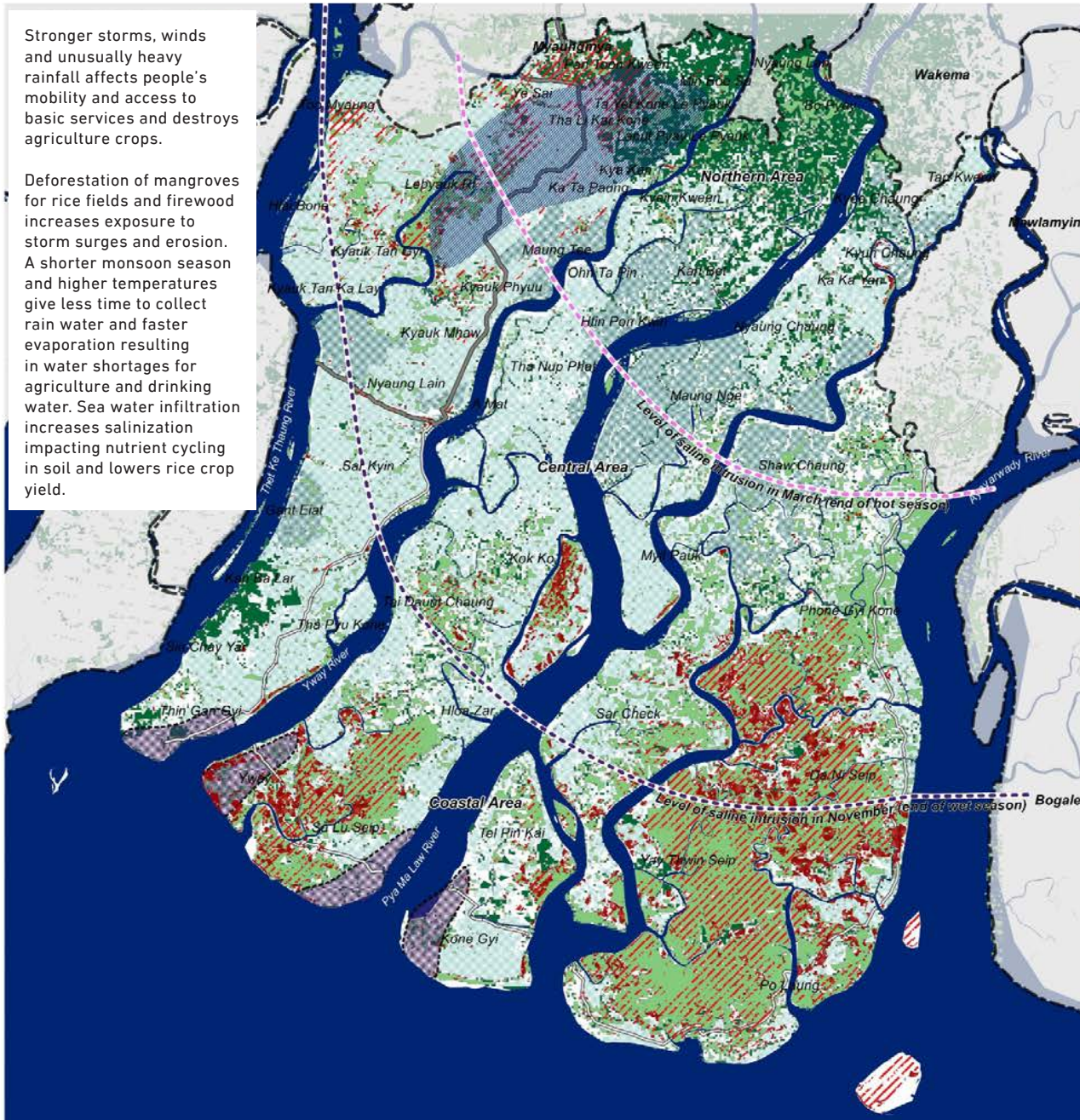
As UNEP noted in 2009, Nargis destroyed 38,000 hectares of natural and replanted mangroves, and damaged 43 per cent of freshwater ponds. Its impacts were exacerbated by earlier damage to the environment, including deforestation and degradation of mangroves, over-exploitation of natural resources such as fisheries, and soil erosion. For example, the heavy loss of life resulting from the storm surge was primarily due to prior loss of about 75 per cent of the original mangrove cover in the Delta, which could have served as a buffer against the storm surge. The deterioration of the natural resource base, in effect, reduced people’s resilience against the impacts of Nargis.



# 2016 | Main impacts observed

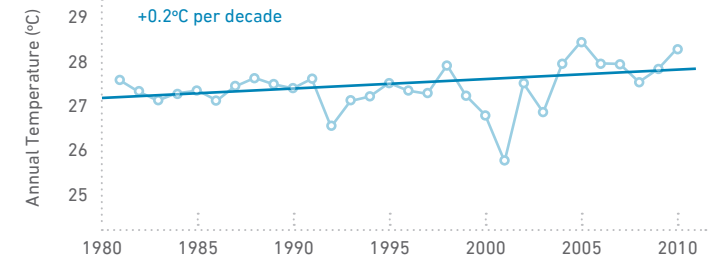
Stronger storms, winds and unusually heavy rainfall affects people's mobility and access to basic services and destroys agriculture crops.

Deforestation of mangroves for rice fields and firewood increases exposure to storm surges and erosion. A shorter monsoon season and higher temperatures give less time to collect rain water and faster evaporation resulting in water shortages for agriculture and drinking water. Sea water infiltration increases salinization impacting nutrient cycling in soil and lowers rice crop yield.

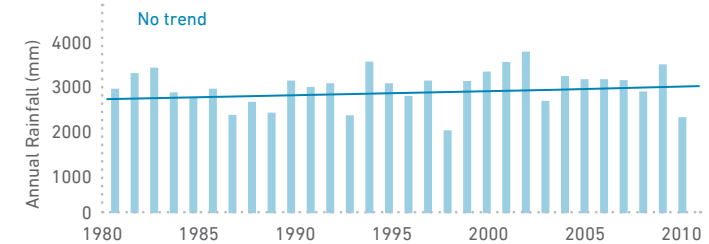


## Historical climate and trends near Labutta

Patheingyi Temperature Trend, 1981-2010



Patheingyi Rainfall Trend, 1981-2010



### Vegetation coverage

- Mangrove
- Open forest
- Degraded forest
- Deforestation areas

### Agriculture

- Irrigated agriculture
- Rainfed agriculture

### Floods

- Occasionally flooded areas
- Storm surge areas

### Main communication routes

- Main road
- Secondary road
- Water canals
- Township boundaries

Disclaimer: The designations employed and the presentation of material on this map do not imply the expression of any opinion whatsoever on the part of the Secretariat of the United Nations concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries.

Data Source: MINU, FAO, WWF, UN-Habitat. Unsupervised classification (i.e. through an automatic definition of the classes), supported by visual interpretation from available Landsat TM (2012) images, UNEP Land Cover (2001) and community consultation (UN-Habitat/2016)

### 3.3. TOWNSHIP CONDITIONS (SOURCES OF VULNERABILITY, EXPOSURE AND SENSITIVITY)

#### ECOSYSTEM CONDITIONS

- The Delta is a naturally highly productive and resilient ecosystem, but decades of deforestation and degradation have severely diminished its capacity to sustain life.
- Mangrove forests are especially critical to maintaining ecosystem services, but without major intervention, will be entirely lost in the coming decade
- Due to its geography and the naturally variable seasonal hydrology, the township is also highly exposed to climate hazards like coastal and upstream floods and droughts
- Low-lying geography at the coastal outlet of the Ayeyawady River makes the township similarly vulnerable to saline intrusion, especially in combination with decreasing dry season flows and upstream uses

Mangrove forests are especially critical to maintaining ecosystem services, but without major intervention, will be entirely lost in the coming decade

Based on its location at the outlet of the Ayeyawady River, which drains two thirds of the country's surface water and thus provides a steady supply of nutrient rich sediments, the larger deltaic ecosystem is historically a highly productive environment, supporting a rich array of life and livelihoods, from fisheries to mangroves. Decades of deforestation and degradation, driven by policies incentivizing land use change for agricultural development, have however significantly affected ecosystem's ability to support the township economy and livelihoods, especially in the face of climate change.

Mangrove forests have been cleared and substantially degraded since the late 1970s, losing 64 per cent of their total area between 1978 and 2011 as agriculture, specifically rice paddy cultivation, has expanded to be the dominant land use (see Map LBT05). This corresponds to an average deforestation rate of 51km<sup>2</sup> (3 per cent) per year, which would lead to total mangrove loss by as early as 2019 in the worst-case scenario.<sup>25</sup> This significantly compromises what was a highly biodiverse, nutrient rich system, directly increasing vulnerability to climate change impacts. As mangroves are cleared, the numerous basic ecosystem services they provide that support climate resilience; erosion control, defence against coastal storms and fisheries habitats, are also lost.

Biodiversity in these systems is especially important in terms of climate vulnerability; a more diverse system provides greater benefits to surrounding populations, including higher productivity and abundance of fisheries and plants used locally. Most importantly, these highly biodiverse forests played a critical role during and after Cyclone Nargis in protecting local populations. Where forests were intact, significantly fewer people were killed than in areas that were deforested, and due to the high diversity, certain mangrove species had very low mortality rates, allowing the forest to recover faster from the cyclone. Mangroves also provide

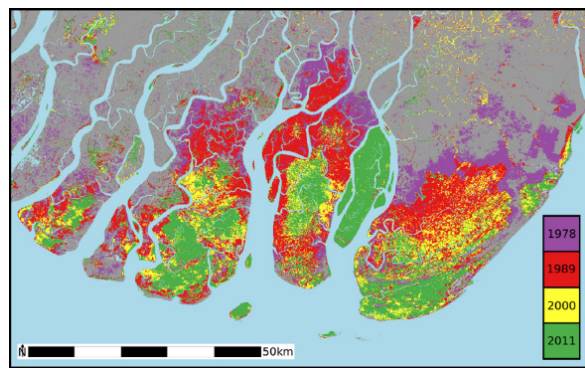


Figure 12. Historical forest coverage in the Ayeyarwaddy delta showing deforestation over time between 1978 and 2011 (adapted from Delta Alliance)

various other ecosystem services critical to fighting the effects of sea level rise, including trapping sediments and soils flowing from upstream, thereby increasing land height and fighting off saline intrusion and defences against increasingly frequent intense coastal storms.<sup>26</sup>

The loss of these forests has therefore left the larger agro-ecosystem in a highly vulnerable state to increasing impacts of existing climate change like sea level rise, coastal erosion, saline intrusion, increasingly frequent and intense storms, and both coastal and upland flooding.

Figure 13. The combined effects of deforestation of mangroves and sea-level rise generate erosion, displacement, risks of storm-surges while fishery habitat is depleted as in Tel Pin Kaing village (Picture)



There is high water availability annually in Labutta, but this is masked by large seasonal variation with lengthy dry and very wet periods that make the Township highly vulnerable to increasing variability and intensity

In general, Labutta has one of the wettest climates in Myanmar, but it is highly seasonal, with the majority of rainfall in the summer monsoon months from June to August and a significant dry period from December to April. The discharge in the Ayeyawady River reflects this, with its lowest flows in February and March, followed by a sharp rise in April-May



as a result of melting snow in the upper catchment and a further steep rise in May-June with the onset of the monsoon. The maximum flow occurs in July or August. This strong seasonality, with pulses of alluvial nutrient deposition during peak flows in the summer months, is critical to the overall productivity of the Delta ecosystem; it is, however, also a substantial contributor to vulnerability.

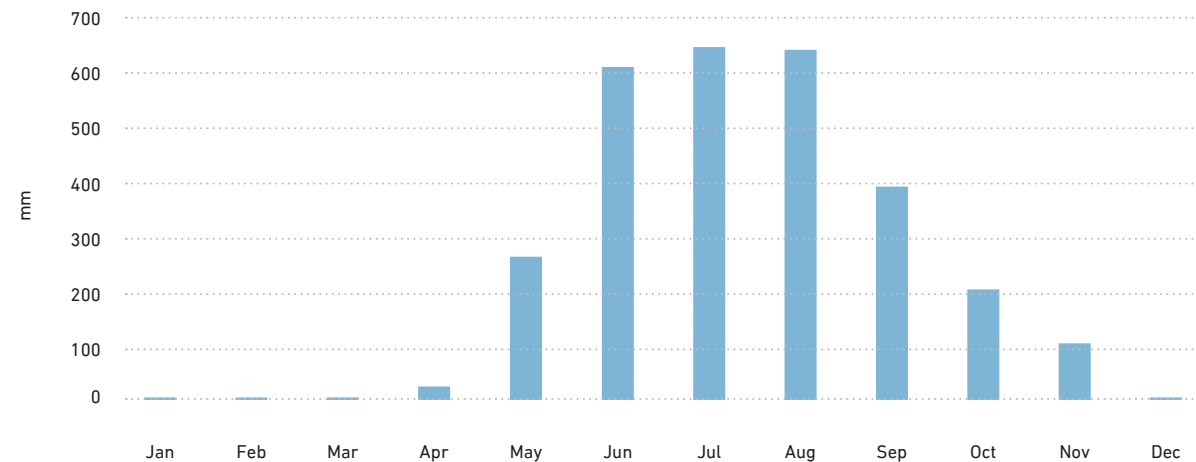
Most waterways are un-engineered natural watercourses, and there is no extensive system of dredged canals; the only major canal being

the Twante canal which links Yangon with the western part of the delta<sup>27</sup>. This lack of flow control infrastructure is beneficial for the overall health and productivity of the ecosystem, allowing the river to change course naturally and deposit upstream sediments throughout, maintaining healthy soils and providing nutrients to fisheries and mangrove systems, and avoiding channelization and scouring that can cause erosion. At the same time, the lack of both concrete and natural infrastructure—mangroves and other vegetation—makes agricultural lands and housing structures along these river

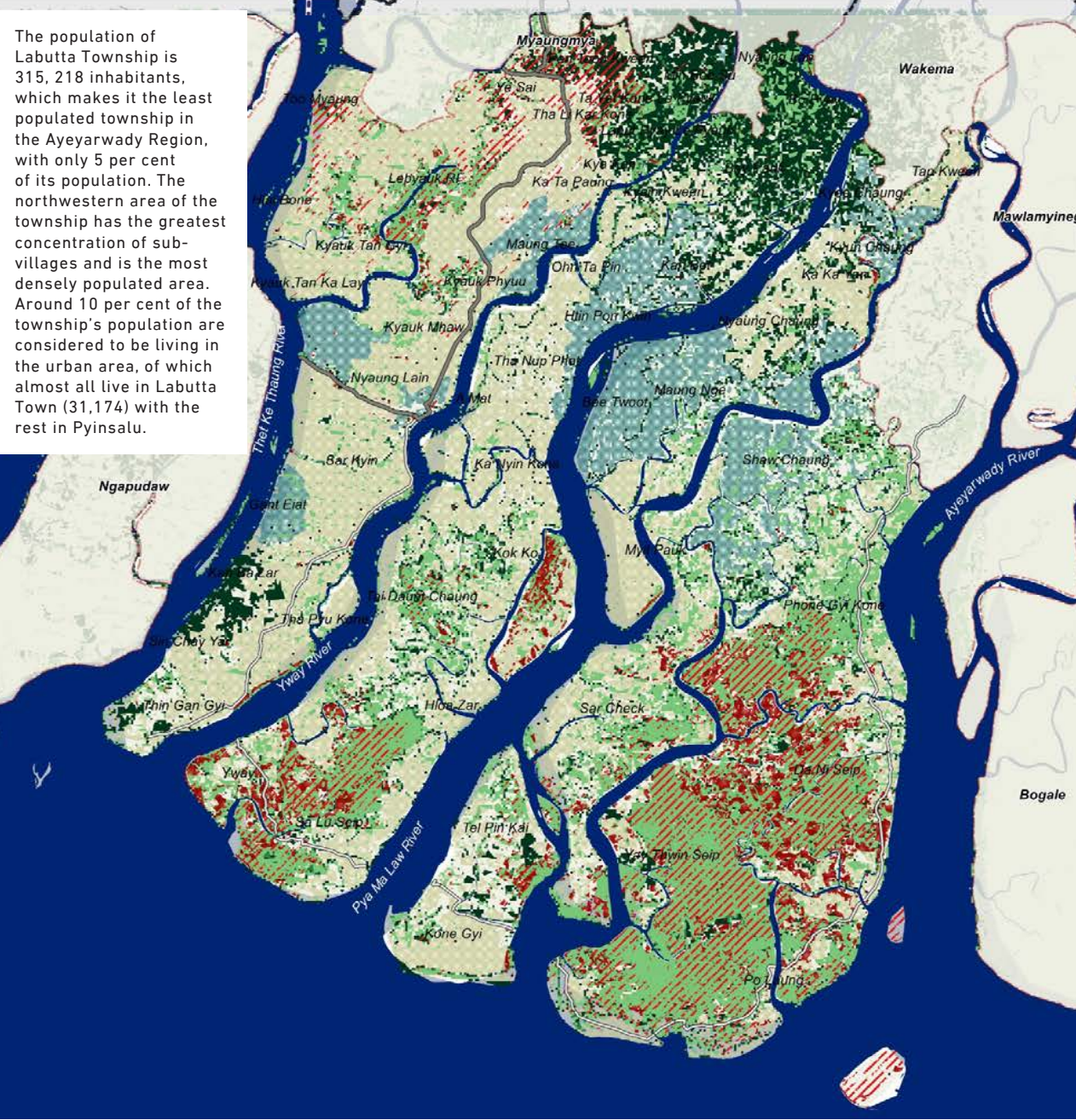
Voices from Labutta:  
Tun Lwin, 51

“For the past 23 years I’ve been a farmer. I own 10 acres of land, which used to be my parents’ land. The water levels are rising every year – this started about 10 years ago. We need an embankment to protect our land – farmers like me worry about salt water flooding a lot. I can’t describe what Cyclone Nargis was like. I don’t want to hear the word again. I lost both my parents. Everybody lost everything.”

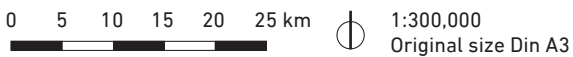
Figure 14. Monthly average rainfall for Pathein, the nearest weather station to Labutta, between 1981-2010. Station data provided by DMH.



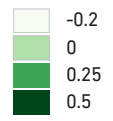
Driel, W.F. van & T.A. Nauta, 2014. Vulnerability and Resilience Assessment of the Ayeyawady Delta in Myanmar. Full assessment phase. Delta Alliance report, no. 10



The population of Labutta Township is 315, 218 inhabitants, which makes it the least populated township in the Ayeyarwady Region, with only 5 per cent of its population. The northwestern area of the township has the greatest concentration of sub-villages and is the most densely populated area. Around 10 per cent of the township's population are considered to be living in the urban area, of which almost all live in Labutta Town (31,174) with the rest in Pyinsalu.



**Normalized difference vegetation index (NDVI)**  
 NDVI is calculated from the visible and near-infrared light reflected by vegetation. Health vegetation absorbs most of the visible light that hits it, and reflects a large portion of the near-infrared light. A zero means no vegetation and close to +1 (0.8- 0.9) indicates the highest possible density of green leaves.



**Soil types**  
 Soil classification concerns the grouping of soils with a similar range of properties (chemical, physical and biological) into units that can be georeferenced and mapped. The classification has generally been based on the distribution of the important land resources for agriculture.

- Dune forest & beach sand
- Mangrove forest soil
- Swampy soil
- Gley & gley swampy
- Saline swampy & meadow gley

- Vegetation coverage**
- Mangrove
  - Forest
  - Open forest
  - Degraded forest
  - Deforestation areas
- Agriculture**
- Irrigated agriculture
  - Rainfed agriculture

- Main communication routes**
- Main road
  - Secondary road
  - Water canals
  - Township boundaries



Disclaimer: The designations employed and the presentation of material on this map do not imply the expression of any opinion whatsoever on the part of the Secretariat of the United Nations concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries.

Data Source: MIMU, FAO, WFP, UN HABITAT

Vulnerability Analysis and Risk Profile

courses extremely vulnerable to climate change effects like increasing variability of the upstream flow regime, and sea level rise and storm surges that are moving further inland during a lengthening dry season as freshwater flows recede.

The reliability of seasonal monsoon rainfall and subsequent river flows is also critical to livelihoods and agriculture production in the delta, both irrigated and rain-fed. Due to limited or degraded water resource management and storage infrastructure like dams and irrigation systems, such a high dependence on seasonal flows also means increased high vulnerability to shifting rainfall patterns and a shortening monsoon season that are both making flows less reliable and increasing exposure to hazards like droughts and floods. Groundwater is a potential solution to some of these challenges, but there is evidence of arsenic contamination, particularly in the shallowest, easiest to access aquifers, and saline intrusion will be a worsening problem as sea levels rise in conjunction with lower dry season flows.<sup>28</sup>

Due to its low-lying deltaic geography, hydrology and ecosystem services are highly vulnerable to the rising sea levels and associated saline intrusion

As a coastal, low-lying delta formed by millennia of alluvial deposition from the enormous upstream

Ayeyawady River basin, Labutta and the surrounding township are in the heart of a constantly shifting freshwater-saltwater pattern. While this has created a highly productive ecosystem that supports livelihoods, already rising sea levels are pushing salt water further inland, affecting systems poorly adapted to such saline hydrology.

The township can be divided in three main areas, depending on the level of saline intrusion: (i) the coastal areas (coastal front), permanently under influence of salt water intrusion; (ii) the central areas (estuarine zone), under seasonal influence of salt water intrusion; and northern areas (flood plain zone), beyond the reach of salt water intrusion. Of these three zones, the central areas are the most vulnerable to the impacts of saltwater encroachment as sea levels rise, as they are the least adapted to high salinity conditions.

Increasingly longer exposure to saltwater will lead to increased mortality of plants and fish adapted to fresh or brackish water, and intrude further into coastal groundwater aquifers used for irrigation and drinking water, limiting already low crop yields. As farmers in the township noted, salinity resulting from the Cyclone Nargis storm surge is still affecting their crop yields; these issues are only likely to worsen in the coming decades as sea levels rise and storm surges move further inland, especially when

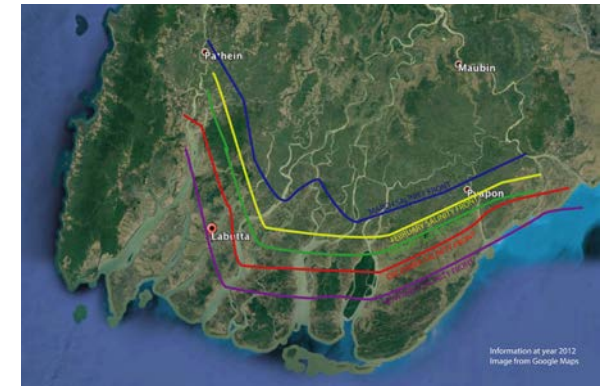


Figure 15a and b. Average salinity intrusion (1ppt line) in the Ayeyawady Delta and seasonal intrusion (adapted from Delta Alliance)

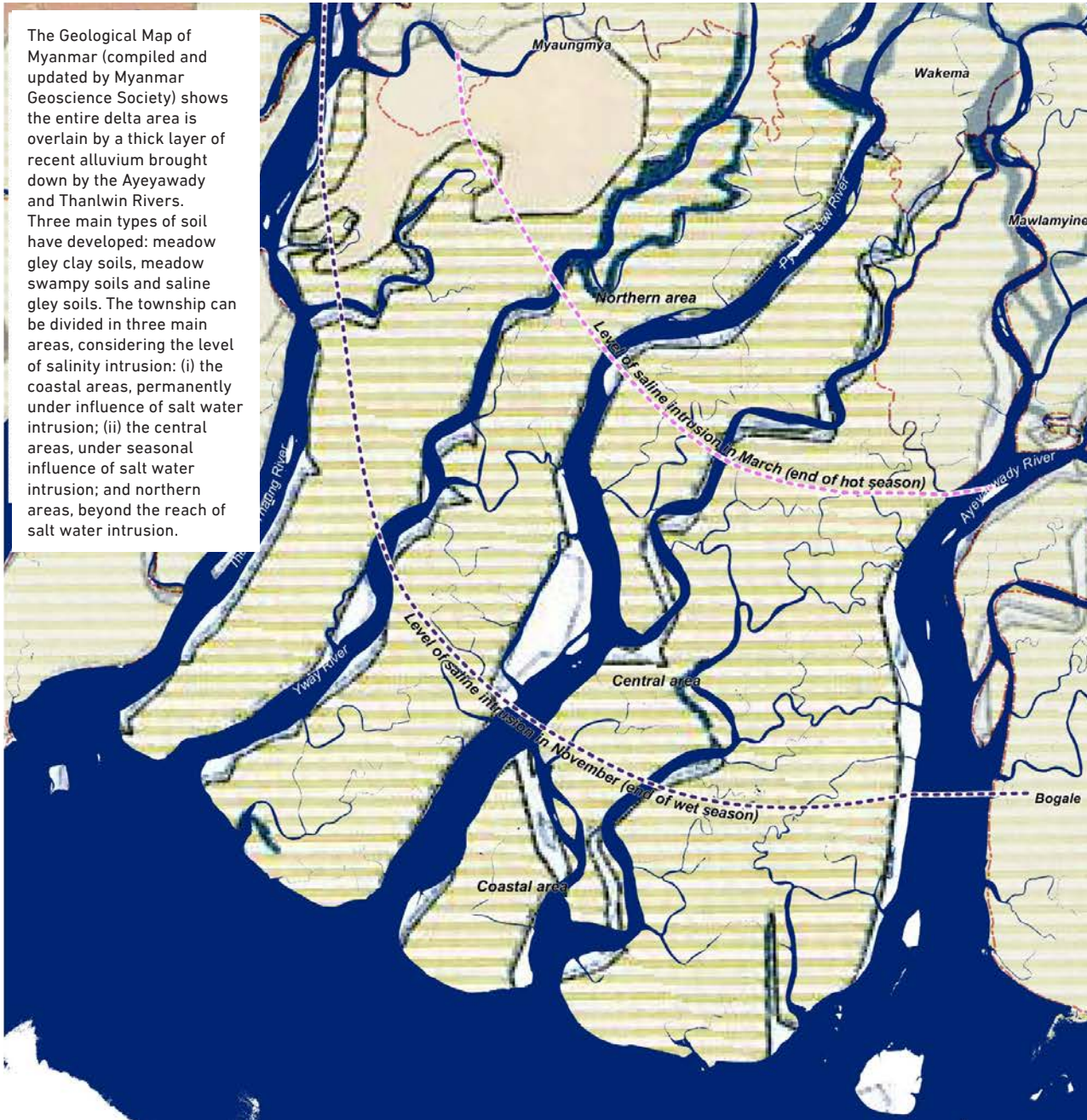
Driel, W.F. van & T.A. Nauta, 2014. Vulnerability and Resilience Assessment of the Ayeyawady Delta in Myanmar. Full assessment phase. Delta Alliance report, no. 10

aided by increasingly intense tropical cyclones. Just like changes in surface water flows, the effects of saline intrusion will be seasonal, likely most significant during the driest winter months when freshwater flows are lowest and seawater naturally moves inland. Coastal areas will be significantly affected as well, but more by permanent inundation and coastal erosion, as they are already well adapted to high salinity.

While some studies suggest the coastline has been largely stable for 156 years, advancing inland at an average rate of no more than 0.34 km per century since 1925<sup>29</sup>, observed data on land subsidence, a critical factor in determining sea level rise rates, is unavailable for the Ayeyawady Delta. Nevertheless, at least one assessment of climate change impacts on the world's major deltas estimated a net sea level rise rate of 3.4-6mm/year for the Ayeyawady Delta, making it "high" or "very high" relative risk. With even 0.5m total rise, the shoreline in the delta could advance as much as 10km.<sup>30</sup> An additional critical factor that could further augment sea level rise and saline intrusion impacts is upstream hydropower dam construction on the main stem of the Ayeyawady River; if dams are built, sediment flows could be significantly limited, increasing land subsidence and ultimately accelerating sea level rise and its impacts.

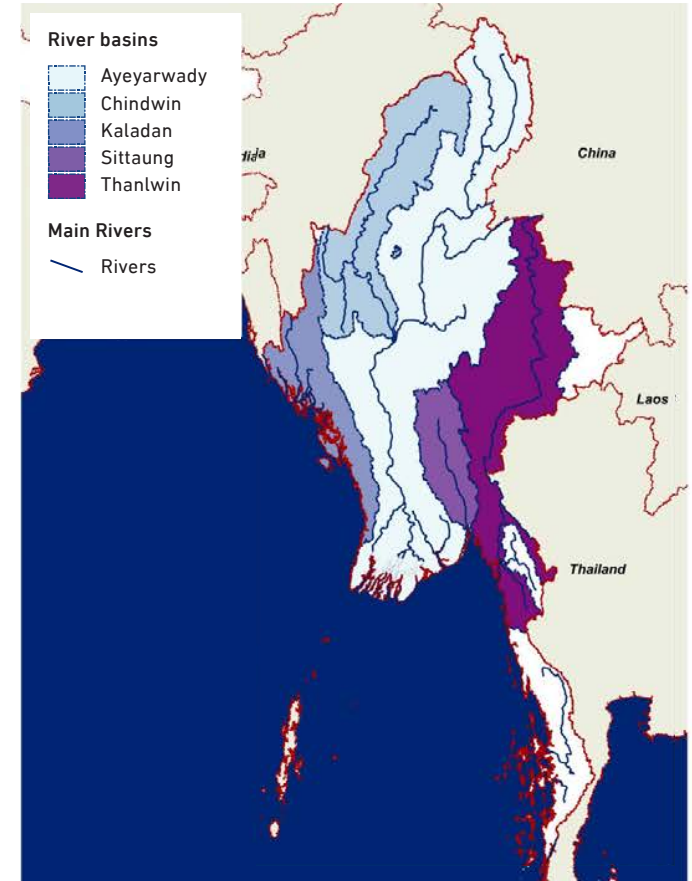


The Geological Map of Myanmar (compiled and updated by Myanmar Geoscience Society) shows the entire delta area is overlain by a thick layer of recent alluvium brought down by the Ayeyawady and Thanlwin Rivers. Three main types of soil have developed: meadow gley clay soils, meadow swampy soils and saline gley soils. The township can be divided in three main areas, considering the level of salinity intrusion: (i) the coastal areas, permanently under influence of salt water intrusion; (ii) the central areas, under seasonal influence of salt water intrusion; and northern areas, beyond the reach of salt water intrusion.



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Major river basins in Myanmar



Sedimentary and metasedimentary rocks

- Q2 | Holocene | Younger Alluvium
- Tm | Miocene | Upper Pegu group of Minbu basin and its equivalents

The catchment area of the principle river basins comprises about 737,800 km<sup>2</sup>. Three main rivers, the Irrawaddy (aka Ayeyawady), the Salween (aka Thanlwin) cross the country north to south. Three-fifths of the country's surface is drained by the Irrawaddy River and its tributaries. The principal drainage system onshore Myanmar comprises the north-south-flowing Ayeyawady River and its associated tributaries, which drain around 66% of onshore Myanmar with the main part of the Ayeyawady system emptying into the Andaman Sea.

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Disclaimer: The designations employed and the presentation of material on this map do not imply the expression of any opinion whatsoever on the part of the Secretariat of the United Nations concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries.

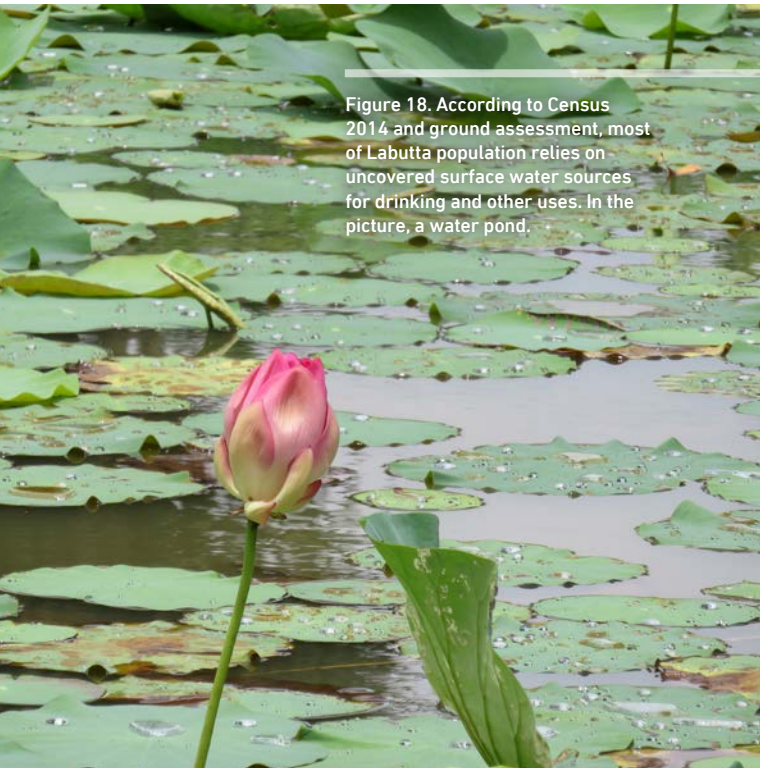
Data Source: MIMU, Myanmar Geoscience Society, FAO, WWF, UN HABITAT



Figure 17. In Myanmar, 35% of housing is in non-durable materials. In Labutta, this nears the 95% of housing. In the picture: House in Da Ni Chaung village



Figure 18. According to Census 2014 and ground assessment, most of Labutta population relies on uncovered surface water sources for drinking and other uses. In the picture, a water pond.



## INFRASTRUCTURE & TRANSPORT CONDITIONS

- 95 per cent of the residential infrastructure of Labutta is in non-durable materials at very high risk of being partially or totally destroyed by strong-winds and floods. Housing safety is further deteriorating as a result of unsustainable use of eco-system services provide less and less materials for construction
- 80 per cent of the population relies only on uncovered water sources (ponds, rivers and streams) for drinking water. Freshwater availability will worsen due to the lack of infrastructure for water storage and management
- Disaster and climate resilient basic services coverage is very limited, e.g. only 10 per cent of the total population has access to cyclone shelters
- The current transportation system is highly vulnerable to hazards, reducing people's mobility and ability to communicate.
- The lack of climate-sensitive land-use planning increases communities' vulnerability to future hazards

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97 per cent of the housing units across the township are built from local materials; wood or bamboo huts with a roof from theike, a local leaf. Houses are often poorly constructed, or not adapted to increased frequency and intensity of hazards. As the availability of wood and other local materials has declined, the cost of these materials has increased, resulting on people using less material, compromising safety.

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Figure 19. Jars are the typical water harvesting system in housing in Labutta, where about 90% of fresh-water for drinking is rain harvested. In the picture, labutta main town © Sukun/MCCL 2016

Housing safety is decreasing due to the population's high dependence on already degraded eco-systems provisioning services

Grid electricity is only available in Labutta Town and the village tracts of Kyauk Hmaw and Kyauk Hpyu Pein Hne Taung, located along the main road to Pathein. Kerosene and batteries are the most common sources of energy for lighting across the township, used by 65 per cent of the households, while solar energy is the least common, with less than 5 per cent of households relying on it as their primary electricity source<sup>31</sup>. Village tracts with solar panels are distributed throughout the south-western, central, and northern areas of the township.

Firewood is by far the most common source of cooking fuel, used by more than 90 per cent of households, while the remaining 10 per cent use a mix of grid electricity, charcoal, and other types of fuels such as kerosene, biogas, grass and LPG.

97 per cent of the housing units across the township are built from local materials; wood or bamboo huts with a roof from theike, a local leaf. Houses are often poorly constructed, or not adapted to increased frequency and intensity of hazards. As the availability of wood and other local materials has declined, the cost of these materials has increased, resulting on people using less material, compromising safety.

Figure 20. Main type of cooking fuel

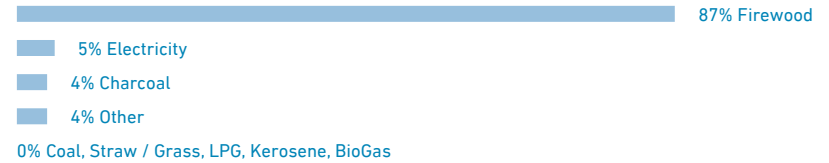


Figure 21. Types of housing units in Labutta

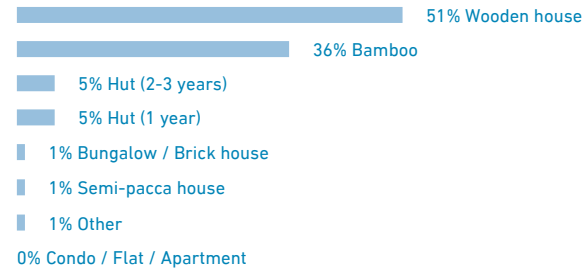
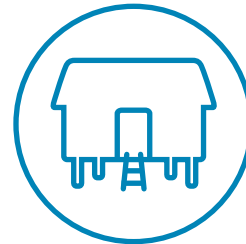


Figure 22. Types of toilets in Labutta

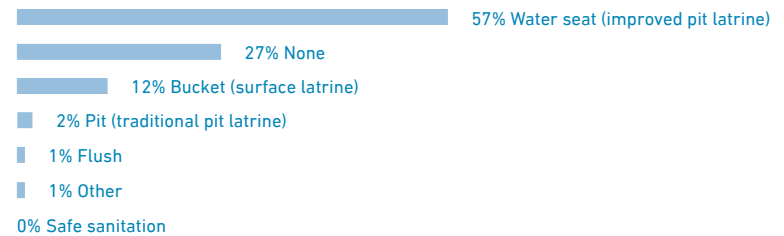
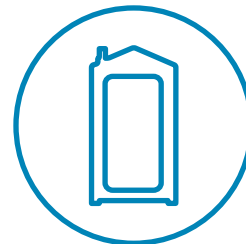


Figure 23. School/cyclone shelter in Yae Won Lay Village



Figure 24. Wooden jetty in Thin Gan Lay Village



Figure 25. Rainwater harvest pond in Htwa Zar Village



This limited access to energy sources coupled with wood harvesting practices that are unsustainable will inevitably lead to the complete deforestation of the vegetation cover, especially mangroves, which will ultimately increase exposure to storm surges and erosion especially in coastal areas.

Water harvesting at household level is often ineffective. Around 80 per cent of households rely on a mix of individual water harvesting (jars) and community ponds, which are more vulnerable to climate-related hazards. Communities reported that the increase in temperatures coupled with shorter rainy seasons is seriously impacting their access to drinking water, as they have less time to collect rainwater and it evaporates faster.

In addition, intense runoff and soil erosion caused by more intense rains and storms results in more damage to water facilities, especially the basins of the rainwater harvest ponds.

Improved pit latrine is the main sanitation facility at household level. However, 27 per cent of households in Labutta do not have access to any type of sanitation facility. This lack of disposal of untreated domestic wastewater will further affect the water quality in the delta as more intense rains and floods are expected to increase.

### Freshwater availability will worsen due to the lack of infrastructure for water storage and management at community level

Coverage of basic services such as water, electricity, and solid waste management, is very limited.

Rainwater harvest ponds are the main water facility for drinking, irrigation and livestock use. There is a lack of infrastructure such as water tanks and reservoirs for water storage at community level and in public buildings such as schools and health posts.

In some parts of the northern area, a system of irrigation canals and dykes allow two cropping seasons. In central areas, communities reported the level of salinization of rivers and streams is moving north after the dry season, which limits the use of freshwater from the river, causing a progressive decline in their agriculture outputs. Some embankments to mitigate salt intrusion have been constructed, but they have proved to be insufficient and require improvement and strengthening every year. Under the projected climate changes in the future, these freshwater sources will be salinized during the whole year, leaving communities highly vulnerable, as they will rely only on rainwater harvest.

### Coverage of disaster and climate resilient basic services is limited

Basic health coverage is fairly good across the township, consisting of 14 rural health centres (RHC) and 76 sub-rural health centres (SRHC) distributed across the township within a distance of 5km to 10km (1-2h walking) between each rural health centre. Each centre provides basic health services to a population between 2,500 and 5,000 inhabitants. Three station hospitals (SH), located in Tu Myaung, Labutta Town and Pyin Ah Lan provide health services to the population in northern, central and southern areas respectively. Finally, one township hospital (TH) located in Kyauk Hmauk along the main road to Myangmya and Pathein, provides specialised health services to the population of the township.

Coverage of basic education is also fairly good, but only 12 village tracts have high schools, which partly explains the very low rates of educational enrolment, and could be a factor in outward migration of young people.

Public buildings are often not disaster-resilient and therefore cannot be used for double purpose in case of cyclones and floods, which increases communities' vulnerability to more intense hazards. Similarly, monasteries remain key in providing informal social services, such temporary shelter

and water, but their limited capacity and resources do not cover all communities.

There is a network of 63 cyclone shelters (including multi-purpose cyclone shelters that can also operate as multi-purpose sports facilities or schools and are available for year-round use by the community) that provide critical emergency shelter in Labutta with a capacity to accommodate 28,492 persons, just under 10 per cent of the total population of the township. The spatial distribution shows a shelter every 5km (about 1 hour's walking time) in the coastal and the northern area, with the capacity to accommodate 25 and 5 per cent of the population respectively<sup>32</sup>, while in the central area distances are larger, especially in the east, where there are no shelters, and only 6 per cent of the population are covered.

As a consequence of Cyclone Nargis in 2008, effort were made by international development partners to support Early Warning Systems (EWS), and disaster preparedness, in particular through committees, evacuation routes and other techniques. This means that there is some understanding of the risks related to strong-winds and cyclones, and to a lesser degree the potential storm-surges and floods linked to tropical storms, especially with tides, and considering sea-level rise. Nonetheless, awareness requires continuous work, preparedness systems entail constant participation, and the heightened



Voices from Labutta:  
Daw Myint Shwe, 61,  
Thingangyin village

“The local school was destroyed so the government built a new one, about a mile-and-a-half away. Some families moved to be close to it and the temporary shelter, but everyone returned within two years. Some stayed as little as a month. The problem was that the jobs are here, near the water, and transport from the new village to this village is difficult because there's no roads. It's dangerous for the children to travel to school when there are floods. And I was born here and I love the river, and I depend on it too. We all do, because we fish for a living. In summer, the big-time fishermen go to the Bay of Bengal to catch the bigger fish. But life is very difficult. The erosion has forced me to move my house several times – I keep moving it back a little at a time, around a hundred feet or so from the water. I move it when the waves start hitting my home. I can't afford to build a new home somewhere else. This year, three families had to move their houses – the year before it was twenty.”

risks related to climate change (for instance changes in return periods of floods, their depth, extension and location), as well as low quality infrastructure and connectivity still pose a challenge and the level of alert on disaster preparedness and response must remain high.

As in many areas, women, children, elderly and people with disabilities are more vulnerable than other sections of society. In most of the cases, women are responsible for looking after the children and the elderly, storing and carrying essential items and ensuring food security during disasters, exacerbating women's difficulty to move safely. In addition, some communities reported that the river/streams were a major barrier to reach the cyclone shelter. Thus, locational barriers should be considered as a contributing factor towards ensuring response to cyclone warnings.

Local people get cyclone warnings from the Cyclone Preparedness Program (CPP)<sup>33</sup>, volunteers, radio, and television. In general, Labutta has a well-distributed network of mobile-phone masts. Radio and television are the main means of communication at household level, followed by mobile telephones<sup>34</sup>. However, in the central-east areas of the township, where there are fewer facilities, radio and television are not available everywhere and communities are deprived from the news of cyclone warning due to their location.

### The current transportation system is highly vulnerable to hazards reducing people's mobility and communication.

As most of the Ayeyawady Delta is characterised by unstable river flows and banks and prone to tropical cyclones with high storm surges, transportation of supplies and people under these physical conditions remains a major challenge.

Labutta Town is located 3-4 hours by the township's only paved road from Pathein. The remaining village tracts rely only on a network of secondary and tertiary unpaved roads with wooden bridges to cross the smaller streams. However, frequent floods and broken bridges were reported during the community consultative workshops leaving some areas without transport for some days.

Only 33 per cent of households in the township own water transport items, mainly wooden canoes,<sup>35</sup> which are highly dependent on weather conditions. The daily public boat transport from Pynsalu to Labutta is poorly adapted to stronger waves and tides, reducing people's mobility especially in the monsoon season. Mobility issues also particularly affect women who are likely to have responsibility for trading goods at the market.

Changes in precipitation patterns and increase in mean temperature are likely to bring stronger rains and cyclones damaging the already underdeveloped transport infrastructure, reducing the capacity of the population to use their transport assets especially in the coastal and central areas of the township.

### The lack of climate-sensitive land-use planning increases communities' vulnerability

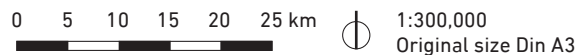
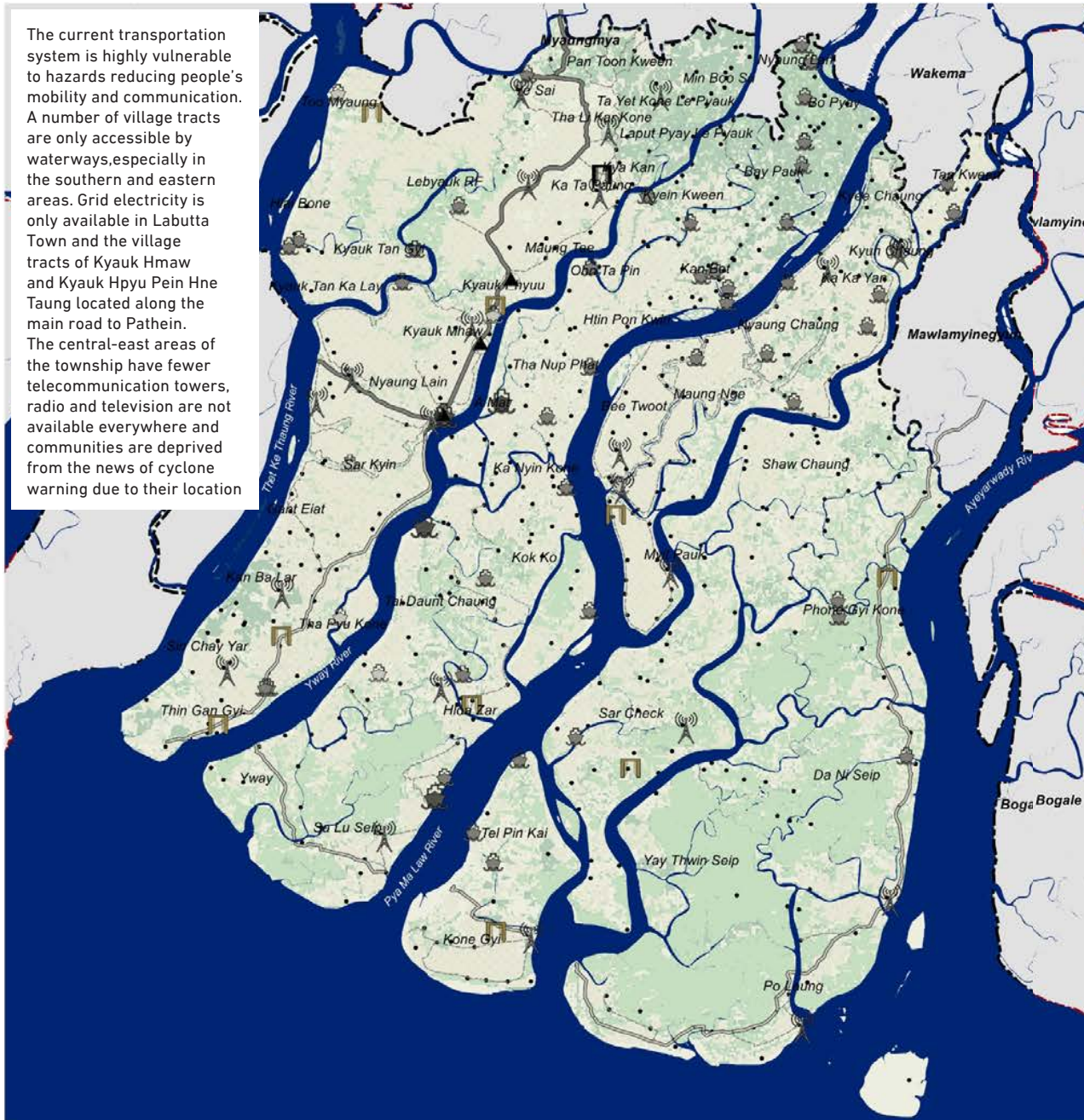
Disaster risk reduction and preparedness has improved dramatically after Cyclone Nargis, and there is greater awareness and robust mechanisms of early warning systems, evacuation routes and disaster management committees. However, land-use planning does not efficiently and systemically consider locations, siting, and orientation of public buildings and settlements and there is no mechanism to integrate additional features resulting from changes in climate to plan for new infrastructure.

This lack of climate-sensitive land-use planning increases household vulnerability, especially in coastal areas where projected sea-level rise will reduce availability of land and ultimately will result in displacement of communities to northern areas.

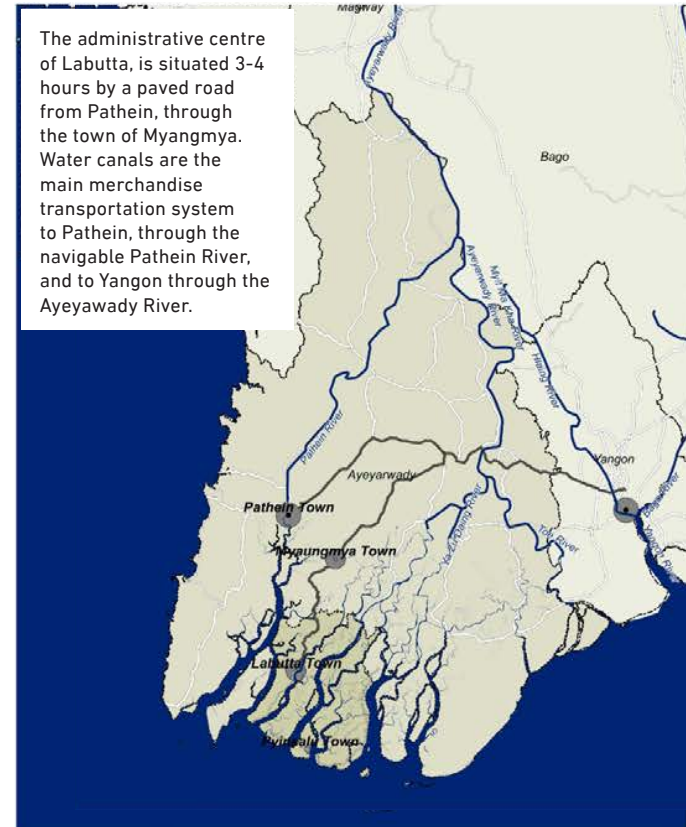
Figure 26. Inundation in Lay, Seik, July 2016, ©MCCA



The current transportation system is highly vulnerable to hazards reducing people's mobility and communication. A number of village tracts are only accessible by waterways, especially in the southern and eastern areas. Grid electricity is only available in Labutta Town and the village tracts of Kyauk Hmaw and Kyauk Hpyu Pein Hne Taung located along the main road to Patheingyi. The central-east areas of the township have fewer telecommunication towers, radio and television are not available everywhere and communities are deprived from the news of cyclone warning due to their location



Main regional transportation routes



The administrative centre of Labutta, is situated 3-4 hours by a paved road from Patheingyi, through the town of Myaungmya. Water canals are the main merchandise transportation system to Patheingyi, through the navigable Patheingyi River, and to Yangon through the Ayeyawady River.

Transport infrastructure

- Main road
- Secondary road
- Tertiary road

Road bridges

- Concrete bridge
- Wooden bridge

Water transport facilities

- Harbour / Port
- Renovated jetty (LPD)
- Jetty
- Water canals

Telecommunications infrastructure

- Mobile repeater

Electricity network

- Electricity

Land use

- Agriculture
- Forest
- Mangrove

Type of settlement

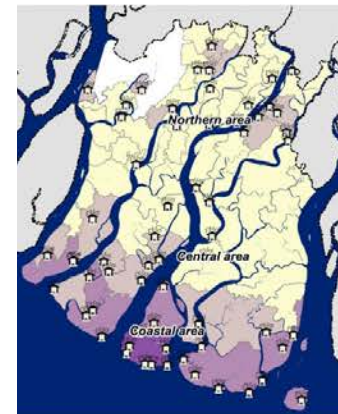
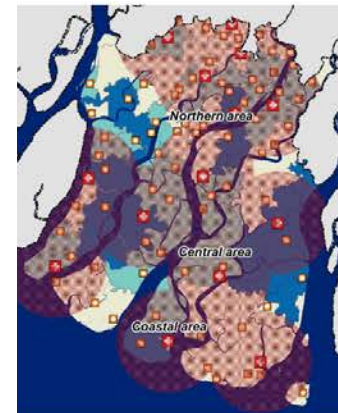
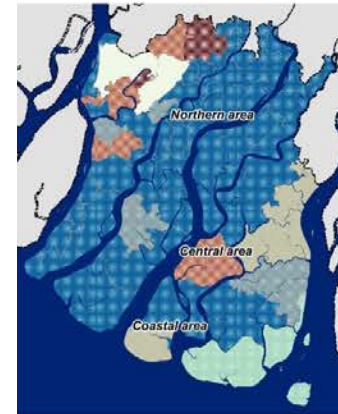
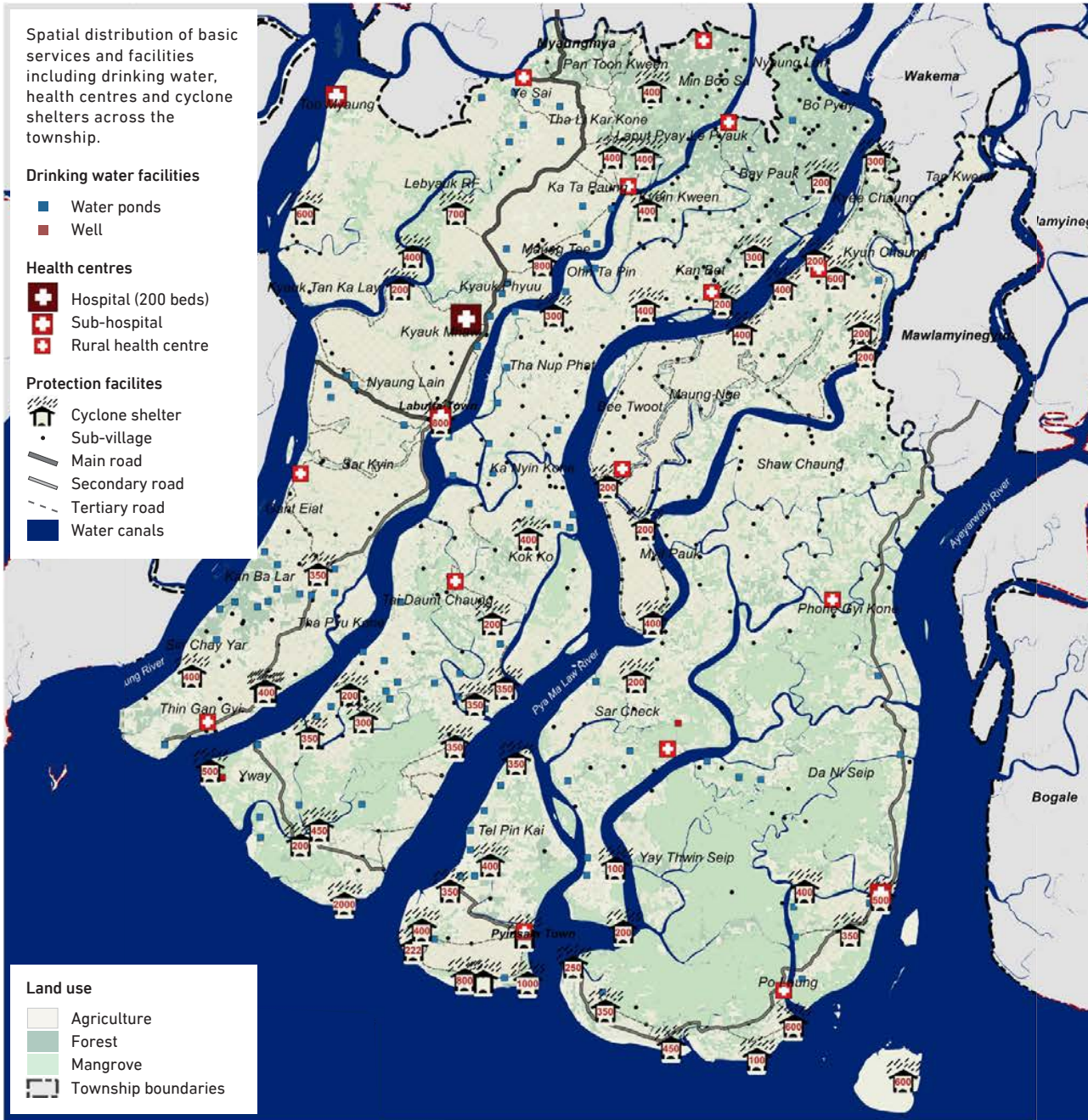
- Sub-village
- Township boundaries



Data Source: MIMU Census 2015, Labutta Township Planning Department, Labutta General Administration Department, UN HABITAT  
 Disclaimer: The designations employed and the presentation of material on this map do not imply the expression of any opinion whatsoever on the part of the Secretariat of the United Nations concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries.



# 2016 | Basic services and shelter



Data Source: MIMU, Census 2015; Labutta Township Planning Department, Labutta General Administration Department, UN HABITAT  
 Disclaimer: The designations employed and the presentation of material on this map do not imply the expression of any opinion whatsoever on the part of the Secretariat of the United Nations concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries.

## SOCIO-ECONOMIC CONDITIONS

- Labutta's economic structure revolves around smallholder production in agriculture and fisheries with little corporate or collective association. This heightens the risk of shocks and means there is no safety net in case of loss of income or assets.
- Market failures, especially in fisheries, keep prices and incomes low. There are many sellers but very few buyers. In agriculture, storage problems are an obstacle for farmers.
- Production is not diverse, because of high dependence on agriculture and fisheries. This means there is little capacity to create value-chains in-township that will help to create wealth, raise incomes and reduce poverty.
- Low educational outcomes and very little vocational training is a problem because there are very few skilled people capable of working in higher value-added sectors.
- Household incomes are very low, which limits the ability to respond to and recover from disasters and invest to offset losses caused by slow-onset changes.
- Female-headed households are more vulnerable; more fragile socio-economic status result in more limited alternatives to livelihoods.
- In general, women are very vulnerable and economically discriminated

The economy of Labutta is defined by agriculture and fisheries, and physical location determines the livelihood profile of the township. In the southern part of the township, and especially in villages close to the ocean and rivers, fishery is the predominant livelihood, with people primarily catching shellfish and crabs. In the central part of the Labutta, agriculture is the main livelihood activity, where people have access to land, with people primarily growing rice as a mono-crop. In the northern part of the township agriculture is also dominant, but the profile is a little more diverse, with some farmers growing two rice crops per year, and others rotating between rice and cash crops such as pigeon peas and green gram. The town of Labutta acts as a culmination of its surrounding rural economy, primarily acting as a trading centre and a transportation hub – especially for road transport, as it is the terminus of the only paved road in the township, which links it with Pathein and Yangon. It also provides some basic industry, as the location of a small rice milling facility.

In all areas, especially those dependent on agriculture, landlessness is an ongoing challenge. In the immediate aftermath of cyclone Nargis, 71 per cent of households did not have access to land for agriculture<sup>36</sup>. Landless families tend to rely on so-called 'daily wages' to make a living. Daily wages are derived from casual labour provided in both the formal and informal sector, and can be in a range of economic sectors, including agriculture, salt production and construction. In agriculture, there tends to be a spike in daily wage labour around peak times; transplanting and harvesting, for example.

The total value of all production in all sectors in Labutta is 358,045,600,000 Myanmar Kyat (298,371,333 US Dollars). This equates to an annual per capita output of US\$946.55<sup>37</sup>. The economy of the township is structured in Figure 27.

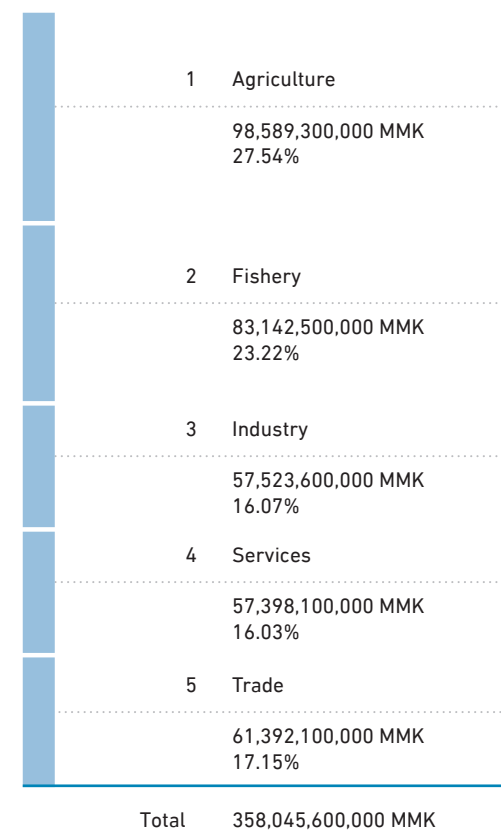
The figure for the 2014-2015 fiscal year was 352,690,700,000 Kyat (293,908,916 US Dollars). This represents a 1.5 per cent annual growth rate from 2014/5 to 2015/6<sup>38</sup>. This compares unfavourably to the national GDP per capita, which in 2015 was US\$1,203.5<sup>39</sup>, and the national GDP growth rate of 7 per cent from 2014 to 2015<sup>40</sup>. The figure for annual per capita output is very much in-line with work done to estimate household incomes in the Ayeyawady Delta, which suggested that household income is around US\$960 per year<sup>41</sup>.

As demonstrated to the right, while agriculture represents only 27.54 per cent of the output of the township, it represents the main source of income for 48.5 per cent of the total population. Labutta has 177,387 hectares of land currently being utilised for growing seasonal crops. Of this, 88 per cent is used for rice paddy. A further 9.47 per cent is used to grow green gram, while the rest is divided between groundnuts, pigeon peas and sesame. Labutta has a further 15,146 hectares of land currently in use for perennial crops. Of this, 58.9 per cent is used for nipa palm, a type of plant that is commonly used in Myanmar to provide roofing material, 21.58 per cent for coconut plantations, 16.05 per cent for bananas, with the rest split equally between palm trees, betel, rubber and cashew nuts.

Rice paddy yields in Labutta are slightly higher than the national average, but still low overall when compared to the region. Planning Department data shows that the yield per hectare for the dry season crop (grown predominantly in the north of the township) was 4.89 tons per hectare in financial year 2014-2015, while the monsoon crop yield was 3.21 tons per hectare, slightly above the national average of around 2.56 tons per hectare.

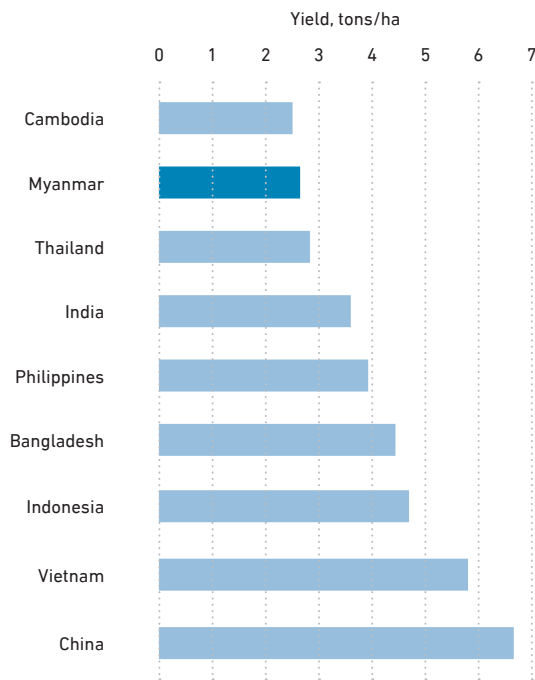
The total size of the labour force, defined as everyone over 10 years old, is 243,109. On the surface, the unemployment rate is very low, at 2.2

Figure 27. Labutta's Economy by sector



per cent. However, this figure is made less reliable by the unusually large proportion of the population that is economically inactive; a situation which is made even less clear by the comparatively low school enrolment. This is partially explained by the prevalence of daily wage labour, as defined above. In reality, daily wage labourers are 'in-

Figure 28. Rice Production in Asia



between' formal and informal, moving between work in salt production, in the formal sector, and agricultural labour, in the informal sector, making the classification of economic activity (i.e. active or inactive) very challenging.

In this case, the assessment uses both the census data and financial year 2015/16 data from the township General Administration Department. The latter gives a figure of the number of 'capable workers' (those economically active and either in work or actively seeking work) as 173,805 people, of whom 164,774 are employed. This figure is lower than the census because it discounts children between 10 and 15 years of age. The employment breakdown for the township can be seen in Figure 29.

**Women are often working, in agriculture and fisheries, but unlikely to report themselves as working, and are thus formally classified as economically inactive.**



Figure 29. Main occupations (Labutta Planning Department)



The assessment calculated that 71.8 per cent of economically active people in Labutta work in agriculture and fisheries when casual labourers are factored in. This means output per capita in these two sectors at US\$1,029 (1,234,800 Kyat) and US\$1,805 (2,166,000 Kyat) respectively. However, given the large number of economically inactive people, we can assume that the incomes of all people who depend on agriculture for their livelihoods are much lower.

One reason this report makes this assumption is because, during the community consultations, the assessment team found that women are often working, beyond household work, performing tasks essential to households' livelihoods. For example, in fishery communities, men are likely to go out to catch fish, while women process and trade.

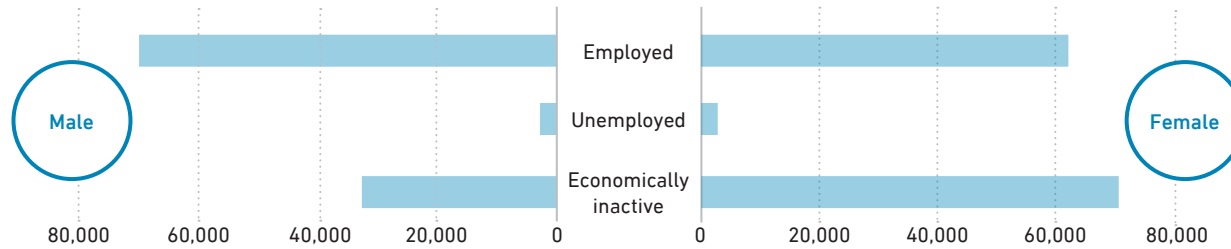
However, as Figure 30 shows, 73 per cent of people classified as economically inactive are women. Therefore, women are often working, in agriculture and fisheries, but unlikely to report themselves as working, and are thus formally classified as economically inactive. Therefore, to accurately estimate income, we need to factor in economically inactive people, who are overwhelmingly female, to get a more accurate picture.

Assuming a proportionate number of economically inactive people also depend on agriculture and fisheries for their livelihood, it means that 152,841 and 73,431 people depend on agriculture and fisheries for their livelihood respectively, and results in annual output per capita of US\$537.54 (644,400 Kyat) and US\$943.57 (1,131,600 Kyat). This points to very acute levels of poverty; even if farmers keep

100 per cent of their output – which is unlikely – their gross earnings translate to US\$1.47 (1,764 Kyat) per day, well below the international poverty line of US\$2 per day<sup>42</sup>. While the equivalent figure for families dependent on fisheries is higher at US\$2.59 (3,108 Kyat) per day. These figures are gross, and do not take into consideration household expenditures like fertilizer and fuels.

In fisheries, incomes are even harder to estimate because of the nature of the market in Labutta. Fishermen tend to act as individuals, rather than corporates or collectives, and because of the distance and complexity involved in travelling to market in Labutta town or further afield, and because women are often less able to travel because of domestic responsibilities, tend to sell their catch to middlemen, often on the informal market. These

Figure 30. Labour Force Participation in Labutta



middlemen then take produce and trade on the formal market in Labutta or Pathein. This has two consequences; firstly, it means that incomes are likely significantly lower than the output per capita, because value-addition is generated by middlemen. Second, it suggests market failure, because the number of sellers far outweighs the number of buyers, driving down the price that individual fishermen receive for their catch.

Myanmar has a national minimum wage of 3,600 Kyat per day (US\$3). However, both consultations with communities and the figures above suggest that many casual (or 'daily wage') labourers are not earning this amount. During the community consultations, people suggested that a more typical daily wage is 2,500-3,000 Kyat for men and 1,500 Kyat for women. As daily wage labour is common

throughout the main sectors in Labutta (agriculture, fisheries and industry) we must assume that daily wages in agriculture and fisheries are less than the 3,600 Kyat wage floor, as average output per capita in both sectors is lower than this; 1,764 Kyat and 3,108 Kyat per person per day, respectively. This is in-line with other research conducted in the Ayeyawady Delta which suggests that the incomes of landless people (who rely on daily wages) are around half those of people with access to land<sup>43</sup>.

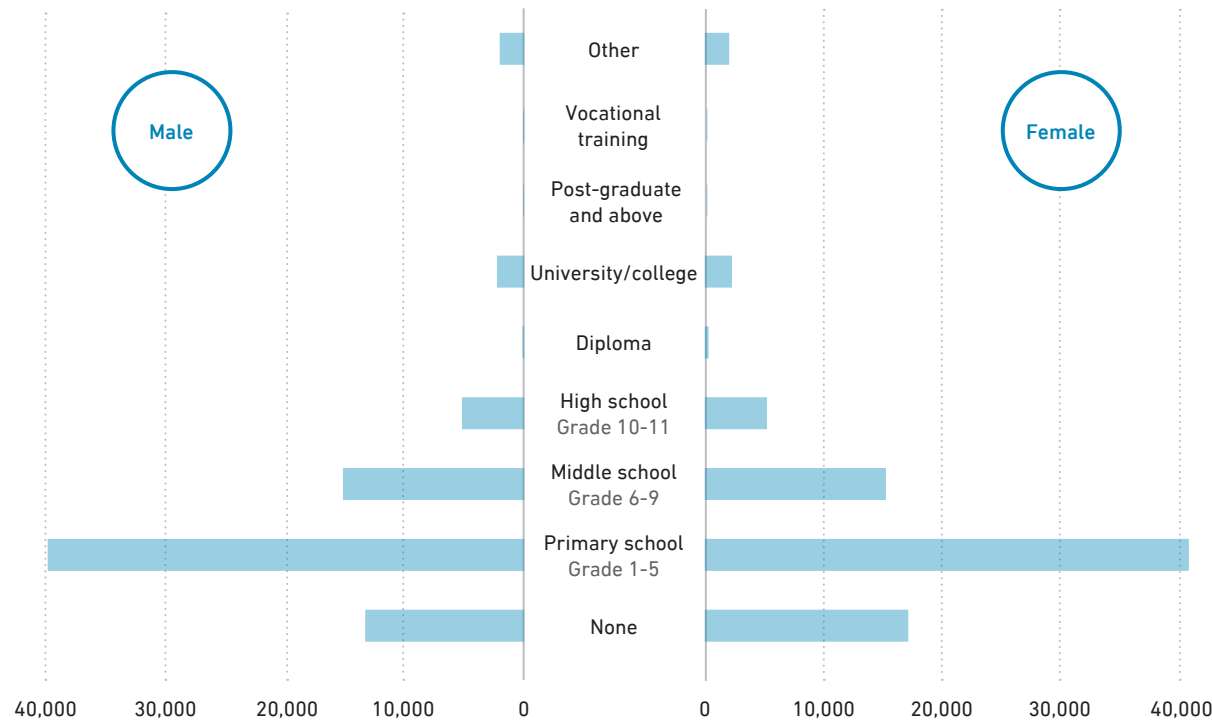
Labutta's demographic and social characteristics reveal a number of issues that make the township vulnerable to shocks, regardless of any longer term impacts of climate change or climate-related hazards, and are likely to exacerbate the impacts of climate change in the future.



Skills are a serious issue in Labutta<sup>44</sup>. Labutta Township has a total of 158,769 people over the age of 25. Of these, 114,008; 71.8 per cent of the total population of over 25, have either no formal education or have only received education up to grade 5 level. For women, the percentage who have received either

no formal education or education only up to grade 5 is even higher, at 75.9 per cent. This causes significant challenges; it means that there is a shortage of skilled people, preventing the development of industry, where skilled workers are needed, and means that those with skills are also more likely to migrate.

Figure 31. Level of education completed people over 25 (Census, 2014)



- 25 Webb et al. (2015) Deforestation in the Ayeyawady Delta and the conservation implications of an internationally-engaged Myanmar
- 26 Aung, T. T; Mochida, Y; Maung Than, M (2013) Prediction of recovery pathways of cyclone-disturbed mangroves in the maga delta of Myanmar
- 27 Driel, W.F. van & T.A. Nauta, 2014. Vulnerability and Resilience Assessment of the Ayeyawady Delta in Myanmar. Full assessment phase. Delta Alliance report no. 10. Bay of Bengal Large Marine Ecosystem (BOBLME) Project, Global Water Partnership (GWP) and Delta Alliance, Delft-Wageningen, The Netherlands
- 28 Driel, W.F. van & T.A. Nauta, 2014. Vulnerability and Resilience Assessment of the Ayeyawady Delta in Myanmar. Full assessment phase. Delta Alliance report no. 10. Bay of Bengal Large Marine Ecosystem (BOBLME) Project, Global Water Partnership (GWP) and Delta Alliance, Delft-Wageningen, The Netherlands
- 29 Driel, W.F. van & T.A. Nauta, 2014. Vulnerability and Resilience Assessment of the Ayeyawady Delta in Myanmar. Full assessment phase. Delta Alliance report no. 10. Bay of Bengal Large Marine Ecosystem (BOBLME) Project, Global Water Partnership (GWP) and Delta Alliance, Delft-Wageningen, The Netherlands
- 30 Driel, W.F. van & T.A. Nauta, 2014. Vulnerability and Resilience Assessment of the Ayeyawady Delta in Myanmar. Full assessment phase. Delta Alliance report no. 10. Bay of Bengal Large Marine Ecosystem (BOBLME) Project, Global Water Partnership (GWP) and Delta Alliance, Delft-Wageningen, The Netherlands
- 31 Table J-1. The 2014 Myanmar Population and Housing Census
- 32 The percentage of population covered in each area is calculated by dividing the total population from the census 2014 and the total capacity of each shelter in each village tract belonging to this area
- 33 The study team attempted to analyse the flow of information, which seems to function as follows: DMH emits the official message, which is conveyed to District General Administration Department, and this to the Township General Administration Department (T/GAD). T/GAD in turn shares the message with Village Tracts' leaders to spread the news in the sub-villages. Many villages use loudspeakers or megaphones to spread the news. Information is also broadcasted by DMH through MRTV, MNTV channels and Myanmar Radio. The warnings will be repeated within 10 minutes or 15 minutes depending on the seriousness of the situation. However, the team was not able to verify information as obtained from local consultations.
- 34 The 2014 Myanmar Population and Housing Census
- 35 Table J-6. The 2014 Myanmar Population and Housing Census
- 36 Driel, W.F. van & T. A. Nauta, 2013. Vulnerability and Resilience Assessment of the Ayeyawady Delta in Myanmar, Scoping phase. Bay of Bengal Large Marine Ecosystem (BOBLME) Project, Global Water Partnership (GWP) and Delta Alliance, Delft-Wageningen, The Netherlands, p.13
- 37 Assuming an exchange rate of USD1 = 1200 Myanmar Kyat
- 38 Combined from the Labutta Township General Administration Department, Fishery Department and Agriculture Department
- 39 World Bank
- 40 World Bank
- 41 Mercy Corps, Welthungerhilfe and GRET (2016); A Strategic Resilience Assessment of the Ayeyawady Delta, p.11
- 42 Explanatory note: This calculation assumes that all income is in the formal sector. It also equates poverty to income. In reality, this is imperfect, because it doesn't account for the difference between wage labour and value generation (wages will always be less than value), but in sectors like agriculture and fishery, where most people are smallholders, it offers a good approximation. It also assumes that there are no informal sector incomes from people who are defined as economically inactive. This is probably incorrect, but measuring incomes in the informal sector is challenging, has not been attempted and was beyond the scope of this assessment
- 43 Delta Alliance (2015) Vulnerability and Resilience Assessment of the Ayeyawady Delta, Myanmar, p.53
- 44 Ministry of Immigration and Population (2015) The 2014 Myanmar Population and Housing Census, Ayeyawady Region, Labutta Township, Table D-6a



Voices from Labutta:

Ma Sandar Aye, 39, Thingangyin village

“Twenty-eight people died in this village during Cyclone Nargis. Those of us who survived did so because we took shelter in the monastery. There have been fewer storms since Cyclone Nargis, but we get two or three bad ones a year. My husband has a fishing net and I help him catch fish. We haven’t been able to fish for over a month because the winds are so strong. The winds were never as strong as this in the past. I don’t know when the weather will improve and my husband and I are starting to think about looking for different work because it’s become too hard to survive. The most we can earn in a day from fishing is K10,000 but some days we get nothing. The average amount is K2,500.

Since Cyclone Nargis we pay a lot more attention to the weather warnings on the TV and radio. Our village chief sends alerts through the loudspeaker at the monastery also. When Cyclone Nargis struck, no one had experienced such a bad storm before, so some people didn’t pay attention to the warnings. We didn’t take it seriously and we weren’t prepared.

I want my four children to get a better education than I did because my work is very physically demanding, so I don’t want them to be fishermen when they grow up. There are 79 households in our village and 20 young people moved to Yangon last year to find work as day labourers or garment factory workers. There just aren’t enough jobs here for the young people.”





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## 3.4. SPATIAL STRUCTURE OF LABUTTA

- Myaungmya provides many socio-economic functions to the northern area of the township, while Pathein provides the highest level of education and health facilities and represents the main market for the agricultural products and provisioning needs of the township.
- Labutta Township has low levels of socio-economic and infrastructure development, 60 per cent of the population live in village tracts where only basic health and education services and some basic services are provided. Eastern and north-western areas are the least developed.
- Labutta Town, Pynsalu Town and Kan Bet and Kyar Kan are the three main clusters of the township covering the highest levels of socio-economic functions and connectivity and recognised as suitable for investment in economic, social and basic services.
- Four primary corridors along the main routes of multimodal transport networks (roads and water canals) enable connectivity and remain crucial to support the economy of the southern areas of the township. These corridors are particularly vulnerable to climatic events, and can be disrupted by floods and inundations.

The analysis of the human settlements using the matrix of functions<sup>45</sup> allows classification of human settlements according to their functional complexity and to identify the territorial and socio-economic linkages between them. It is based on empirical understanding of the regional structure, the territorial dynamics, and the role human settlements and eco-systems services play in this structure.

The assumption, in this assessment, is that human settlements that have fewer functions available are more vulnerable, and their vulnerability would be reduced by providing the services that are largely missing. At the township level, we can visualise the linkages between villages, for example we could determine the degree of dependency in terms of health or education services. This is very

important to map and quantify the villages affected so that if disaster affects a village providing the health or education services it helps to determine a regional sensitivity.

Using the results of a questionnaire exercise with village administrators, the assessment established that 80 of the suggested 88 functions are available in Labutta<sup>46</sup>. These are presented in twelve categories in the figure in this page (right). The only functions not available are public water network on grid, vocational training schools, university, museum, grains, tobacco, natural medicines (i.e. spirulina).

The analysis of the matrix of functions (figure in the next page) identifies three types of rural village tracts; local village tracts, intermediate village tracts and main village tracts and two types of urban wards; local urban centre and main urban centre, and establishes a functional complexity and level of hierarchy for each type based on the number of times that a given function is present in all the village tracts and wards (Figure 34).

Labutta Township shows low levels of socio-economic and infrastructure development. More than 70 per cent of the village tracts are classified as local village tracts, providing only basic health and education services and some basic needs. Intermediate village tracts are mainly located along the water canals and the main road linking Labutta to Myaugnmya which allows the

Figure 32. List of Functions checked

CATEGORY	NAME OF FUNCTION	NUMBER
1. Public Utilities and Facilities	1.1. Telecommunication transmitter (mobile phone repeater); 1.2. Radio station; 1.3. Post office; 1.4. Rain water harvest pond; 1.5. Well with hand pump; 1.6. Public water network on grid (piped water); 1.7. Irrigation system; 1.8. Private solar panel electricity supply; 1.9. Public electricity network on grid; 1.10. Sewerage drainage system; 1.11. Storm water drainage system	11
2. Road Connection and Transportation Infrastructure	2.1. Paved roads; 2.2. Unpaved roads; 2.3. Bus transport on daily basis; 2.4. Bus station; 2.5. Boat transport on daily basis (two ways same day); 2.6. Boat transport every two days (one way per day); 2.7. Port/Harbour; 2.8. Petrol supply station	8
3. Markets	3.1. General market; 3.2. Livestock market; 3.3. Fish market	3
4. Industries and Commercial Establishments	4.1. Groceries shop; 4.2 Retail shop; 4.3. Restaurant; 4.4. Hotel; 4.5. Bicycle repair garage; 4.6. Motor vehicle repair garage (motorbike /car); 4.7. Factory; 4.8. Salt production; 4.9. Aquaculture (Crabs / Shrimps); 4.10. Banks/western union	10
5. Health Facilities	5.1. Public sub-rural health centre; 5.2. Public rural health centre; 5.3. Public station hospital; 5.4. Public township hospital; 5.5. Private Clinic	5
6. Specialized Health Staff and Services	6.1 Midwife; 6.2 Dentist; 6.3 Eye specialist; 6.4. Pharmacy	4
7. Educational Institutions	7.1. Kindergarten; 7.2. Basic education primary schools; 7.3. Basic education post-primary schools; 7.4. Basic education middle schools; 7.5. Basic education high schools; 7.6. Vocational training schools; 7.7. University	7
8. Public recreational and Cultural Facilities	8.1. Cultural centre; 8.2. Library; 8.3. Museum	3
9. Security Services	9.1. Cyclone shelter; 9.2. Disaster management committee; 9.3. Police check point; 9.4. Police station; 9.5. Fire station	5
10. Community Organizations and NGOs	10.1. Religious organization/monastery; 10.2. Civil society organisation; 10.3. Cooperative union; 10.4. NGOs	4
11. Own account worker	11.1. Fishermen; 11.2. Street sellers; 11.3. Carpenters; 11.4. Weaving/sewing; 11.5. Lawyers; 11.6. Accountants; 11.7. Electricians; 12.8. Plumbers	8
12. Provisioning, supporting and regulating eco-system services	12.1. Rice; 12.2. Grains; 12.3. Groundnuts; 12.4. Maize; 12.5. Beans; 12.6. Flowers; 12.7. Tobacco; 12.8. Vegetables; 12.9. Livestock; 12.10. Roof/wall material; 12.11. Wood for charcoal; 12.12. Natural medicines (i.e. spirulina); 12.13. Mangroves; 12.14. Forest; 12.15. Water channels; 12.16. Streams; 12.17 Rivers; 12.18. Reptiles (Olive Ridley Turtle); 12.19. Birds (Spotted Greenshank); 12.20. Congregatory water birds	20



presence of higher range of cultural and security services and some industries (mainly aquaculture). Main village tracts, located surrounding Labutta Town and Pyinsalu Town and in the central area, have access to more public utilities and transportation infrastructure which allows the presence of more types of economic activities such as a general market, restaurant, salt

production. Finally, Pyinsalu Town has the highest level of physical and socio-economic development in the southern area, with more types of markets (fish and livestock) and specialised own account workers (lawyers and electricians); and Labutta Town is the main urban centre, covering the highest number of functions and the most unique ones across the Township.

In the Ayeyawady Region, Myaungmya provides many socio-economic functions to the northern area of the township, while Pathein provides the highest level of education and health facilities and represents the main market for the agricultural products and provisioning needs of the township.

Figure 34. Type of Village tracts

TYPE	LOCAL VILLAGE TRACT (LVT)	INTERMEDIATE VILLAGE TRACTS (IVT)	MAIN VILLAGE TRACTS (MVT)	LOCAL URBAN CENTRES (LUC)	MAIN URBAN CENTRES (MUC)
<b>CENTRALITY SCORE</b>	38.97 – 118.73	131.39- 187.66	219.01- 308.05	523.62	835.17
<b>LEVEL OF HIERARCHY</b>	1 2	3 4 5	6 7 8	9 10 11	15
<b>FUNCTIONAL COMPLEXITY</b>	The analysis of the type of functions covered shows the current dependency of the population in rain-fed water and solar panels as the main energy source, while boats are the main mean of transportation. Only basic health and education coverage is provided, and the basic needs are provided through small groceries and street sellers. Agriculture is the main economic activity (mainly rice and vegetables) together with fishermen mainly in communities in coastal areas.	This typology provides better transportation facilities, such as harbour, higher range of cultural and security services, for example cyclone shelters than the previous typology. Some industries, mainly aquaculture are present.	Access to more public utilities (mobile phone repeater, wells and irrigation channels) and transportation infrastructure (paved roads and bus transportation) allows the presence of more types of economic activities (general market, restaurant, salt production).	Presence of more types of markets such as fish and livestock and specialised own account workers like lawyers and electricians	Highest level of physical and socio-economic development, covering the highest number of functions and the most unique ones across the Township.
<b>POPULATION CHARACTERISTICS</b>	According to the 2014 Census, 58% of the total population of the township lives in village tracts belonging to this category	According to the 2014 Census, 24% of the total population of the township lives in the village tracts belonging to this category	According to the 2014 Census, 7% of the total population of the township lives in village tracts belonging to this category	According to the 2014 Census the total population of Pyinsalu is 2,229 inhabitants, representing only 1% of the total population of the township.	Labutta concentrates 10% of the total population of the township
<b>NAME OF VILLAGE TRACTS / VILLAGE SETTLEMENTS</b>	More than 70% of the village tract.	Sa Lu Seik, Da Ni Seik, Ka Tha Paung, La Put Ta Loke (South), Baing Daunt Chaung, Maung Dee, Tha Pyu Kone, Tu Myaung, Maung Nge, Kyauk Hpyu Pein Hne Taung, Bi Tut, Yae Twin Seik, La Put Ta Loke (North), Kyuak Hmaw	Kyar Kan, Kan Bet, Pyin Ah Lan	Pyinsalu	
<b>SPATIAL DISTRIBUTION</b>	The eastern and north-western areas are the least developed	The majority of these village tracts are located along the primary and secondary water canals and along the main road linking Labutta to Myaungmya	Village tracts surrounding Labutta and Pyinsalu Town and village tracts located in central areas	Pyinsalu has the highest level of physical and socio-economic development of the southern area	Main town of the township

At Township level, the spatial structure of the township relies on:

- Three main “clusters” of settlements which support and complement each other in terms of socio-economic functions and connectivity and are recognised as suitable for investment in economic, social and basic services:
- And four primary corridors along the main routes of multimodal transport networks (roads and water canals) enable connectivity among these three clusters: Labutta Town is well connected with Pathein through the main paved road and the Thet Ke Thaug river, while Pyinsalu’s main transportation route to Labutta is through the Pya Ma Law and Yway rivers and to Kan Bet and further to Wakema Township and Yangon through Pya Ma Law River. These corridors remain crucial to support the economy of the southern areas of the township.

<b>LOCATION</b>	Centred in Labutta Town and including the villages tracts along the main road to Myangmya and along the secondary road to Laputta Loke (Thet Ke Thaug River)	Centred in Pyinsalu Town, including the villages tracts of the south-western area of the township.	Centred in Kan Bet, and including the surrounding village tracts located at the centre of the township along the Pya Ma Law river.
<b>VILLAGE TRACTS</b>	Labutta Town, La Put Ta Loke (South), Kyauk Hmaw, Nyaung Lein, La Put Ta Loke (North), Ka Tha Paung, Kyar Kan, Kyauk Hpyu Pein Hne Taung, Maung Dee	Pyinsalu Town, Yae Twin Seik, Pyin Ah Lan, Da Ni Seik	Kan Bet, Bi Tut, Maung Nge, Htin Pon Kwin
<b>TOTAL POPULATION</b>	62,327 inhabitants (20% of the total population of the township)	24,907 inhabitants (8% of the total population of the township)	26,409 inhabitants (9% of the total population of the township)
<b>FUNCTIONAL COMPLEXITY</b>	These village tracts are the most important cluster of settlements of the township, centred in Labutta Town, the most developed settlement in terms of physical infrastructure and socio-economic activities as it provides, the highest levels of health and education services and economic activities in the township	Despite Pyinsalu Town being the economic centre of this cluster, it only provides basic local markets for fish and livestock and some specialised own account workers (lawyers and electricians), which, at township level, shows the economic dependency with Labutta Town. Pyin Ah Lan is the most important village tract in terms of health services in the form of a station hospital and provisioning, supporting and regulating eco-system services, mainly mangroves	These four village tracts configure a cluster strategically located at the centre of the township, their access to more public utilities (wells and irrigation channels) and transportation infrastructure (paved road, harbour) allows higher yields and more crops (beans) and more types of economic activities (general market, restaurant, salt production)

45 Complete technical report with the methodology is available on request at UN-Habitat Myanmar and will be published at [www.myanmarcalliance.org](http://www.myanmarcalliance.org)

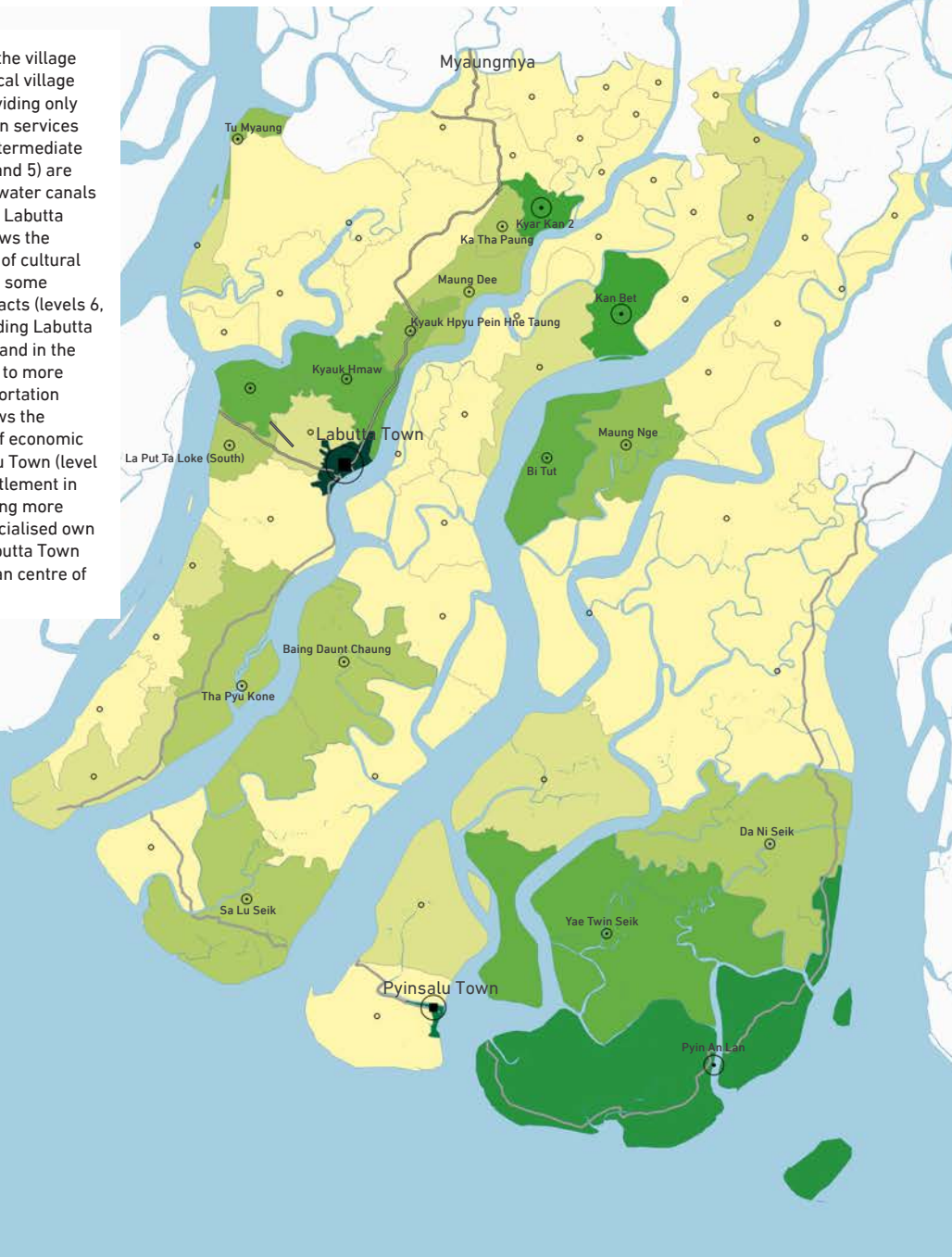
46 NB: not how many times the function is present, just if it is present or not, this is a normalized method





# 2016 | Spatial distribution of the type of settlements (MoF)

More than 70 per cent of the village tracts are classified as local village tracts (level 1 and 2), providing only basic health and education services and some basic needs. Intermediate village tracts (levels 3, 4 and 5) are mainly located along the water canals and the main road linking Labutta to Myaungmya which allows the presence of higher range of cultural and security services and some industries. Main village tracts (levels 6, 7 and 8), located surrounding Labutta Town and Pyinsalu Town and in the central area, have access to more public utilities and transportation infrastructure which allows the presence of more types of economic activities. Finally, Pyinsalu Town (level 10), is the main urban settlement in the southern area providing more types of markets and specialised own account workers; and Labutta Town (level 15) is the main urban centre of the township



**Levels of hierarchy**

- level 1
- level 2
- level 3
- level 4
- level 5
- level 6
- level 7
- level 8
- level 9
- level 10
- level 11
- level 12
- level 13
- level 14
- level 15

0 5 10 15 20 km 1:325,000 Original size Din A3



**Type of settlement**

- Local Village Tract (LVT)
- Intermediate Village Tract (IVT)
- Main Village Tract (MVT)
- Local Urban Centre (LUC)
- Main Urban Centre (MUC)
- Sub-township
- Township
- State Capital

**Main communication routes**

- Major road
- Secondary road
- Water canal

0 40 80 km 1:2,000,000 Original size Din A3

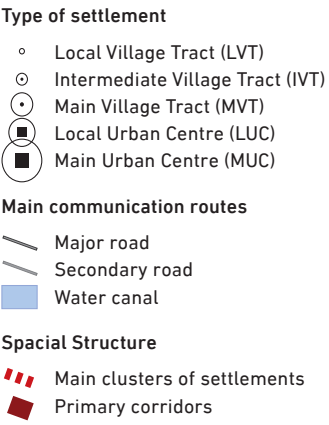
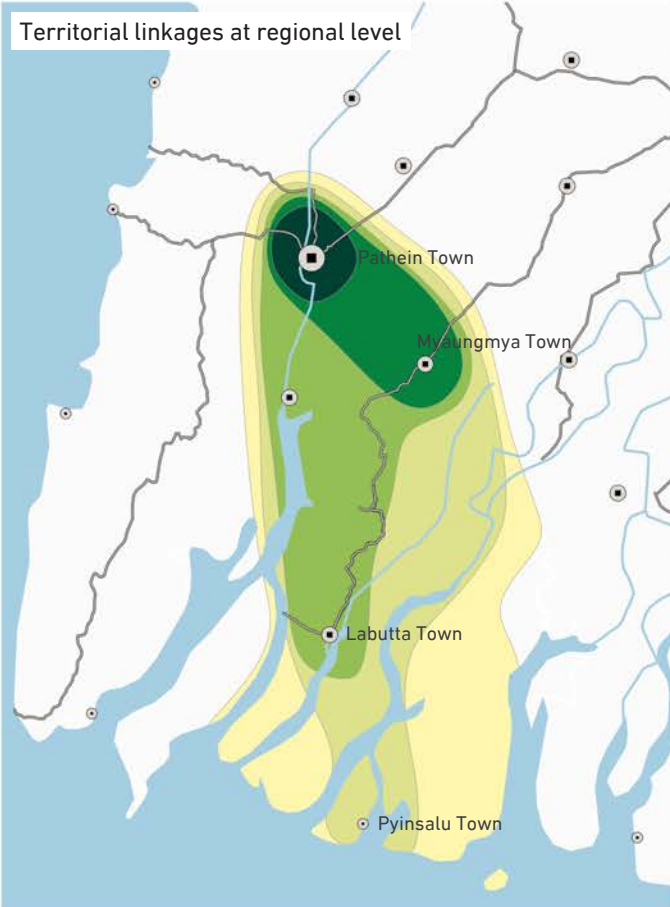
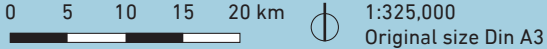
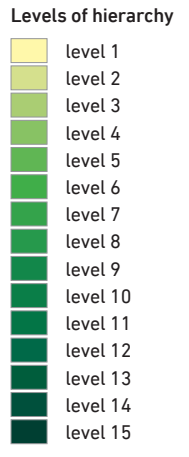
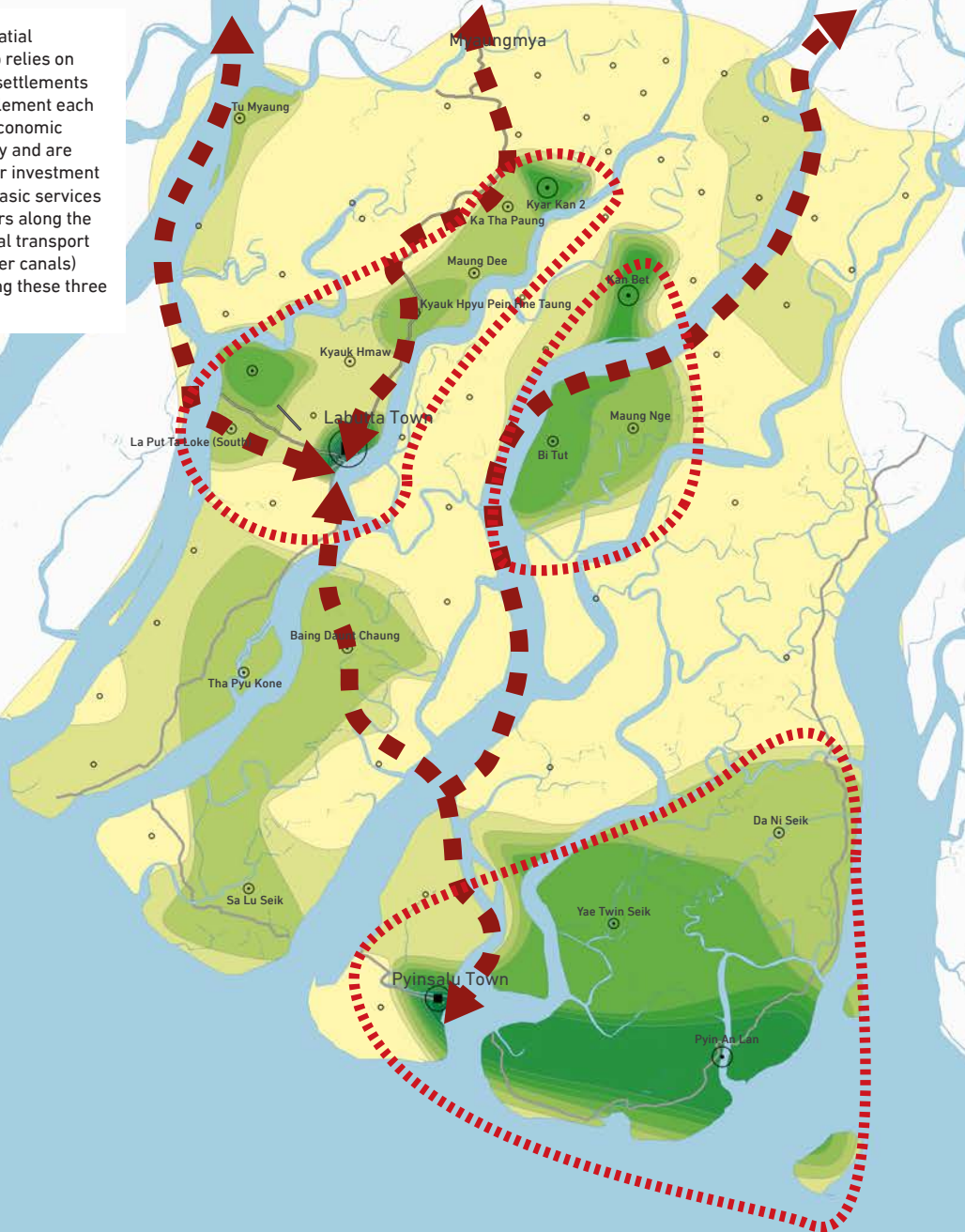
Disclaimer: The designations employed and the presentation of material on this map do not imply the expression of any opinion whatsoever on the part of the Secretariat of the United Nations concerning the legal status of any country, territory, city or area or its authorities, or concerning the delimitation of its frontiers or boundaries.

Data Source: MIMU, UN HABITAT



# 2016 | Spatial structure and territorial linkages

At Township level, the spatial structure of the township relies on three main "clusters" of settlements which support and complement each other in terms of socio-economic functions and connectivity and are recognised as suitable for investment in economic, social and basic services and four primary corridors along the main routes of multimodal transport networks (roads and water canals) enable connectivity among these three clusters.



At regional level, Myingmya provides main socio-economic functions to the northern area of the township, while Patheingyi provides the highest level of education and health facilities and represents the main market for agricultural products and provisioning needs of the township.

**Type of settlement**

- Sub-township
- Township
- State Capital



**Disclaimer:** The designations employed and the presentation of material on this map do not imply the expression of any opinion whatsoever on the part of the Secretariat of the United Nations concerning the legal status of any country, territory, city or area or its authorities, or concerning the delimitation of its frontiers or boundaries.

Data Source: MIMU, UN HABITAT

Vulnerability Analysis and Risk Profile

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## 3.5 CURRENT VULNERABILITY INDEX

The report calculates an index of vulnerability by village tract. This allows to understand which locations have greater vulnerability levels. The index considers access to drinking water, forest quality and access to irrigation water under the ecosystems component, education level, output per capita and labour force participation rate under the socio-economic component and type of housing, access to transport and access to cyclone shelters under the infrastructure component. Together these make up the sensitivity of the village tracts. Under hazards, the index considers storm surge potential and salinization under the sea-level rise component, flooding under the intense rains component and cyclones and droughts/heat waves under the increase in mean temperature component. The total score for sensitivity is multiplied by the total score for hazards.

The calculations in the index are presented in the Figure in the next page and the results are shown in map LBT11. The index clearly shows that village tracts closer to the coast face greater levels of vulnerability than those in-land. This is because they have clear challenges in accessing fresh water for drinking and irrigation water and less access to transport services. Meanwhile, their incomes, housing structures, labour force participation and access to cyclone shelters is not better (and in some cases also worse) than other areas in the township.

Meanwhile, while drought/heatwaves and cyclones can affect the whole township (hence all village tracts have the same score for these hazards), storm surge, salinity and flooding are all likely to impact the coastal areas of the township more than the inland areas.

This means that, according to the vulnerability index, the coastal areas of the township are currently facing greater threats from climate change related hazards. This indicates that activities to build resilience can be targeted more effectively if they benefit these areas.

Figure 35. A rundown communication station, not in use, Tyingangin ©MCCA

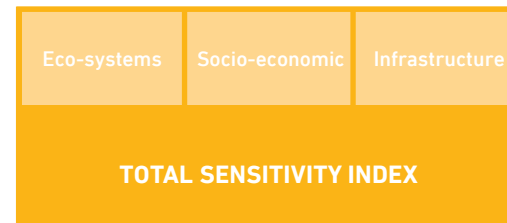
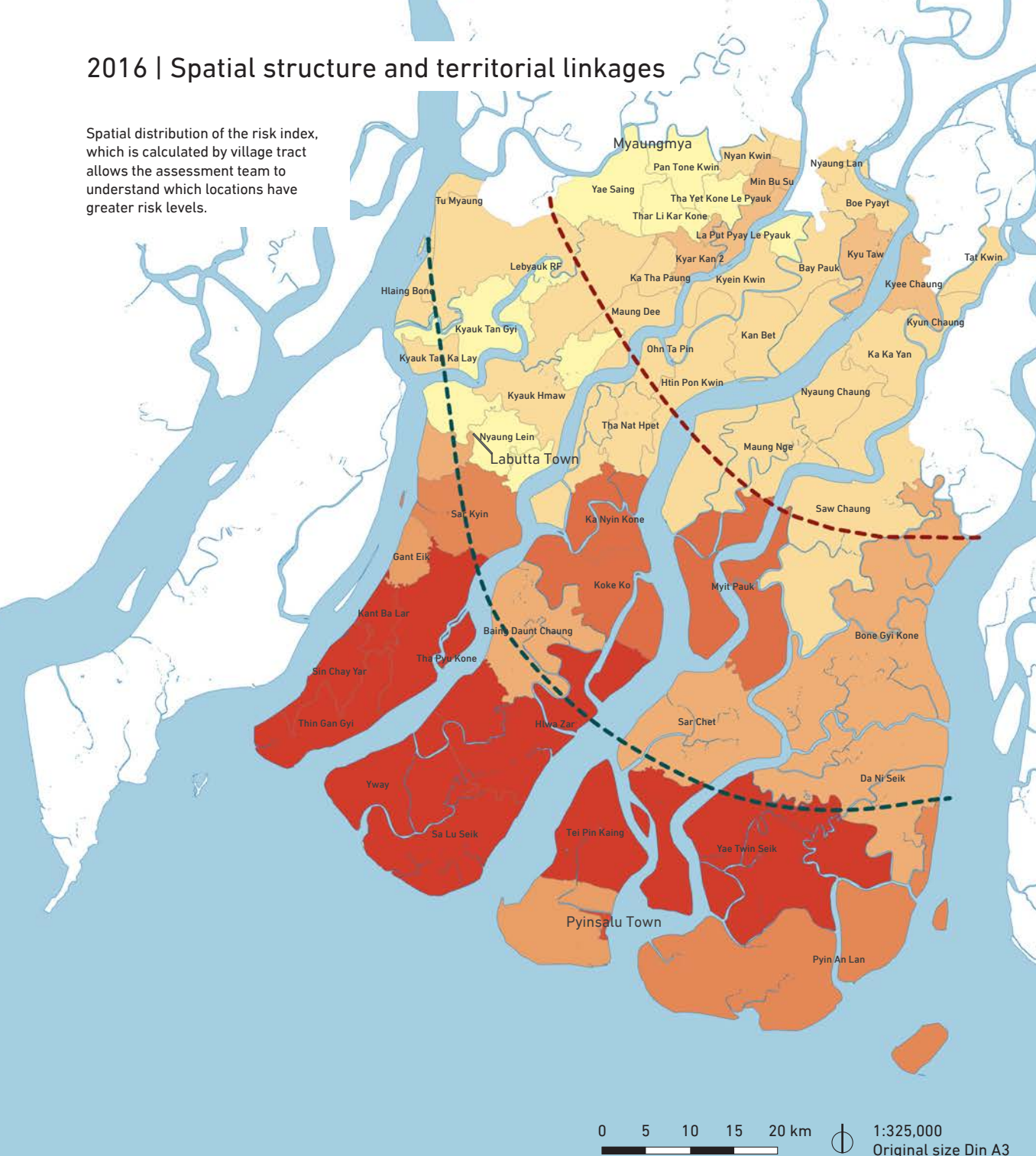


Figure 36. Vulnerability Ranking

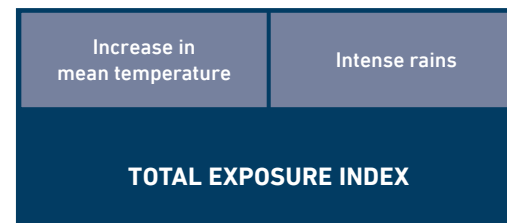
Village Tract	SENSITIVITY INDEX									Total Sensitivity Index	HAZARD INTENSITY (frequency/magnitude)					Total Exposure Index	Total Risk Index
	ECO-SYSTEMS			SOCIO-ECONOMIC			INFRASTRUCTURE				SEA-LEVEL RISE		INTENSE RAINS	INCREASE IN MEAN TEMPERATURE			
	I1.	I2.	I3.	I1.	I2.	I3.	I1.	I2.	I3.		Storm surge	Salinization	Flooding	Cyclone	Drought/ Heat Waves		
	Access to drinking water	Quality of the forest	Access to irrigation water	Level of education completed	Income per capita	Labour force participation rate	Type of housing units	Access to transport services	Access to cyclone shelters								
Nyaung Lain	2	4	2	4	2	2	4	1	4	25	0	1	1	4	1	7	175
Kyauk Tan Gyi	1	4	2	4	2	2	4	2	4	25	0	1	1	4	1	7	175
Ye Sai	2	3	2	4	2	2	4	2	4	25	0	1	1	4	1	7	175
Tha Li Kar Kone	2	3	2	4	2	2	4	2	4	25	0	1	1	4	1	7	175
Pan Toon Kween	2	4	2	4	2	2	4	2	4	26	0	1	1	4	1	7	182
Myoay Hauk	2	3	2	4	2	3	4	2	4	26	0	1	1	4	1	7	180
Kyauk Phyu	3	4	3	4	2	1	4	1	4	26	0	1	1	4	1	7	182
Laputta Loap Myauk	3	3	3	4	2	2	4	1	4	26	0	1	1	4	1	7	184
Kyein Kone Gyi	4	2	4	4	2	1	4	1	4	26	0	1	1	4	1	7	184
Ta Yet Kone Le Pyauk	2	3	1	4	2	4	4	2	4	26	0	1	1	4	1	7	184
Urban Labutta	4	3	4	4	1	2	4	1	4	27	0	1	1	4	1	7	186
Maung Nge	4	3	4	4	2	2	4	1	4	28	0	1	1	4	1	7	193
Kyauk Tan Ka Lay	4	2	4	4	2	2	4	2	4	28	0	1	1	4	1	7	193
Tha Nup Phat	4	2	4	4	2	2	4	2	4	28	0	1	1	4	1	7	194
Lebyauk	4	3	4	4	2	2	4	1	4	28	0	1	1	4	1	7	194
Hlai Bone	4	3	3	4	2	3	4	1	4	28	0	1	1	4	1	7	194
Kyauk Mhaw	4	3	4	4	2	2	4	1	4	28	0	1	1	4	1	7	196
Htin Pon Kwin	4	2	4	4	2	2	4	2	4	28	0	1	1	4	1	7	196
Too Myaung	4	3	3	4	2	2	4	2	4	28	0	1	1	4	1	7	198
Ka Ta Paung	4	3	4	4	2	2	4	1	4	28	0	1	1	4	1	7	198
A Mat	4	2	4	4	2	2	4	2	4	28	0	1	1	4	1	7	198
Bar Thar Kone	4	2	4	4	2	1	4	3	4	28	0	1	1	4	1	7	198
Nyaung Lan	4	4	4	4	2	1	4	2	4	29	0	1	1	4	1	7	200
Bee Toot	4	3	4	4	2	2	4	2	4	29	0	1	1	4	1	7	200
Bo Pyay	4	3	4	4	2	2	4	2	4	29	0	1	1	4	1	7	201
Ka Ka Yan	4	4	4	4	2	1	4	2	4	29	0	1	1	4	1	7	203
Kan Bet	4	3	4	4	2	2	4	2	4	29	0	1	1	4	1	7	201
Nyaung Chaung	4	3	4	4	2	2	4	2	4	29	0	1	1	4	1	7	201
Ohn Ta Pin	4	2	4	4	2	3	4	2	4	29	0	1	1	4	1	7	203
Kyein Kween	4	3	4	4	2	2	4	2	4	29	0	1	1	4	1	7	203
Gon Hmyin Tan	4	3	4	4	2	2	4	2	4	29	0	1	1	4	1	7	203
Shaw Chaung	4	3	4	4	2	2	4	2	4	29	0	1	1	4	1	7	203
Kyun Chaung	4	3	4	4	2	2	4	2	4	29	0	1	1	4	1	7	203
Tap Kween	4	3	4	4	2	2	4	2	4	29	0	1	1	4	1	7	203
Maung Tee	4	3	4	4	2	2	4	2	4	29	0	1	1	4	1	7	203
Bay Pauk	4	2	4	4	2	2	4	3	4	29	0	1	1	4	1	7	205
Nyan Kween (Kan Yar)	4	3	4	4	2	2	4	2	4	29	0	1	1	4	1	7	205
Kyu Taw	4	4	4	4	2	2	4	2	4	30	0	1	1	4	1	7	210
Laput Pyay Le Pyauk	4	4	4	4	2	2	4	2	4	30	0	1	1	4	1	7	210
Kyee Chaung	4	3	4	4	2	2	4	3	4	30	0	1	1	4	1	7	208
Kya Kan	4	4	4	4	2	2	4	2	4	30	0	1	1	4	1	7	210
Min Boo Su	4	3	3	4	2	2	4	4	4	30	0	1	1	4	1	7	210
Laputta Loap Taungww	2	2	2	4	4	2	4	4	4	25	0	2	2	4	1	9	228
Tai Daunt Chaung	3	3	1	4	4	2	4	1	4	26	0	2	2	4	1	9	232
Sar Check	2	3	2	4	4	4	4	1	4	26	0	2	2	4	1	9	232
Da Ni Seip	3	3	1	4	4	2	4	1	4	26	0	2	2	4	1	9	232
Phone Gyi Kone	1	3	3	4	4	2	4	1	4	26	0	2	2	4	1	9	232
Gant Eiat	4	3	4	4	4	2	4	2	4	31	0	1	2	4	1	8	244
Kone Gyi	3	2	2	4	3	2	4	1	2	23	1	3	2	4	1	11	256
Po Laung	1	3	2	4	3	2	4	2	3	24	1	3	2	4	1	11	261
Sar Kyin	4	2	4	4	4	2	4	1	4	29	0	2	2	4	1	9	264
Myit Pauk	4	3	4	4	4	2	4	2	4	31	0	2	2	4	1	9	277
Kok Ko	4	3	4	4	4	2	4	2	4	31	0	2	2	4	1	9	277
Ka Nyin Kone	4	2	3	4	4	3	4	3	4	31	0	2	2	4	1	9	279
Urban Pynsatu	4	3	4	4	4	2	4	1	4	27	1	3	2	4	1	11	292
Sa Lu Seip	4	2	4	4	4	2	4	2	3	28	1	3	2	4	1	11	311
Tel Pin Kai	4	3	4	4	3	2	4	2	3	29	1	3	2	4	1	11	319
Yway	4	3	4	4	3	1	4	2	4	29	1	3	2	4	1	11	319
Hloa Zar	4	3	4	4	3	2	4	2	4	30	1	3	2	4	1	11	330
Tha Pyu Kone	4	3	3	4	3	3	4	2	4	30	1	3	2	4	1	11	330
Thin Gan Gyi	4	3	4	4	4	2	4	3	3	30	1	3	2	4	1	11	330
Yay Thwin Seip	4	3	4	4	3	2	4	2	4	30	1	3	2	4	1	11	330
Sin Chay Yar	4	2	4	4	3	2	4	3	4	30	1	3	2	4	1	11	333
Kan Ba Lar	4	2	4	4	3	3	4	3	4	31	1	3	2	4	1	11	341

# 2016 | Spatial structure and territorial linkages

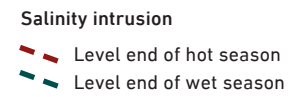
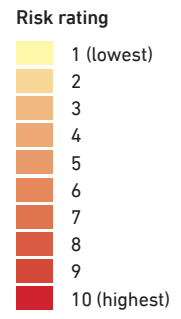
Spatial distribution of the risk index, which is calculated by village tract allows the assessment team to understand which locations have greater risk levels.



**X**



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Data Source: MIMU, FAO, WFP, UN HABITAT

Vulnerability Analysis and Risk Profile

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## 3.6 SUMMARY OF VULNERABILITIES

Labutta Township, as a whole, is very vulnerable to both acute shocks and chronic stressors resulting from climatic processes and natural hazards.

Non resilient infrastructure and fragile transport; degrading eco-system from which the communities depend highly; and non-diversified economic sources make the Township extremely sensitive to climatic risks.

Within the overall vulnerability context, there are spatial differences. Village tracts closer to the coast face greater levels of vulnerability than those in-land because of even greater challenges in accessing fresh water for drinking and irrigation water, less access to transport services and the exposure to storm-surges in addition to cyclones, for instance, which also potentially affect the whole township.

Their income, housing structures, labour force, participation and access to cyclone shelters are also not better than in other areas in the township, although these communities can count on fishery. In addition, while drought, heatwaves and cyclones can affect the whole township, storm-surge, salinity, erosion and flooding are all likely to impact the coastal areas of the township more than the inland areas.

Coastal areas of the township are recurrently facing relatively greater threats from climate change related hazards. However, in absolute terms, it is important to understand that all communities in this townships are extremely vulnerable and require support to build resilience.

The following pages summarize the sensitive aspects of each system studied by this report: the ecological, socio-economic and infrastructure and transport systems. The interplay of these sensitivities with the exposure and the natural hazards explain the vulnerability of the township.

## ECO-SYSTEMS

Forests provide multiple benefits to the township population, but due to deforestation trends that are affecting forests nationally, they are degraded, limiting their ability to provide benefits to people.

People in Labutta rely heavily on mangroves for cooking fuel and nipa palm to make theike, a roofing material. Unsustainable dependence on these ecosystem services is leading causing their degradation and, in some cases, total loss.



Mangrove forests have been cleared for agriculture, specifically rice paddy cultivation and substantially degraded since the late 1970s, losing 64 per cent of their total area between 1978 and 2011.

This increases the vulnerability of people in Labutta because ecosystem services will also be critical for their adaptation response in the future.

## INFRASTRUCTURE

Housing construction is vulnerable to strong winds and floods, because it primarily uses local materials and is often poorly executed, or not adapted to increased frequency and intensity of hazards.

Roofs and walls are constructed from natural materials found locally (such as leaves) or in the wider Ayeyawady Region Material availability has declined and will likely continue to do so with deforestation trends. This is a potential source of vulnerability as costs of materials and construction will increase, and this may push some to use less materials, while there is no indication that construction techniques are improving or adapting to heightened intensity of cyclones and floods.



Energy consumption is mostly wood for cooking, kerosene and candles for lighting. A few have solar panels.

Grid electricity is only available in Labutta Town and the villages located along the main road to Pathein. Electrification is a challenge because coverage has an impact on industry and therefore economic output. Some communities have access to solar panels that allow street lighting in main streets.

Households heavily rely on wood for cooking, mainly from cutting mangroves. This practice is unsustainable

## SOCIO-ECONOMIC

Low educational outcomes and an almost total lack of vocational training is a problem because there are few skilled people able to work in high value-added sectors.

The only economic sectors that provide large scale employment are agriculture and fisheries, which are highly climate sensitive, and daily wage labour (often in agriculture and fisheries) which is very insecure. Agriculture produces very low output per capita, which translates to low incomes. There are three main causes of this; little mechanisation, poor fertilization and management and high dependency on rain water, rather than irrigation.

Low education outcomes and a lack of skills are causing a negative cycle which contributes to both climate change vulnerability and poverty. Because skill levels are low and the majority of people don't have education beyond basic grade-5 level, people are resigned to unskilled labour in agriculture and fisheries. These livelihoods are heavily dependent on conducive climate and ecosystem services.



## ECO-SYSTEMS

As a result of deforestation in the delta, driven by agriculture, aquaculture expansion and cutting for fuel, mangroves are extremely degraded, and are unable to provide resilience benefits like coastal protection to the township population.



Figure 40. Fuelwood from mangroves for households ©MCCA

Mangroves in southeast Asia, especially those in the Ayeyawady Delta, are highly resilient systems due to their high biodiversity; mortality rates of some species were low after Nargis, except for the actual loss from the violent storm.

These resilient mangrove species can respond to, and recover from the impacts of climate driven



Figure 41. A waterway through mangroves near Kone Gyi ©MCCA

## INFRASTRUCTURE

as depletion of the natural capital of forestry makes households increasingly vulnerable as depletion is much faster than replenishment, meaning there is a net loss of mangroves, increasing prices, and reduced regulating services vis-à-vis storms and storm-surges, water cycle replenishment, soil management, coastal erosion, and habitats for fish. Only Labutta Town has electricity through the grid.

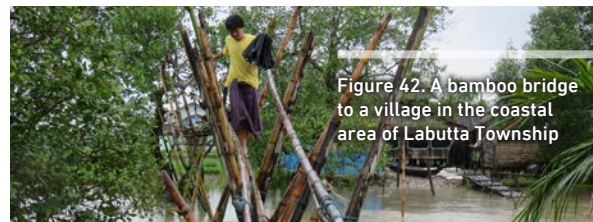


Figure 42. A bamboo bridge to a village in the coastal area of Labutta Township

The already vulnerable transport infrastructure will worsen by more floods and inundation as a result of severe storms and sea-level rise.

The current transport infrastructure relies on a network of secondary and tertiary unpaved roads with wooden bridges to cross the smaller streams. People's mobility and connectivity will worsen as flooding and inundation increase across the whole township, but especially in the south and central area.

Public boats that serve the main connection between Pyinsalu and Labutta are highly dependent on weather conditions in the wet season. In southern coastal areas, accessible only through the main canals, this is a major source of vulnerability as weather may isolate people from markets, secondary schools and advanced healthcare for days in a row. The southeast is particularly vulnerable and with climate change will become even more isolated, and gradually less able to support life, because of sea-level rise.

## SOCIO-ECONOMIC

In these low-paying and highly vulnerable sectors, people cannot accumulate savings to invest in new technologies or upskill. Because of this situation, Labutta Township becomes a less attractive place to invest in higher value-added, non-climate-dependent industry, like manufacturing, as there is a shortage of skilled and semi-skilled people to work in these sectors.

Women are disproportionately affected by the socio-economic impacts of climate change.

Women are far more likely to be economically inactive than men. Even though women play an active role in earning household incomes (through food processing or trading, for example) they tend to identify themselves as not participating in the labour force, or to be employed informally.

Women also have lower education outcomes, and women who are pregnant or breastfeeding have worse nutritional outcomes than men. When women do work, often in daily wage labour, their



Figure 43. A soft-crab farm in southwest Labutta ©MCCA



## ECO-SYSTEMS

hazards such as coastal storms, and slow-onset changes like sea-level rise.

Vulnerability is further increased by direct impacts of climate change on mangroves and related ecosystem services. Degradation and disappearance of mangroves affect ecosystem services, such as fresh water supply, habitat for fishes, which in turn reduces the productivity of ecosystem-reliant sectors, such as fisheries.

Loss of mangroves has resulted in declining fish availability

A 1 hectare loss of mangrove results in a reduced fish catch of around 480 kilogrammes per year.



## INFRASTRUCTURE



Basic health and education coverage is fairly good across the township.

However, public buildings are often not disaster resilient and therefore don't have dual purpose usage in the case of cyclones and floods, which increases communities' vulnerability to more intense hazards. Similarly, monasteries remain key in providing informal social services, such temporary shelter and water, but their limited capacity and resources don't cover all communities

Poor siting, orientation and location of some settlements and individual housing make communities more vulnerable.

Land-use planning does not efficiently and systemically consider locations, siting, orientation of public buildings and settlements and there is no mechanism to integrate additional features resulting from changes in climate to plan for new infrastructure. This lack of climate-sensitive land-use planning increases potential vulnerability of all households.



## SOCIO-ECONOMIC

incomes are usually lower, and can be as little as 1,500Kyat per day, less than half of the minimum wage.

Women's roles in earning income, which involve trade, are also more easily disrupted by transportation issues, which occur frequently. This means that they are unable to access markets, and can face disproportionate disruption when disasters affect transportation links.



Production is not diverse; it is highly dependent on rice paddy cultivation and open water fisheries

This means that if one of these two sectors is affected by a climate change related hazard there is no mechanism to provide income for a large part

## ECO-SYSTEMS

Increasing ocean temperature changes fish behaviour and migration patterns, possibly driving them further away from the coast – or at least, existing fishing grounds. This will further decline fish catches, reducing incomes and increasing vulnerability. The assessment can't prove definitively whether reducing fish populations are due to climate change related factors or as a result of over-fishing, and the nature of the interaction between the two issues. Fishing equipment handed out after Nargis has a significant impact on fish populations.



Figure 48. Groundwater pump ©MCCA

## INFRASTRUCTURE

Disaster risk reduction and preparedness has been improving dramatically after Nargis, however locational barriers should be considered as a contributing factor towards ensuring response to cyclone warnings.

There is a generally good level of awareness and robust mechanisms of early warning systems, evacuation routes, disaster management committees. However, there are some gaps in the central-eastern areas of the township, where there are fewer facilities, radio and television are not available everywhere and communities are deprived from the news of cyclone warning due to their location. Women are more vulnerable because in most cases, women are responsible for looking after the elder and their children, storing and carrying essential items and ensuring food security during disaster, exacerbating women's difficulty to safe mobility. In addition, some communities reported that the river/streams were a major barrier to reach the cyclone shelter.

There is a network of cyclone shelters as a result of support received from development partners after Cyclone Nargis, with development partners and with the national strategy and MAPDRR.

However, this vulnerability assessment shows significant gaps in their coverage; meaning that a substantial number of people are still without easy access to cyclone shelters.

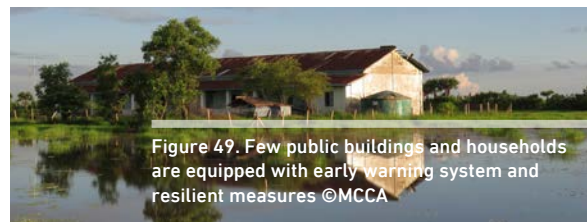


Figure 49. Few public buildings and households are equipped with early warning system and resilient measures ©MCCA

## SOCIO-ECONOMIC

of the population. This economic system, dependent on two sectors for more than 70% of people's livelihoods, does not have the flexibility to withstand or recover quickly from shocks.

The economic structure of the township revolves around smallholder production with little collective or corporate association. This increases the risk level for individuals. There is almost no functional redundancy and no safety net in case of failure.

Fishermen especially suffer market failures from a situation in which there are many individual sellers but only a handful of buyers. Farmers similarly tend



Figure 50. A boat-builder at his workshop ©MCCA

to sell produce as individuals, and do not tend to pool savings or work collectively to achieve better prices. This also means that there is no support mechanism in the event of a sudden decline in catch

## ECO-SYSTEMS

The structure of the aquifer limits the ability of people to dig wells and thus have access to an additional water source that is less affected by increasing variability and intensity of rainfall.

In the coastal area people would have to dig very deep (to the third layer of the aquifer) to reach good quality freshwater.<sup>47</sup>

This, coupled with a lack of storage infrastructure, results in a high reliance on rain-fed water sources that are increasingly affected by intense and erratic rainfall during the monsoon season.



## INFRASTRUCTURE



Households mostly rely on a mix of individual water harvesting (jars) and community ponds.

Water harvesting is often ineffective, management of the water consumption is insufficient, and hygiene problematic. Open surface water leaves the households vulnerable to increased evaporation. In effect, stronger rains in a shorter period of time renders water harvesting and management of water storage challenging. Piped water is only available in some areas of Labutta Town. Salinization affects many these ponds

Rain water harvest ponds are the main water facility for drinking, irrigation and livestock use, and are highly vulnerable to climate changes

90 per cent of Labutta's population relies on ponds, rivers and streams for drinking water and irrigation. This makes the entire township vulnerable to rain variability, increased temperatures and salinization. Higher temperatures will increase evaporation and increase concentration of salt in water; a shorter monsoon season could reduce the amount of days for collection of rain, while more intense rain will damage storage infrastructure. Ponds will be infiltrated increasingly by salt as the sea level rises.

## SOCIO-ECONOMIC

in fisheries or crop failures in agriculture. In both sectors low and declining productivity will have a knock on effect on declining availability of daily wage labour.



Migration rates are very high

The causes of migration are complex, but the fact that outward migration almost always takes places among youth demographic, suggesting that a lack of education and employment opportunities are the overwhelming drivers. Added to this is a gender disparity – more than twice the number of men migrate than women. As the migrants are young and generally unskilled, migration with dignity becomes a

## ECO-SYSTEMS

With its location as the outlet of the Ayeyawady, high sedimentation rates, while positive for the overall productivity of the system, can also cause siltation of infrastructure and affect surface drinking water quality.

Increased frequency and intensity of extreme storms locally and upstream will increase sedimentation and decrease water quality.

The seasonal pattern, and dependence on rice paddy cultivation means that, without infrastructure, almost all agricultural production must take place during the rainy season.

Because of this, food security is dependent on what can be grown in the wet season. As a result, increasing rainfall variability limits productivity and could have a knock-on effect on food security

Due to its humid monsoon climate, crop pests and disease are a natural limitation to agricultural yields.

With expected increased humidity in the future as temperatures rise and rainfall increases, these are expected to worsen, further limiting crop yields.

The topography is flat and low-lying, which means the agro-ecosystem is affected by saline intrusion across the entire township by the end of the dry season (March).

Sea-level rise will exacerbate this problem. With a shorter monsoon (and thus longer dry season) in the future, saline intrusion will likely last even longer

## INFRASTRUCTURE

There is a lack of infrastructure for water storage at community level (such as water tanks and reservoirs) and in schools, health posts and other public buildings.

Exceptions are to be found in monasteries, and in development organization buildings such as cyclone shelters, but they are insufficient to meet requirements. Management of the existing storage is an ongoing problem as some users tend to deplete resources and not manage them wisely.

Sanitation in households is limited, and overtime, with more floods and heavy rains, pit latrines can overflow, contaminate water sources, and ultimately increase the risk of water-borne diseases

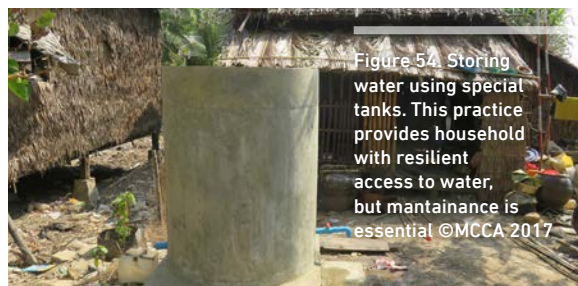


Figure 54. Storing water using special tanks. This practice provides household with resilient access to water, but maintenance is essential ©MCCA 2017

This lack of adequate disposal of untreated domestic wastewater will further affect the water quality in the delta as more intense rains and floods are expected to increase.

The current irrigation system is challenged by salinization of freshwater sources.

In some parts of Northern areas, a system of irrigation canals and dykes allow for use of freshwater for two cropping seasons, allowing higher yields. In central areas, there is some capacity to pump water from the

## SOCIO-ECONOMIC

serious challenge. As incomes decrease because of climate change, greater levels of migration are inevitable.

Dependence on remittances make economic planning and investment difficult as they are unreliable

Remittances can increase household incomes, but they are also unstable and make economic planning more difficult. Although according to some international organizations in the short to mid-term remittances support populations, in the longer-term they may weaken the socio-economic fabric.



Figure 55. A farmers' group meeting in the school room ©MCCA 2016

## ECO-SYSTEMS

and affect areas farther north of the township when flows are lowest during the dry season months.

The entire fresh-brackish-salt water continuum is moving further in-land, affecting wildlife crops and drinking water. As an alluvial plain, there is naturally high soil productivity in the Ayeyawady, but this is being challenged by increasing saline intrusion (in south and central areas) which is seasonal (in the central area) and worsened by storm surges.

In many areas, farmers still report low productivity resulting from salt water intrusion during Nargis.



## INFRASTRUCTURE

river, but they experience a seasonal salinity and there is a progressive decline in outputs. The lack of freshwater is especially challenging in the southern area of the township

Lack of capacity to prevent salt intrusion through formal infrastructure, and some attempts to manage it through autonomous community small infrastructure.

In central and southern areas, all farmers complain of increased salinity and lack of capacity to prevent salt intrusion. Systems of local embankments have been constructed, but their effectiveness is limited and require frequent improvement and strengthening.

In addition, the system of dykes-roads is antiquated and unable to withstand the projected impacts of sea-level rise, storm-surges, inundations and floods from intense rains

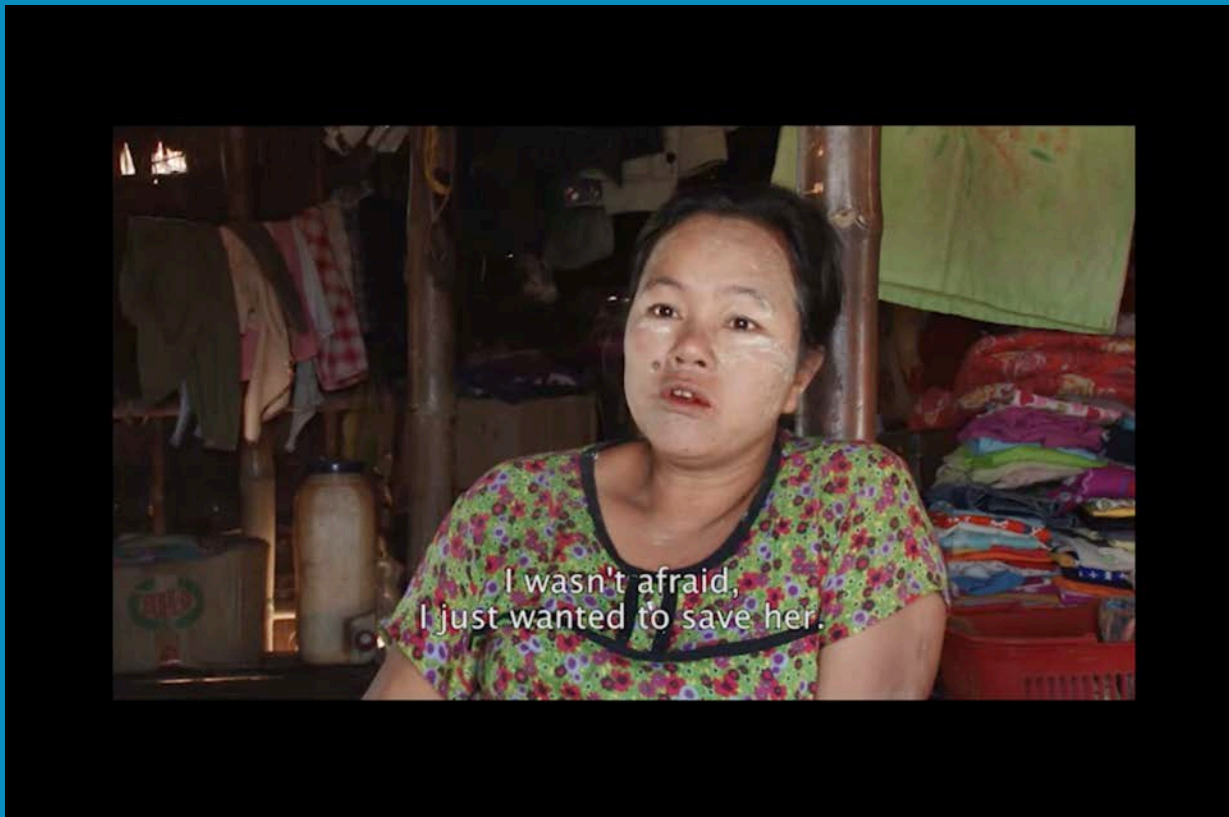


## SOCIO-ECONOMIC

Low incomes per household limit flexibility and capacity to prepare and respond to rapid on-set disasters, reduce capacity to adapt to slow on-set phenomena such as salinization, increases in temperatures and variability, and to recover after the event.

For instance, they cannot afford to try seeds that are more adapted to new temperatures as they cannot assume risks of failure or lower productivity. A lack of saving means that capital investment in actions that would enable preparedness and recovery. A lack of technology and machinery hinders efficient production, while a lack of insurance and other basic safety nets means that risk is almost entirely borne at the household level.





From interviews for the climate change documentary 'Warmer Days: Myanmar in the Age of Climate Change' produced by the Yangon Film School for MCCA:

"Thingangyin village used to be a big village. That was before Nargis, now it's small. As the water level rises and the sea gets warmer the fish are dying. Erosion is also on the increase. Young people are leaving the village and heading to Yangon to find work to help support their families."

Ma Sandar Aye helps her husband who is a fisherman. There is less fish now. She talks about how the village used to be big but is now small. The village used to have a fish paste factory but it has closed down. She tells us about her Nargis experience. Most of the village was flooded; so many people lost their lives.

She really wants her children who are aged between four and 18 years old, to be educated. Though they are poor she tries hard to earn enough money to send them away to school. The school is far away from the village and in rainy season it's dangerous to get there. So they have to hire a motorbike taxi to take them, which adds another expense to their already stretched resources.

(by Khin Myanmar, Yangon Film School for MCCA)

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The documentary 'Warmer Days: Myanmar in the Age of Climate Change' is available here: [www.myanmarccalliance.org](http://www.myanmarccalliance.org)



# 4

## CLIMATE CHANGE AND FUTURE RISK

In this chapter, projected changes in climate are presented up to the year 2050 and potential impact discussed against the current ecological, infrastructure & transport, and socio-economic conditions.

This chapter concludes that Labutta will face changes in climatic conditions that will lead to increased risk of rapid on-set disasters, such as cyclones and inundations; and the effects of transformative climatic processes, such as sea-level rise and associated salinization of land or water scarcity.

Sea level rise up to 40 centimeters by mid-century will result in larger flooding risks and the receding of the coastline; salinization of water sources; inundation and waves from storm surges and high tides associated with storms.



Increased average temperatures in Labutta of up to 2.0°C by 2050 will affect water availability from increased evaporation of surface water sources; affect crops; eco-system services; and contribute to form cyclones. In addition, by mid-century, the extreme heat days are projected to occur at a frequency of 4-17 days per month.

Total rainfall for Labutta may also increase during the monsoon season, therefore producing stronger raining events, although models are less clear on the rainfall projections.

Decision-makers will therefore need to plan for coastal flooding, salinization, cyclones, warmer average and peak temperatures, greater amounts of rainfall in a shorter monsoon season, and unknown rainfall changes during other seasons.



## CLIMATE MODELLING METHODOLOGY

Myanmar’s temperature, precipitation, sea level, and extreme events are projected to shift dramatically in the coming decades, resulting in lasting impacts on Myanmar’s ecosystems, which in turn will impact human health, agriculture, food security, infrastructure, local livelihoods, and the larger economy. The climate risk information for Labutta was developed as a part of the ADVANCE partnership between WWF and the Columbia University Center for Climate Systems Research (CCSR) at The Earth Institute. In Myanmar, ADVANCE is collaborating with the Department of Meteorology (DMH), the Myanmar Climate Change Alliance (MCCA), and other key stakeholders that can aid adaptation and resilience planning across many sectors in Myanmar.

Through this cooperation, the CCSR and WWF, in cooperation with MCCA published the “Assessing Climate Risk in Myanmar: Technical Report”<sup>47</sup> The report downscaled projections for Labutta and Pakokku. All figures and tables concerning climate change projections are extracted from this report.

Outputs from 21 climate models and two scenarios of future changes in greenhouse gases corresponding to low and high estimates of change (from RCP 4.5 and RCP 8.5) are used to project annual and seasonal temperature and rainfall



Figure 59. Average Historical Climate in Labutta for 1981-2010 (data from nearby Pathein weather station)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Minimum temperature (°C)	17.3	19.0	21.6	24.2	25.1	24.3	24.0	24.0	23.9	23.9	22.1	18.7
Maximum temperature (°C)	32.0	33.8	35.7	36.6	34.3	30.8	30.3	30.0	31.0	32.2	32.1	31.3
Mean temperature (°C)	24.6	26.4	28.6	30.4	29.7	27.6	27.1	27.0	27.4	28.0	27.1	25.0
Rainfall (mm)	2	8	7	26	269	615	652	633	379	186	92	4

● Wettest month      ● Hottest month  
● Driest month      ● Coldest month

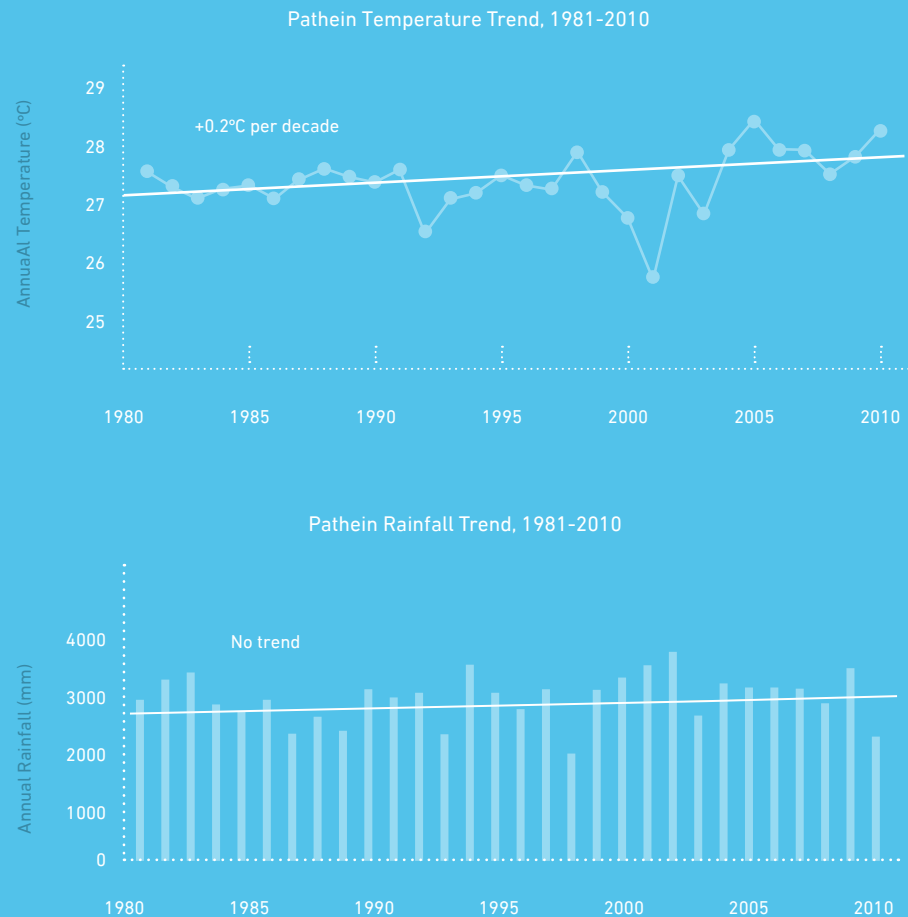
<sup>47</sup> Horton, R., De Mel, M., Peters, D., Lesk, C., Bartlett, R., Helsing, H., Bader, D., Capizzi, P., Martin, S. and Rosenzweig, C. 2017. *Assessing Climate Risk in Myanmar: Technical Report*. New York, NY, USA: Center for Climate Systems Research at Columbia University, WWF-US and WWF-Myanmar.

changes for the early (2011 to 2040) and mid-21st century (2041 to 2070). The NASA Earth Exchange Global Daily Downscaled dataset is the dataset used to develop these climate projections. To project sea level rise, outputs from 24 climate models and two greenhouse gas emissions scenarios are integrated with other sources of information (see annex for detailed methodology). Observed climate analysis uses weather station data from 1981-2010 based on data provided by the Myanmar Department of Meteorology and Hydrology (DMH). Sea level rise projections are also presented for the entire coastline of Myanmar, including the coastal delta area closest to Labutta.

## OBSERVED CLIMATE

Figure 43 shows the average historical weather conditions (climatology) during 1981-2010 for the nearest weather station to Labutta – Pathein station, located 70km north of Labutta. The proximity of Pathien to Labutta and its location within the Ayeyawady Delta region suggests that the two sites likely experience comparable climate conditions. The results in Table A.1 suggest that the driest month is January and the wettest is July. The warmest parts of the year are April and May, and the coolest months are December and January.

**Figure 60. Annual mean temperature and total rainfall over 1981-2010 at the Pathein weather station. Data are complete throughout. There is no noteworthy trend in rainfall, but temperature increased by 0.2°C per decade over the time period**



## 4.1 CLIMATE CHANGE PROJECTIONS

- Sea level for the coastal area closest to Labutta is projected to increase by 20 to 41 centimetres by mid-century, while projections for the end of the century could exceed 1 metre.
- Temperature in Labutta is expected to rise over the coming decades; by mid-century, annual average temperatures are projected to rise by 1.1-2.0°C
- Warming in the hot season (March-May) and cool season (November-February) is projected to slightly exceed warming in the wet season (June-October); by mid-century, extreme heat days between March and May are projected to occur at a frequency of 4-17 days per month, relative to a historically-defined rate of 1 per month.
- Climate models suggest an increase in total rainfall for Labutta, with the increase projected to be experienced principally during the monsoon season.
- The direction of rainfall change in the hot and cool seasons is unclear. Climate models project a wide range of potential rainfall changes, spanning from an increase to a decrease.

### SEA-LEVEL RISE

The climate change middle range estimates for this coastal area of Myanmar —that is, the middle 50 percent of all the projected outcomes — suggest 20 centimetres to 40 centimetres of sea level rise by the 2050s (2041-2070). By the 2080s (2071-2099), the middle range of projections indicate between 37 centimetres and 81 centimetres of sea level rise, with the potential for up to 121 centimetres in the highest range of projections for this time period.

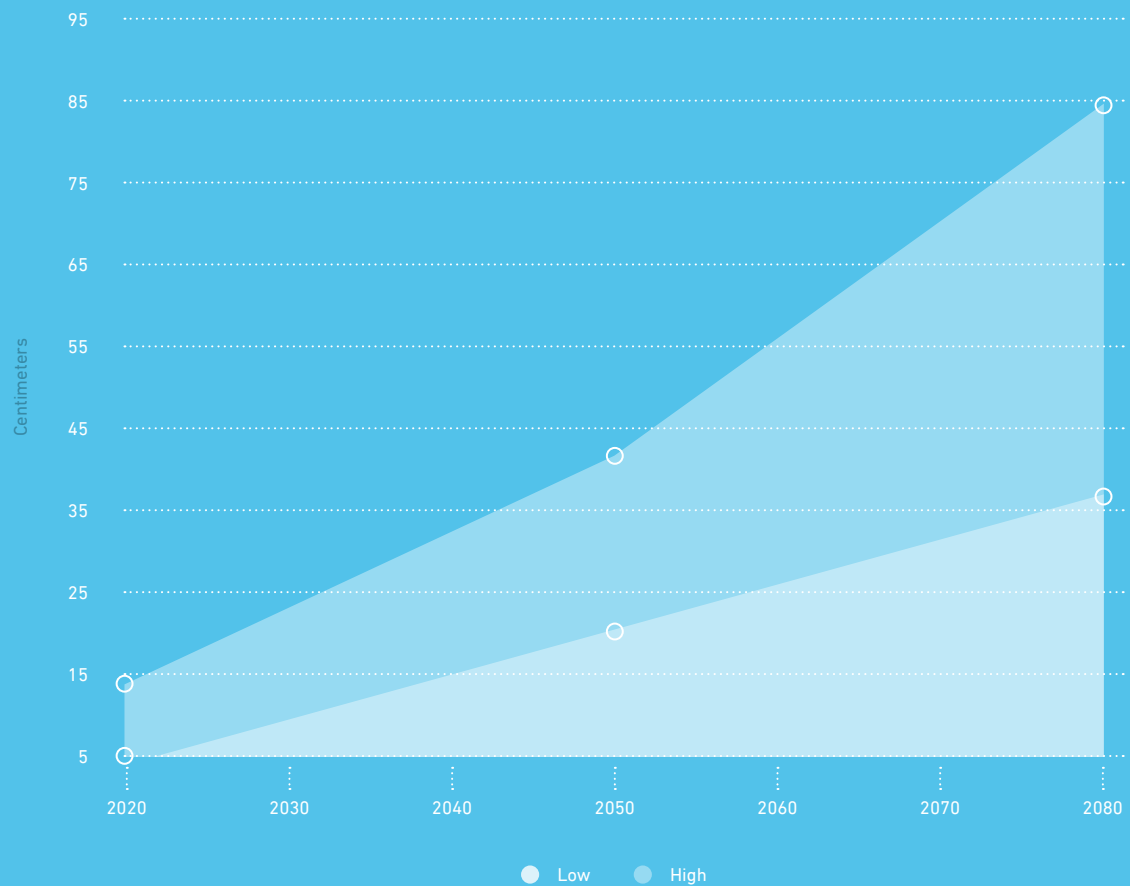
The magnitude of these projections are similar along the entire coastline of Myanmar. These projections take into account global and regional components that contribute to changes in sea level. These include thermal expansion and local ocean height (ocean component), loss of land ice, and global land water storage. Due to the absence of observed data, the results do not take into account local land subsidence. For much of the Myanmar coastline, local land subsidence is negligible; however, in delta regions near Labutta, land subsidence may lead to effective sea level rise amounts that are larger than those presented here.

Given that this region is low-lying, these sea level rise projections would mean a large increase in area flooded (both permanently along the current coast, and sporadically further inland as a result of storms and high tides further inland). Sea level rise also increases the frequency and magnitude of flooding for any given coastal area. As was evidenced by the devastating effects in the densely populated delta that occurred during Cyclone Nargis in 2008, Myanmar is already highly vulnerable to coastal flooding. This projected increase in sea level would allow coastal storms of equal magnitude to carry waters even further inland in the future, resulting in even wider-reaching impacts.

### TEMPERATURES (AVERAGE AND PEAKS)

Temperature in Labutta is expected to rise over the coming decades because of increasing greenhouse gas concentrations, though the magnitude of warming varies by season. By mid-century (2041-2070), the annual average temperatures are expected to rise by 1.1-2.0°C compared to the 1980-2005 base period. Warming in the hot season (March-May) and cool season (November-February) is projected to slightly exceed warming in other seasons. Regional projections for the Ayeyawady Delta show similar patterns. Locally, while temperature in Labutta and the Ayeyawady Delta

Figure 61. Projected Sea Level Rise in Myanmar



region is projected to rise, the models suggest that the magnitude of warming may be less than the national average.

The analysis shows how extreme hot days in Myanmar are expected to change. During the 1981-2010 period, about 1 extreme heat day per month<sup>48</sup> was observed in the maximum temperature data. By the 2041-2070 period, the incidence of extreme heat days during March to May is projected to rise substantially, ranging from 4-17 days per month.

### RAINFALL

Total annual rainfall is projected to increase in Labutta, the Ayeyawady Delta region, and Myanmar as a whole. Model results suggest that total rainfall increases in Labutta may primarily be driven by monsoon season increases. In contrast, in the hot and cool seasons, models project a wide range of rainfall changes, spanning from increase to decrease.

Figure 62. Projected change in mean temperature (+°C) and mean total rainfall (%) in 2041-2070 compared to the 1980-2005 average baseline for Labutta, the Ayeyawady Delta region and for Myanmar

	ANNUAL		HOT SEASON March to May		WET SEASON June to October		COOL SEASON November to February	
	Low Estimate*	High Estimate**	Low Estimate	High Estimate	Low Estimate	High Estimate	Low Estimate	High Estimate
<b>LABUTTA</b>								
TEMPERATURE	+1.1°C	+2.0°C	+1.2°C	+2.3°C	+1.0°C	+1.9°C	+1.1°C	+2.3°C
RAINFALL	+3%	+23%	-7%	+17%	+3%	+24%	-8%	+15%
<b>REGIONAL - AYEYAWADY DELTA</b>								
TEMPERATURE	+1.1°C	+2.1°C	+1.2°C	+2.4°C	+1.0°C	+2.0°C	+1.1°C	+2.4°C
RAINFALL	+3%	+23%	-7%	+19%	+3%	+25%	-9%	+15%
<b>MYANMAR</b>								
TEMPERATURE	+1.3°C	+2.7°C	+1.4°C	+2.9°C	+1.1°C	+2.4°C	+1.3°C	+2.8°C
RAINFALL	+6%	+23%	-7%	+19%	+6%	+27%	-12%	+11%

- Wettest month
- Hottest month
- Driest month
- Coldest month

\* Low estimate refers to the 25th percentile of model outcomes in greenhouse gas emissions scenario RCP 4.5;

\*\* High estimate refers to the 75th percentile of model outcomes in greenhouse gas emissions scenario RCP 8.5; Note: Please note that the baselines for each region in Myanmar differs, therefore the actual change in rainfall (in mm), will depend on the various baselines of each region.

<sup>48</sup> Extreme heat days' are defined as days with a maximum temperature exceeding a threshold corresponding to the 95th percentile of daily maximum temperatures for the month in the historical record (1981-2010).

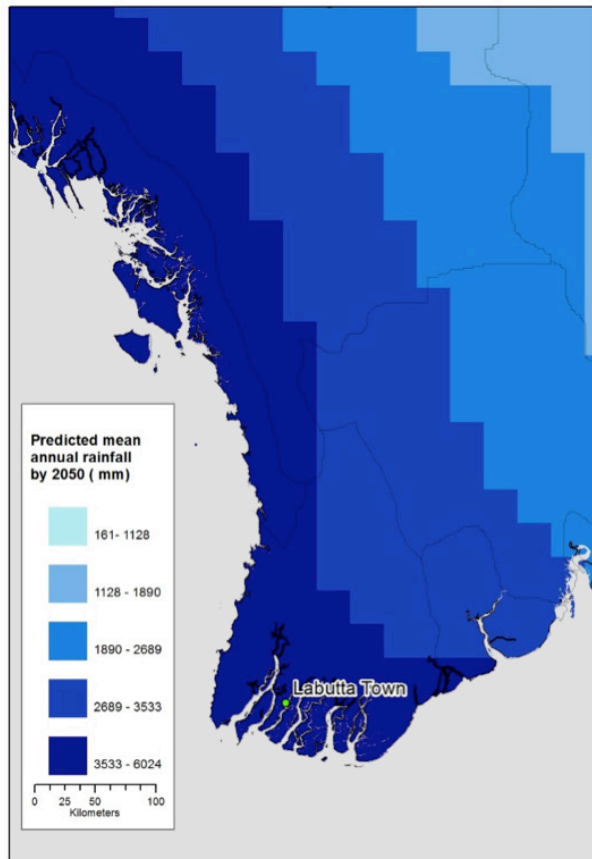


Figure 63. Projected annual rainfall totals are based on greenhouse gas emissions scenario RCP 8.5, representing the 75th percentile among 21 model runs, and at 0.25 degrees (25 km) spatial resolution. Darker areas indicate higher rainfall totals, while lighter areas lower. Because these are model estimates, differences between each colored region are not statistically significant, only indicating potential future rainfall with considerable spatial uncertainty. Notably, coastal areas show more substantial increases in rainfall than inland.

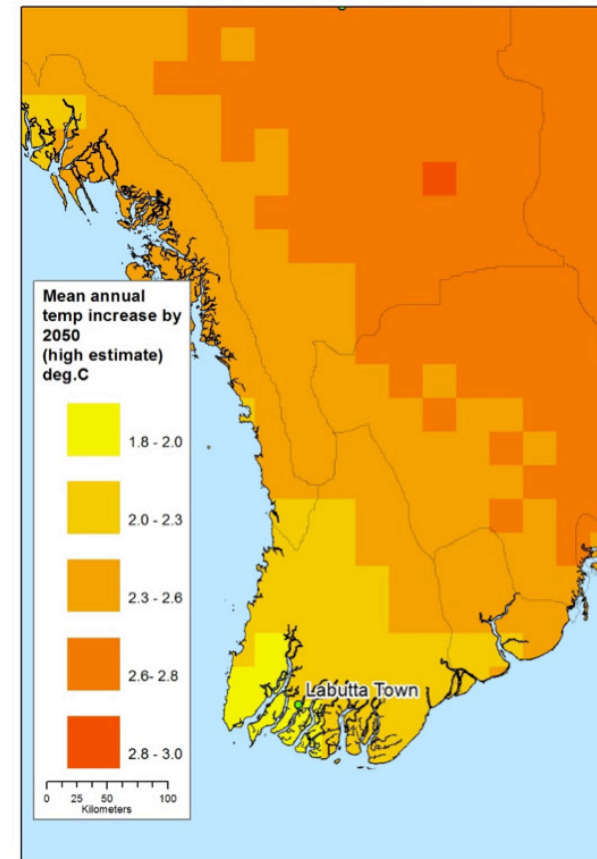


Figure 64. Projected mean annual temperature increase is based on greenhouse gas emissions scenario RCP 8.5, representing the 75th percentile among 21 model runs (high estimate), compared to model baseline temperatures, and at 0.25 degrees spatial resolution (25 km). Darker areas indicate greater increases, while lighter areas lower. Because these are model estimates, differences between each colored region are not statistically significant, only indicating one estimate of potential temperature increase with considerable spatial uncertainty. Notably, coastal areas experience lower increases than inland.

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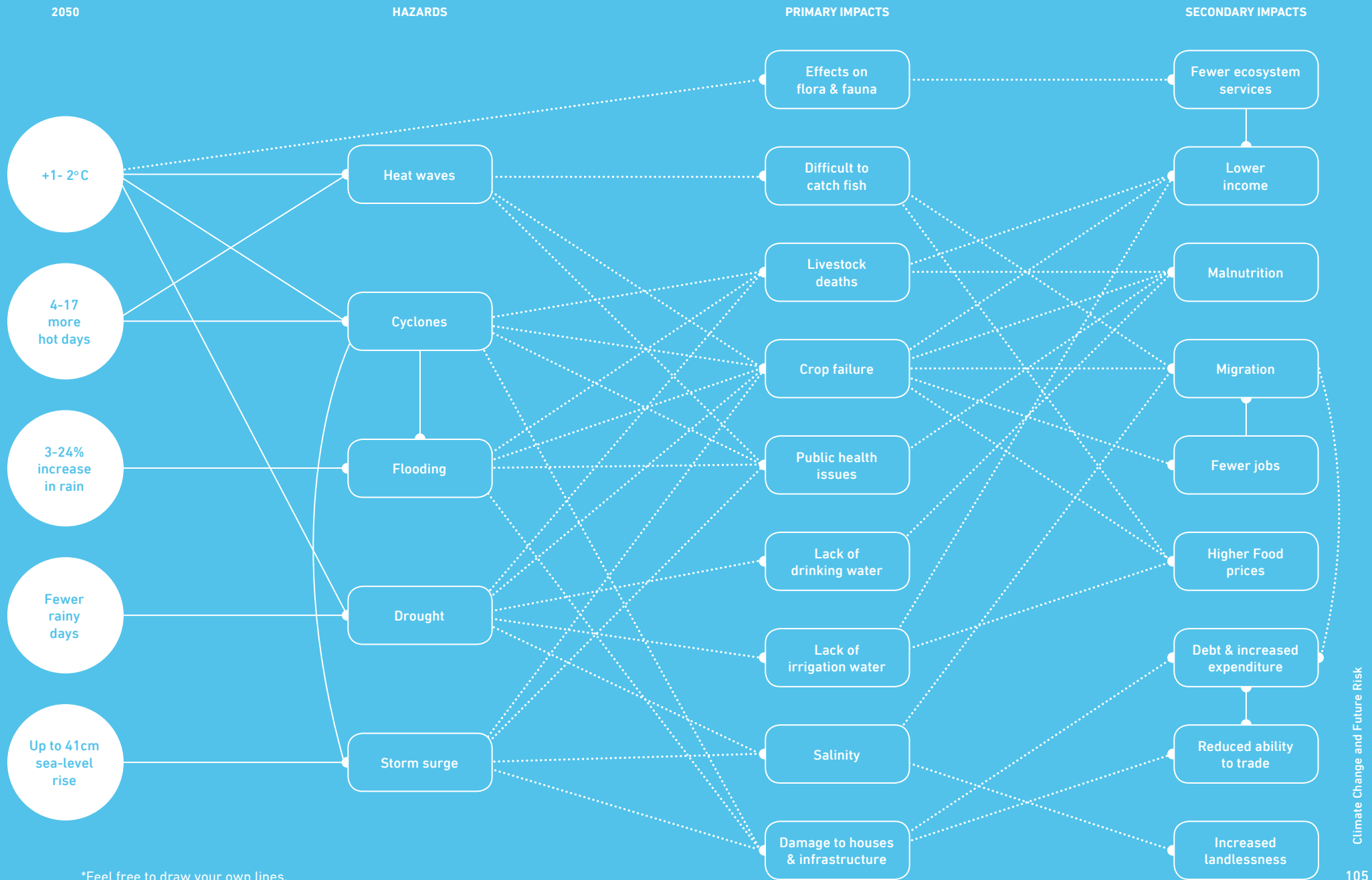
## 4.2 POTENTIAL IMPACT PATHWAYS

Through the analysis of secondary data and models, and in consultation with the communities, the assessment suggests a 'path to impact' graphic as shown in this chapter. The figures show how changes in climatic features will alter the hazard profile of the township; and this in turn may generate a chain of primary and secondary impacts - with varying degrees of correlation - that may occur from now to 2050 and beyond. The path to impact graphic also shows the complex correlation between hazards and impacts, including how a given primary impact can cause multiple secondary impacts. The graphic assumes the present conditions of vulnerability as starting point. This is not a forecast, but an effective visual representation of the effects climate change can have on Labutta.

The left-hand column shows the full range of projected changes in the climate as discussed in Section 4.1. of this report. The second column shows what the team and communities have identified to be the five major hazards that are already affecting Labutta, and are likely to become more severe in the future because of projected climate change. These are: floods and inundation, cyclones, heat waves, drought, and storm surges. The primary impacts that result from these hazards are listed in the next column. Here we see that some impacts can be caused by multiple hazards. For example, crop failure and pests can result from all five of the hazards identified. By understanding this relationship, we can begin to see which people are more likely to be vulnerable; farmers are highly vulnerable because the crops on which they depend for their livelihood can be impacted by numerous hazards. Secondary impacts consider the broader, knock-on effects in the township. Continuing the example of crop failure, the graphic shows that this results in worsening nutritional outcomes, because many farmers keep a substantial amount of their crops for household consumption. They also cause waves of migration, because many farmers will be forced to leave the township in order to seek work, either in Patheingyi, Yangon or abroad. They can also have an impact on the capacity to grow crops in the future as a result of decreased soil fertility. Primary and secondary impacts can also cause a vicious cycle. For example, crop failure and a lack of water for agriculture can reduce agricultural productivity while increasing food prices. This in turn can drive migration and indebtedness, as people either seek work elsewhere or borrow to meet their basic needs. If people do not take such coping actions, they may instead suffer from malnutrition and as a result public. Importantly, communities and authorities possess coping strategies: this graphic only shows that climate change will test these strategies greatly.



Figure 65. Pathways to potential climate change impact\*



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## 4.3. FUTURE RISK PROFILE AND VULNERABILITIES

The projected changes described in the previous chapter will result into two main large consequences:

- i. Firstly, they will increase the intensity, and perhaps frequency, of rapid on-set disasters. This will result in a greater impact from destructive weather systems such as cyclones, intense rains and floods, inundation and potential 'double effects', such as high tides during cyclones and strong rains that heighten the extent of floods and inundation.
- ii. Secondly, they will continue to produce profound, transformative effects on the eco-system - such as salinization, higher temperatures - and therefore on the way communities benefit from its services. In turn this will affect productive systems, particularly agricultural productivity and access to water

This section of the assessment assumes that business will be conducted as usual, meaning that no consistent and extensive adaptation actions will be taken to mitigate climate change effects by, for instance, investing in resilient infrastructure, diversifying the economy and managing eco-system services in a sustainable manner.

As such, the future vulnerabilities presented in this chapter are not a forecast of the situation of Labutta's ecosystem, infrastructure, or socio-economic conditions in 2050. They rather illustrate how climate change, given the current conditions of these systems, will affect Labutta if no corrective measures are taken to address sensitivities assessed by this study.

## i. INCREASED RISKS OF RAPID ON-SET DISASTERS

The changes in climate will result in increasingly intense hazardous events. As vulnerability depends on the interaction of hazards with the exposure of people and assets and their sensitivity to external factors, the risk of destruction and loss of lives will increase in the coming decades. Labutta's hazard and risk profile will worsen, with a combination of more severe rains, cyclones and tropical storms, storm-surges, floods and inundations, and heat waves. Under the current conditions and trends, there is no indication that vulnerabilities will be reduced in the socio-economic, infrastructure and ecological systems.

The threat to people's safety and of loss of life from destructive events will increase, as current infrastructure, planning, and productive methods are not able to withstand increasingly severe hazards. This is because there will be greater risks of rapid on-set disasters from floods and inundation, intense rain, cyclones and tropical storms, storm-surges, and heat-waves.

The tables on this page summarize schematically the impact that changing climatic features will have in case vulnerabilities are not reduced through climate change adaptation and disaster risk reduction.



### + 2° C Warmer

Increase in mean temperature of 1.1 to 2.0° C<sup>49</sup>

HAZARD	MAIN PROJECTED IMPACTS
Heat waves	Crop failure and low yields; Livestock health impact; Human health impact, Decline in worker's productivity; Heightened unemployment and climate-induced migration
Reduced water availability	Severe water shortages, resulting in lack of consumable water and water for irrigation
Cyclones/ strong winds	Damage to land and crops; Damage to housing and infrastructure; Damage of coastal ecosystems and ecosystem services; Loss of lives and livelihoods; Saline intrusion in agriculture fields; Impact to people's mobility; Displacement of people



### +/- Rainfall

Changes in precipitation patterns, with rainfall projected to change by -13% to +18% in the hot season; and -27% to +13% in the cold season<sup>50</sup>

HAZARD	MAIN PROJECTED IMPACTS
Intense rains	Flash floods and intense surface runoff and soil erosion resulting in damage of crops; Enhanced problems during La Niña due to excessive water levels
Flooding/ storm surges	River floods, flash floods, and urban flooding, with characteristic effects on people and assets; Severe inundation of land; Damage of coastal ecosystems and ecosystem services; Damage to land and crops; Damage to housing, assets and infrastructure; Loss of lives and livelihoods; Impact to people's mobility; Displacements leading to potential conflict over land
Extreme high temperatures	Heat waves and urban heat island effect; Reduced water availability; Human health impact; Livestock health impact



### + Sea Level

Sea-level rise, with middle range sea level rise projections of 20-40cm in the 2050s<sup>51</sup>

HAZARD	MAIN PROJECTED IMPACTS
Inundation	Inundation of cultivated lands and villages with seawater; Loss of land, infrastructure, and coastal habitats; and Saltwater intrusion and coastal erosion
Floods/ Storm surge	Inundation of land; Damage of coastal ecosystems and ecosystem services; Damage to land and crops; Damage to housing, assets and infrastructure; Impact to people's mobility
Salinization	Disturbance to soil and water characteristics; Damage to coastal ecosystems and ecosystem-services; Reduced water availability for consumption and irrigation
Erosion	Loss of land and human settlements; Destruction of coastal ecosystems and riverbanks; Conflicts over land allocation

## ii. INCREASED RISKS OF SLOW ON-SET DISASTERS AND NEGATIVE EFFECTS KEY SECTORS

This section introduces the vulnerabilities that are likely to emerge or worsen under projected future climate change.

It follows on from the pathway to impact graphic, shown in Section 4.2, by applying coefficients of change to the complex and interlinked primary and secondary impacts.

By undertaking this analysis, the assessment shows how the new climatic features will intersect with the ecosystems, infrastructure and socio-economic conditions in the future. This will create scenarios for the township, explained in the next chapter.

While analysing all systems in the township is not possible, it focuses on the main, interlinked systems that people in Labutta depend on. These are:

### 1. The capacity of the population to benefit from agriculture and incomes in the agriculture sector will decline sharply by 2050

The capacity of the population to benefit from agriculture relies mainly on three eco-systems services; freshwater, soil and crops, that will be highly impacted by projected climate change:



+ 2° C Warmer

HAZARD	ECO-SYSTEM SERVICE	MAIN PROJECTED IMPACTS
Higher average temperatures cause big changes in extreme heat	Soil	Increased evaporation causes increased aridity and soil moisture loss, decreasing productivity
	Freshwater	Increased evaporation leads to lower flows and less water availability in the dry season
	Crop	Rice crop failure and lower yields, caused by the above. Incomes gradually decrease. Water use and the need for irrigation will increase



+/- Rainfall

HAZARD	ECO-SYSTEM SERVICE	MAIN PROJECTED IMPACTS
More heavy rain, which is less useful and more damaging	Soil	Increased soil loss due to increased erosion from increasingly frequent intense storms
	Freshwater	Increased water availability, but difficult to capture because of intensity; possible quality declines due to flooding
	Crop	Severe inundation of land results in damaged crops. In flood years, there will be 'voids' – total loss of crops, forcing people to temporarily seek daily wage work



+ Sea Level

HAZARD	ECO-SYSTEM SERVICE	MAIN PROJECTED IMPACTS
Level of sea salinity intrusion moving further north	Soil	Saltwater intrusion is one of the most important constraints to rice production, particularly for rain-fed system in the saltwater and mixed zones. Soil productivity has declined since Nargis as a result of increased salinity.  Total loss of rice fields in worst affected areas and loss of second crop in northern areas. Incomes of agriculture households will decline. Increased migration would be likely because of further reduced income
	Freshwater	Lack of freshwater for irrigation
	Crop	Constraints to rice production, particularly for rain-fed system in the saltwater and mixed zones.

If no significant adaptive action is taken, the capacity of people to depend on agriculture will be severely limited. The salt line will move further to the north and east, meaning that a much greater proportion of Labutta's agricultural land will be too saline to support the current mix of crops. This increase in salinity will also further restrict the availability of water for irrigation, meaning that areas in the central and northern area that are not currently affected by salinity will be more so, reducing their freshwater access.

The longer dry season will result in more evaporation, exacerbating the lack of freshwater while decreasing the quality of the soil, making agricultural land more arid in the dry season. Erosion will also be an issue, especially in the rainy season, as flooding will be increasingly likely. Inundation will also damage soil and make production much more difficult, meaning that in some years there would be a total loss of crops.

All of this will result in a decrease in incomes across the township, as such a large share of the population depends on agriculture, these reductions in income are discussed at the end of this chapter.

While forecasting likely output per capita is complex and prone to error, we can use some

projections to estimate potential crop yields. Crop modelling conducted throughout Southeast Asia shows that yields could reduce by as much as 15 per cent in Myanmar under RCP 4.5 with the CO<sup>2</sup> effect<sup>52</sup>. At present, output per capita in agriculture in Labutta is US\$537 per year (when factoring in economically inactive people who depend on agriculture). A 15 per cent reduction in output as a result of climate change would result in a revised per capita output of US\$456.45 (547,740 Kyat).

However, this does not factor in loss of productivity as a result of inundation or total losses in flood years. Indeed, agriculture will likely not be a viable livelihood in the coastal area under a business as usual scenario. The land near the coast would be permanently or seasonally inundated making it unsuitable for growing crops. Meanwhile, as the 'salt line' moves north and eastward, a larger area will become saline, meaning that more farmers will either be unable to grow a second, winter crop, or will be unable to practice agriculture altogether. If we assume, conservatively, that a further 10 per cent of land will be inundated or sufficiently saline to prevent crops from growing and that there will be an extreme event once every ten years that eliminates yields, this would reduce output per capita to \$369.85 (443,820 Kyat), based on the same assumptions.



Figure 66. MCCA builds a disaster resistant house based on the results of this assessment, as model for the communities

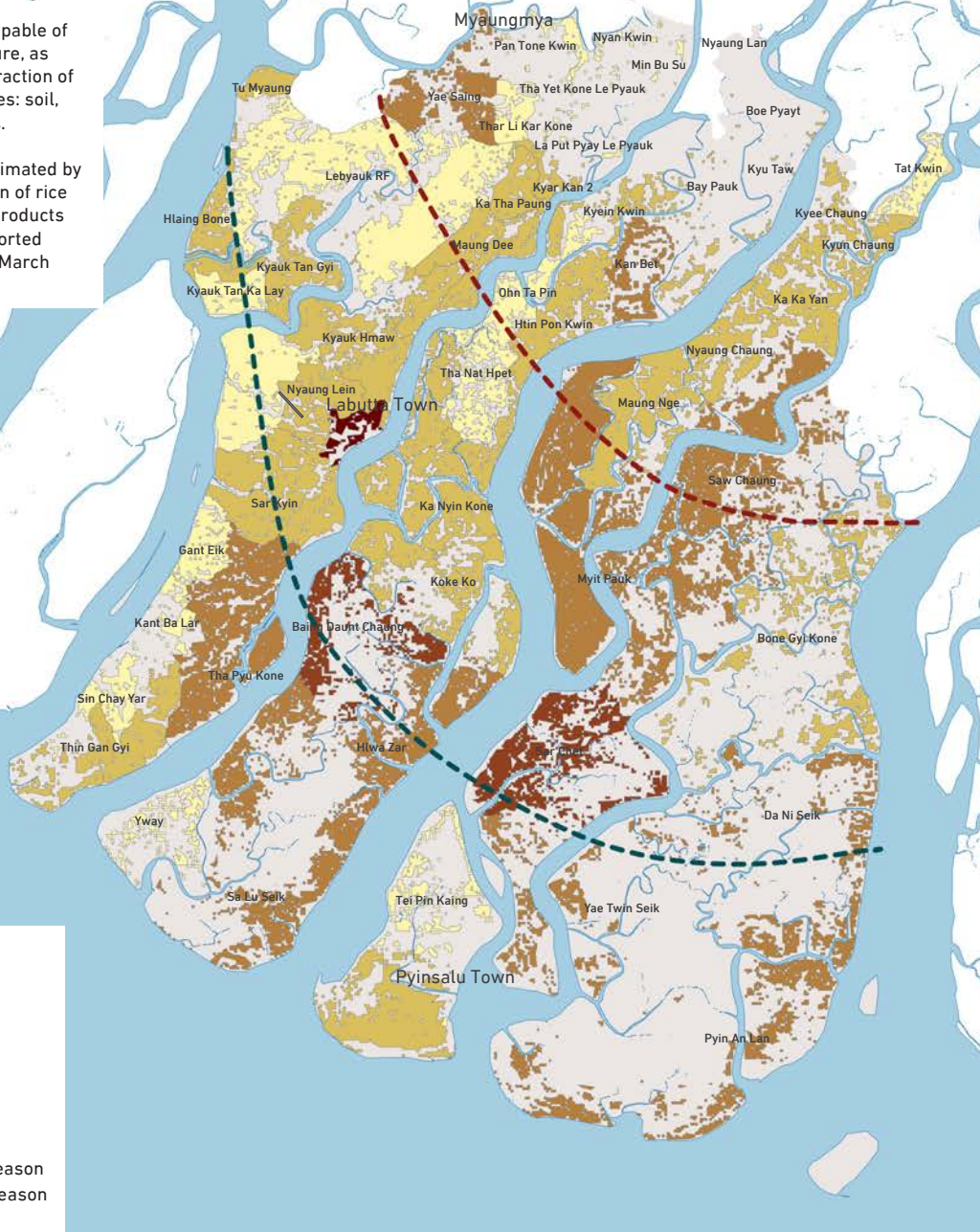
Such a reduction in output per capita – which would translate to incomes of around US\$1 (1,200 Kyat) per day – would inevitably result in increased migration, as (predominantly) young people from rural villages would leave the township in search of higher paying work and greater opportunities. Reduced output would also likely result in nutritional issues, especially for women and children, and higher rates of disease (linked with worse nutritional outcomes). Reduced incomes would have a greater effect on women if presents income trends continue, as women currently earn less and are less likely to migrate.

The following maps LBT12a and LBT12b show the current situation and the future scenario in 2050, estimated by applying a coefficient of reduction on 2016 baseline (refer to annex A3 for detailed calculations).

# 2016 | Capacity of the population to benefit from agriculture

The number of people capable of benefiting from agriculture, as the result of the the interaction of three eco-system services: soil, crops and water sources.

The population is approximated by calculating the proportion of rice crop in the agricultural products in Labutta Township exported between April 2015 and March 2016 (80% of the total).

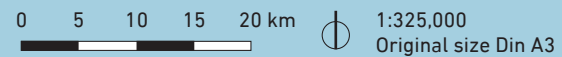


**Population (number)**

- 0-2500
- 2500-5000
- 5000-7500
- 7500-10000
- >10000

**Salinity intrusion**

- Level end of hot season
- Level end of wet season
- Water canal



## Crop types

Type of crops cultivated in each village tract in 2016.

- Beans
- Flowers
- Groundnut
- Maize
- Rice
- Vegetables



## Soil types

Soil classification concerns the grouping of soils with a similar range of properties (chemical, physical and biological) into units that can be geo-referenced and mapped. The classification has generally been based on the distribution of the important land resources for agriculture

- Dune forest & beach sand
- Mangrove forest soil
- Swampy soil
- Gley & gley swampy
- Saline swampy & meadow gley



## Water sources

Rainfed agriculture is the main type of agriculture across the township. In some parts of the northern area, a system of irrigation canals and dykes allows two crops per year

- Rainfed
- Irrigated



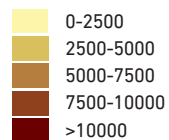
Disclaimer: The designations employed and the presentation of material on this map do not imply the expression of any opinion whatsoever on the part of the Secretariat of the United Nations concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries.

Data Source: MIMU, FAO, WWF, UN HABITAT

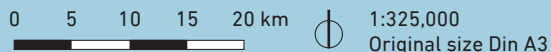
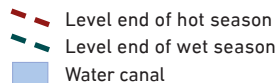
# 2050 | Capacity of the population to benefit from agriculture

Estimated population capable to benefit from agriculture in 2050, by applying a coefficient of reduction on 2016's baseline given the projected climate changes in temperature and rainfall.

## Population (number)

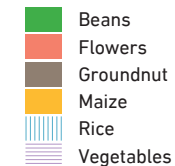


## Salinity intrusion



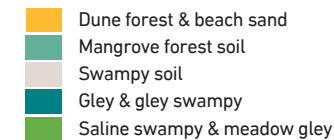
## Crop types

Type of crops cultivated in each village tract in 2016.



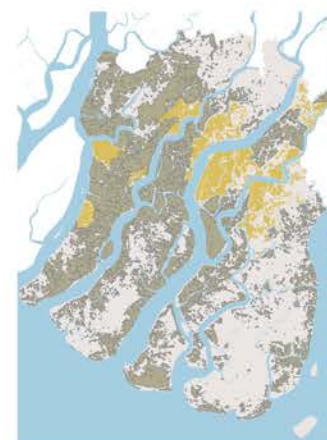
## Soil types

Soil classification concerns the grouping of soils with a similar range of properties (chemical, physical and biological) into units that can be geo-referenced and mapped. The classification has generally been based on the distribution of the important land resources for agriculture



## Water sources

Rainfed agriculture is the main type of agriculture across the township. In some parts of the northern area, a system of irrigation canals and dykes allows two crops per year



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Data Source: MIMU, FAO, WWF, UN HABITAT

Climate Change and Future Risk

## 2. Much fewer people are expected to have access to freshwater for drinking water from surface sources especially in coastal and central areas by 2050

Water scarcity has become a daily challenge in Labutta especially during the dry season. The 2014 census shows that more than 75 per cent of the population of 47 Village Tracts rely only on surface water sources (rivers and streams) and rain harvest facilities (ponds).

Communities reported that increased temperatures coupled with a shorter rainy season have seriously impacted their access to drinking water, especially during 2016 when they had to rely on distribution of water supplies from NGOs, monasteries and government.

Based on consultations with communities, the level of salinization of rivers and streams is moving north, meaning that in the future, freshwater sources (groundwater and surface water) in northern areas, which are not currently experiencing salinity, could become more salinized.

Each year, communities in the Ayeyawady Delta are exposed to riverine flooding originating from upstream. Intense runoff and soil erosion caused by more intense rains results in more water facilities



+ 2° C Warmer

HAZARD	ECO-SYSTEM SERVICE	MAIN PROJECTED IMPACTS
Higher average temperatures cause big changes in extreme heat	Surface water	Increased temperatures will increase evaporation rates, raising the concentration of dissolved salts in the water often deeming it unsuitable for drinking purposes
	Vegetation cover	Potential ecosystem productivity declines as water availability for vegetation growth decreases



+/- Rainfall

HAZARD	ECO-SYSTEM SERVICE	MAIN PROJECTED IMPACTS
More heavy rain, which is less useful and more damaging	Surface water	Strong tidal and storm surges create large-scale intrusion events, salinizing drinking water supplies, inundating fields, rivers, and streams with saline water
	Geology	Large quantities of rain falling over short periods will be difficult to capture due to limited storage infrastructure This will result in limited replenishment of waterways
	Vegetation cover	Large quantities of rain falling over short periods. This will result in flooding, erosion, and loss of land



+ Sea Level

HAZARD	ECO-SYSTEM SERVICE	MAIN PROJECTED IMPACTS
Level of salinity intrusion moving further north	Surface freshwater	Sea-level rise coupled with increased upstream water use could increase the geographic extent of saltwater intrusion
	Vegetation cover	Inundation results in loss of land





Figure 67. Mangrove re-plantation by the Village Adaptation Committee with MCCA in Tin Gan Lay © MCCA, 2017

damaged, especially the basins of the rainwater harvest ponds.

The capacity of the population to have access to surface freshwater for drinking use relies mainly on three eco-systems services (surface freshwater, geology and vegetation cover) that will be highly impacted by the projected Climate Change.

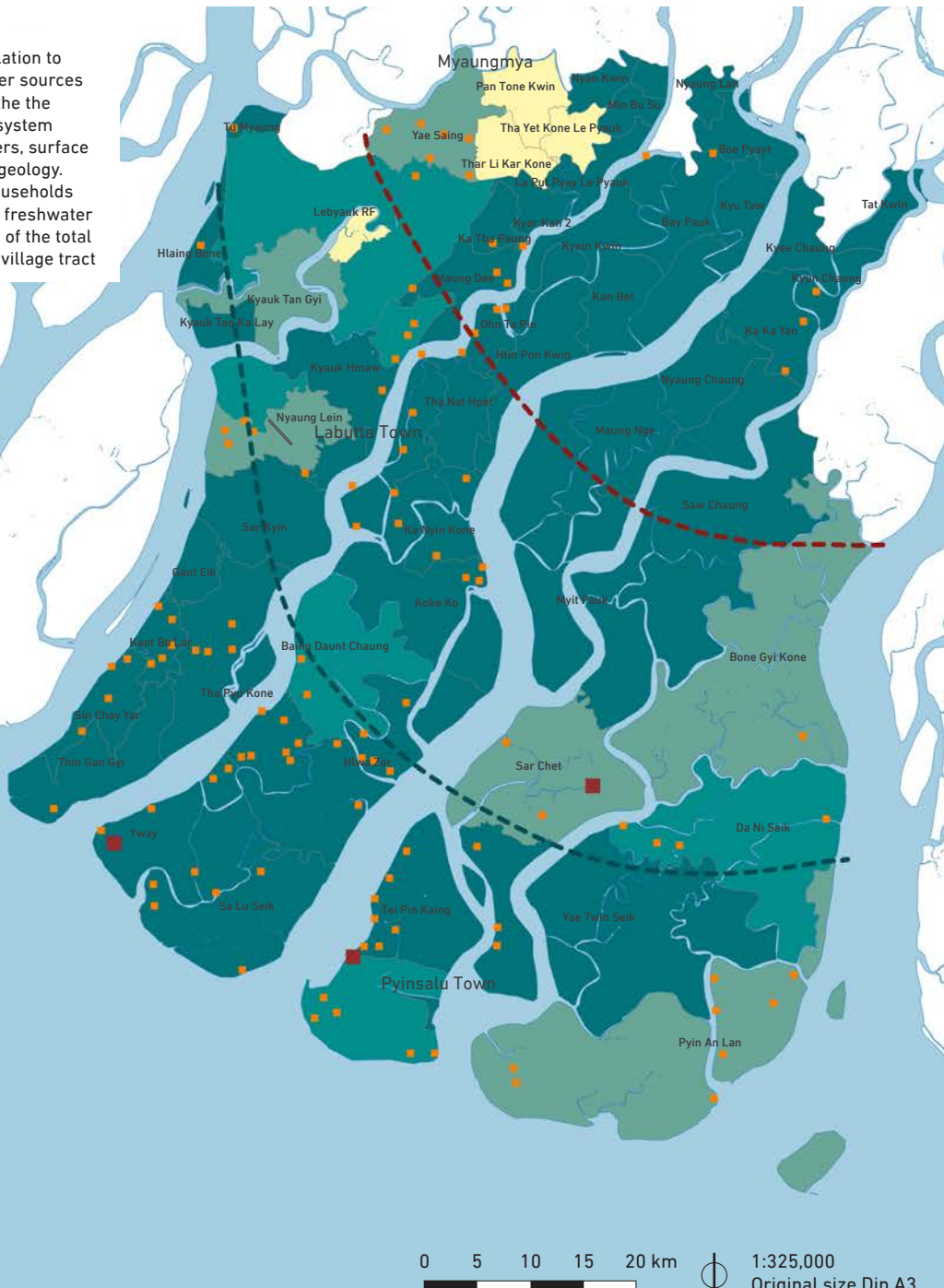
Because around 80 per cent of the township depends on uncovered sources of water, salinization will reduce the quality and availability of drinking water. This is partly because ponds will become inundated with saline water and partly because the longer dry season will result in a greater amount of evaporation, while water storage is not capable to store greater amounts of rain in a shorter rainy season.

Inundation is also likely because of more intense cyclones, which will cause storm surges. These will mean that less land is available, which will also compromise water storage facilities.

The following maps LBT13a and LBT13b show the current situation and the future scenario in 2050, estimated by applying a coefficient of reduction on 2016 baseline (refer to annex A3 for detailed calculations).

# 2016 | Capacity of the population to have access to freshwater for drinking use

The capacity of the population to access surface freshwater sources in 2016, as the result of the the interaction of three eco-system services: vegetation covers, surface freshwater sources and geology. The percentage of the households having access to surface freshwater sources is calculated out of the total population living in each village tract



0 5 10 15 20 km 1:325,000 Original size Din A3



**Vegetation cover**  
The predominant land use in Labutta Township, based on custom classification of 2015 Landsat Imagery using Google Earth Engine, is agriculture, covering 45% of the land, followed by mangroves (28%) mainly located in the southern areas, scrubland (15%) and forests (12%) located in northern area.

- Scrubland
- Agriculture
- Mangrove
- Open forest
- Forest



**Hydrology**  
The Geological Map of Myanmar (compiled and updated by Myanmar Geoscience Society) shows the entire delta area is overlain by a thick layer of recent alluvium brought down by the Ayeyawady River. The township can be divided in three main areas, considering the level of salinity intrusion: (i) the coastal areas, permanently under influence of salt water intrusion; (ii) the central areas, under seasonal influence of salt water intrusion; and northern areas, currently beyond the reach of salt water intrusion.

- Population (%HHs)**
- 0-25
  - 25-50
  - 50-75
  - 75-100

- Main facilities for drinking water**
- Ponds
  - Wells
  - Water canal

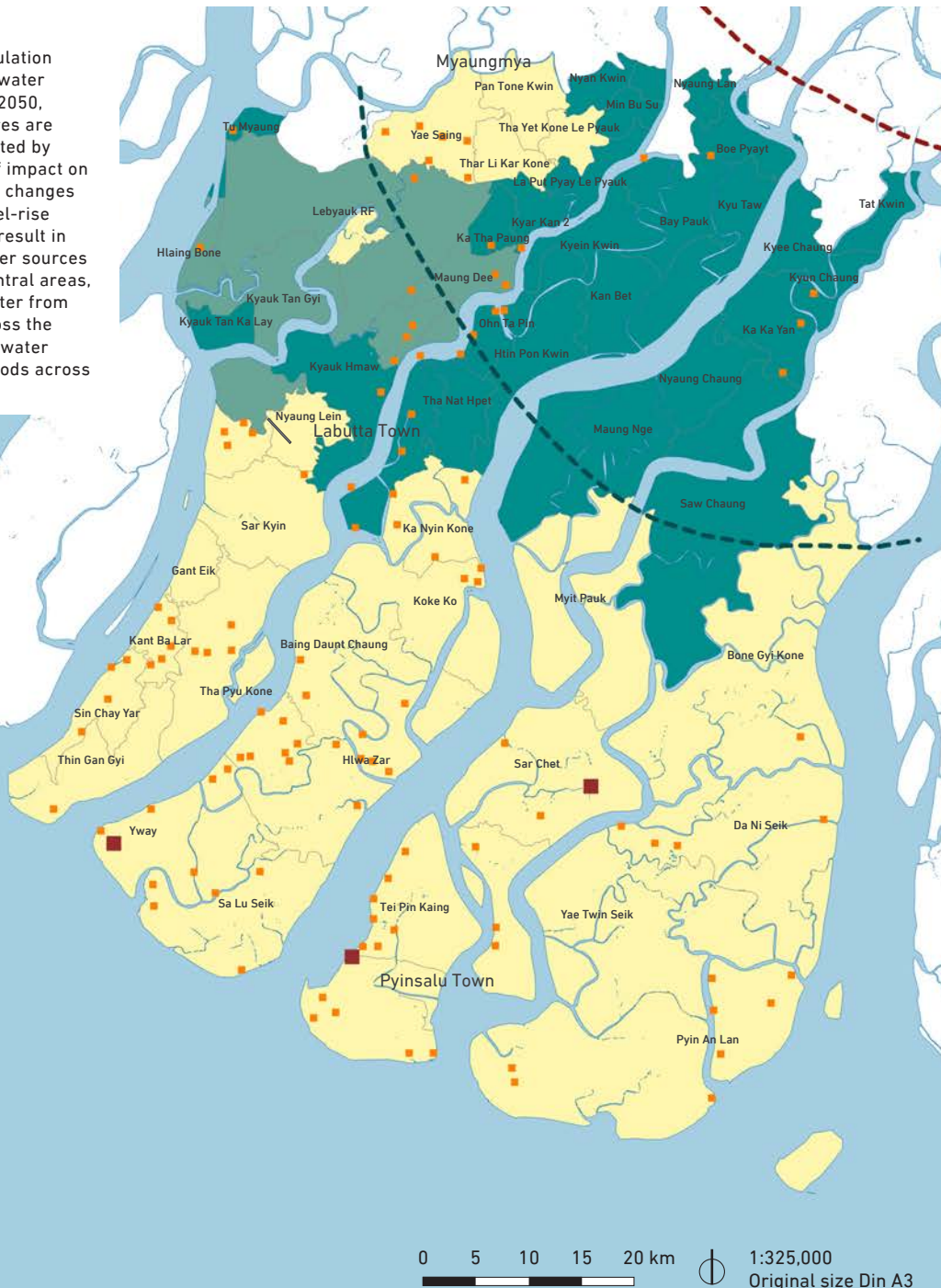
- Salinity intrusion**
- Level end of hot season
  - Level end of wet season

0 20 40 km 1:1,000,000 Original size Din A3

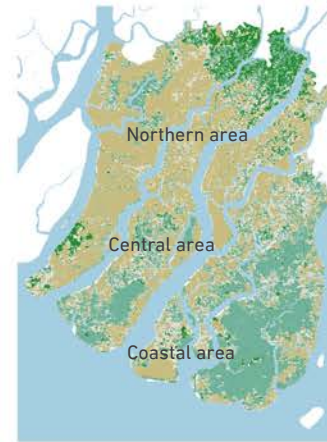
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Data Source: MIMU, FAO, WWF, UN HABITAT

# 2050 | Capacity of the population to have access to freshwater for drinking use

The capacity of the population to access surface freshwater sources for drinking in 2050, if no adaptation measures are implemented, is calculated by applying a coefficient of impact on 2016 baseline given the changes in temperature, sea level-rise and rainfall, which will result in salinization of freshwater sources in coastal areas and central areas, more evaporation of water from uncovered sources across the township and damaged water facilities for longer periods across the township.



0 5 10 15 20 km 1:325,000 Original size Din A3



**Vegetation cover**  
The predominant land use in Labutta Township, based on custom classification of 2015 Landsat Imagery using Google Earth Engine, is agriculture, covering 45% of the land, followed by mangroves (28%) mainly located in the southern areas, scrubland (15%) and forests (12%) located in northern area.

- Scrubland
- Agriculture
- Mangrove
- Open forest
- Forest



**Hydrology**  
The Geological Map of Myanmar (compiled and updated by Myanmar Geoscience Society) shows the entire delta area is overlain by a thick layer of recent alluvium brought down by the Ayeyawady River. The township can be divided in three main areas, considering the level of salinity intrusion: (i) the coastal areas, permanently under influence of salt water intrusion; (ii) the central areas, under seasonal influence of salt water intrusion; and northern areas, currently beyond the reach of salt water intrusion.

- Population (%HHs)**
- 0-25
  - 25-50
  - 50-75
  - 75-100

- Main facilities for drinking water**
- Ponds
  - Wells
  - Water canal

- Salinity intrusion**
- Level end of hot season
  - Level end of wet season

0 20 40 km 1:1,000,000 Original size Din A3

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Data Source: MIMU, FAO, WWF, UN HABITAT

Climate Change and Future Risk

**3. Deforestation trends would increase mangrove degradation, reducing people’s capacity to depend on forestry resources and fishery livelihoods by 2050**

Mangrove forests have been cleared and substantially degraded since the late 1970s, losing 64 per cent of their total area between 1978 and 2011 as agriculture—and specifically rice paddy—has expanded to be the dominant land use. Firewood is by far the main source of cooking fuel (used by more than 90 per cent of households), while the remaining 10 per cent is equally distributed by electricity, charcoal and other types of fuels (such as kerosene, biogas, grass, LPG).

Intact forest provides greater protection from cyclones and storm surges than deforested areas, as it acts as a barrier, protecting coastal assets, land and people from sea water. Because the high diversity, certain mangrove species had very low mortality rates, allowing the forest to recover faster.

Mangroves also provide various other ecosystem services critical to defending coastal areas from the effects of sea level rise, including trapping sediments and soils flowing from upstream, thereby increasing land height and preventing saline intrusion and defences against increasingly frequent and intense coastal storms.



**+/- Rainfall**

HAZARD	ECO-SYSTEM SERVICE	MAIN PROJECTED IMPACTS
More heavy rain, which is less useful and more damaging	Soils	Large quantities of rain falling over short periods will result in flooding and erosion
	Vegetation cover	More frequent cyclones and stronger winds will result in destruction of mangrove areas



**+ Sea Level**

HAZARD	ECO-SYSTEM SERVICE	MAIN PROJECTED IMPACTS
More land inundated	Soils	Inundation will result in loss of land
	Vegetation cover	Inundation will result in loss of land, and protection of mangroves

The capacity of people to be able to depend on forestry sources for energy consumption would be significantly reduced.

Fisheries will be very seriously impacted by loss of mangroves. One study estimates that for every hectare of mangrove cleared, there would be a decline in fish catch of 480 kilogrammes<sup>53</sup>. In 2015-16, 54,312,036 kilogrammes of fish and prawn were caught in Labutta in open capture (i.e. excluding farmed shrimp). If we assume that the 480 kilogramme calculation is linear – that each hectare of lost mangrove results in a 480 kilogramme reduction – Labutta can only afford to lose a further 113,150 hectares before fisheries are completely eliminated. If we assume more realistically that present deforestation trends continue, that would mean a further decline in mangrove coverage of 60 per cent and a likely catch of 21,724,814 kilogrammes. Translating this to output per capita in the fishery sector, at present the per capita output of those working in fisheries (including those not economically active) is US\$943 (1,131,600 Kyat) per year. With this reduction in catch, the new figure would be US\$377 (452,400 Kyat), only marginally above agriculture, and also translating to gross income of around US\$1 (1,200 Kyat) per day.

With government focus on developing the fisheries sector, this may drive production away from capture

fisheries towards aquaculture. Such a move would have adaptation benefits, giving producers more control over their production and, in theory, allowing production to take place in less exposed locations. However, evidence exists that shrimp farming and other forms of aquaculture is actually a driver of deforestation (both mangrove and terrestrial forests). Despite aquaculture contributing a relatively small amount to the total amount of fisheries, evidence suggests that in the Ayeyawady Region as a whole, aquaculture has been a greater driver of deforestation than agriculture.

The following maps LBT14a and LBT14b show the current situation and the future scenario in 2050, estimated by applying a coefficient of reduction on 2016 baseline (Detailed calculations for research purposes can be shared on demand).

DIVISION/ STATE	Ayeyarwady
<b>TOTAL MANGROVE (1980)</b>	679,019
<b>OTHER LAND USE (AC)</b>	
Agriculture	265,917
Shrimp pond & other	301,784
Total	567,701
<b>CURRENT MANGROVE (2013)</b>	111,318

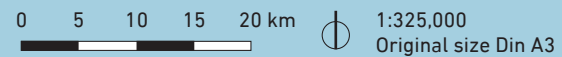


# 2016 | Mangrove coverage

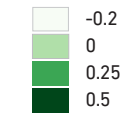
Mangrove forests have been cleared and substantially degraded since the late 1970s, losing 64% of their total area between 1978 and 2011 as agriculture—and specifically rice paddy—has expanded to be the dominant land use.

Intact forest provide greater protection from cyclones and storm surges than deforested areas, and due to the high diversity, certain mangrove species had very low mortality rates, allowing the forest to recover faster.

Mangroves also provide various other ecosystem services critical to defending coastal areas from the effects of sea level rise, including trapping sediments and soils flowing from upstream, thereby increasing land height and preventing saline intrusion and defences against increasingly frequent intense coastal storms



**Normalized difference vegetation index (NDVI)**  
 NDVI is calculated from the visible and near-infrared light reflected by vegetation. Health vegetation absorbs most of the visible light that hits it, and reflects a large portion of the near-infrared light. A zero means no vegetation and close to +1 (0.8- 0.9) indicates the highest possible density of green leaves.



**Soil types**  
 Soil classification concerns the grouping of soils with a similar range of properties (chemical, physical and biological) into units that can be geo-referenced and mapped. The classification has generally been based on the distribution of the important land resources for agriculture

- Dune forest & beach sand
- Mangrove forest soil
- Swampy soil
- Gley & gley swampy
- Saline swampy & meadow gley

- Degraded forest
  - Deforestation areas
  - Intact forest
  - Irrigated agriculture
  - Rainfed agriculture
- Salinity intrusion**
- Level end of hot season
  - Level end of wet season
  - Water canal



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Data Source: MIMU, FAO, WWF, UN HABITAT

# 2050 | Mangrove coverage

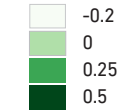
If no adaptation measures are implemented, the current deforestation trends would increase mangrove degradation and in a worst scenario would mean total loss of mangrove forest by 2050.

This significantly compromises what was a highly biodiverse, nutrient rich system, directly increasing vulnerability to climate change impacts.

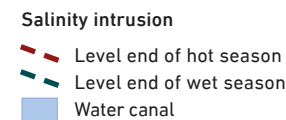
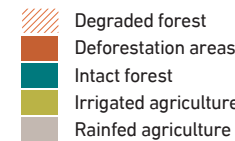
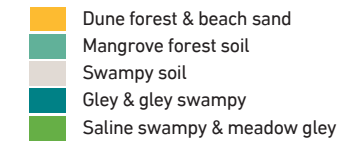
As mangroves are cleared, the numerous basic ecosystem services they provide that support climate resilience—erosion control, defences against coastal storms, fisheries habitats, etc—are also lost.



**Normalized difference vegetation index (NDVI)**  
 NDVI is calculated from the visible and near-infrared light reflected by vegetation. Health vegetation absorbs most of the visible light that hits it, and reflects a large portion of the near-infrared light. A zero means no vegetation and close to +1 (0.8- 0.9) indicates the highest possible density of green leaves.



**Soil types**  
 Soil classification concerns the grouping of soils with a similar range of properties (chemical, physical and biological) into units that can be geo-referenced and mapped. The classification has generally been based on the distribution of the important land resources for agriculture



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Data Source: MIMU, FAO, WWF, UN HABITAT

Climate Change and Future Risk

**4. The capacity of the population to access transportation services will be highly reduced in coastal and central areas by 2050**

The transportation system in Labutta mainly relies on unpaved roads and wooden jetties that are only accessible in favourable weather conditions, meaning that frequent floods and broken bridges leave some southern areas isolated for some days.

Labutta Town is well connected with Pathein through the main paved road and the Thet Ke Thaug river, but water transport remains a key means of mobility and communication, especially in the southern and eastern areas of the township, where most the village tracts are only accessible by waterways. Pyinsalu’s main transportation route to Labutta is through the Pya Ma Law and Yway rivers and to Kan Bet and further to Wakema Township and Yangon through Pya Ma Law river.

Access to transportation services mainly relies on the interaction of two eco-systems services (type of vegetation and soil) that are already highly impacted by climate change:

Some coastal areas could become permanently inundated while tides will severely affect others, rendering them partially inundated. This will also mean that what road infrastructure exists in these



**+/- Rainfall**

HAZARD	ECO-SYSTEM SERVICE	MAIN PROJECTED IMPACTS
More heavy rain, which is less useful and more damaging	Soils	Large quantities of rain falling over short periods will result in flooding and erosion
	Vegetation cover	More frequent cyclones and stronger winds will result in destruction of mangrove areas – River systems become more frequently impassable anwhich also leads to damage to roads and bridges



**+ Sea Level**

HAZARD	ECO-SYSTEM SERVICE	MAIN PROJECTED IMPACTS
More land inundated	Soils	Inundation will result in loss of land
	Vegetation cover	Inundation will result in loss of land, and protection of mangroves



Figure 68. Labutta main jetty © MCCA



areas will be either completely or partially unusable. This also means that the existing network of boat piers may become increasingly unusable or unsuited.

The existing transport infrastructure relies heavily on small canoe type boats at the household level, which are used for fishing and some transportation, as well as larger passenger boats. Using canoes is likely to become more dangerous and they will be less able to pass the larger channels because of high waves that will accompany storms and inundation.

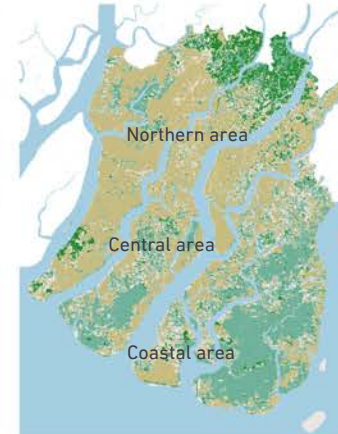
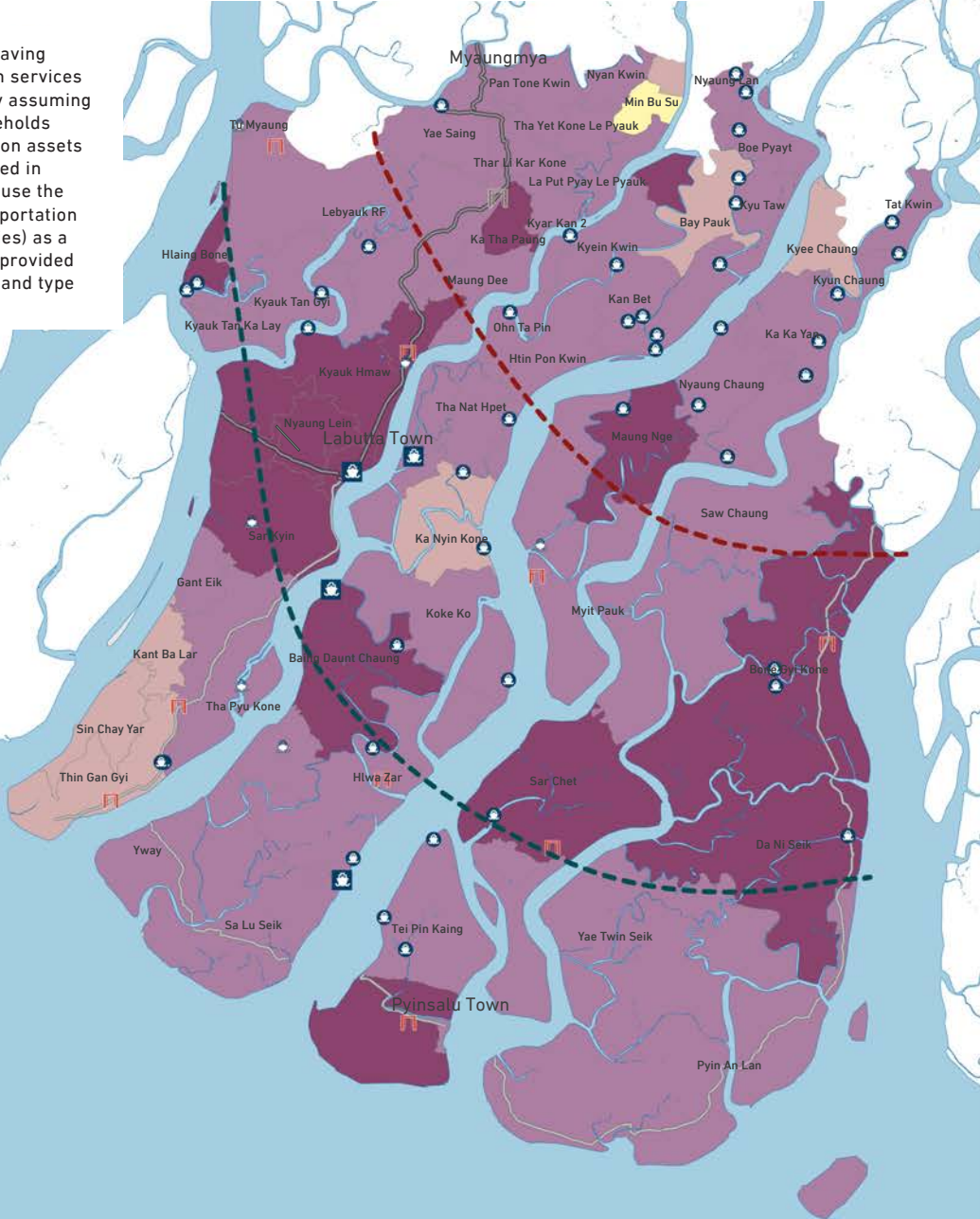
Because the coastal areas rely heavily on boat transport to Labutta town and elsewhere, damage to this infrastructure would be critical, because it would result in isolation, with serious impacts on other areas. If inundation due to floods continues to become more severe, it will also affect road transport from Labutta Town. This would have a knock-on impact on industry, for example, as discussed below.

The following maps LBT15a and LBT15b show the current situation and the future scenario in 2050, estimated by applying a coefficient of reduction on 2016 baseline (Detailed calculations for research purposes can be provided on demand).

- 49 According to Columbia University downscale climate projections for Ayeyawady 2011-2040, as compared to 1980-2005 average
- 50 According to Columbia University downscale climate projections for Ayeyawady 2011-2040, as compared to 1980-2005 average.
- 51 Middle range sea-level rise projections for coastal areas in Myanmar, in 2050s, according to Columbia University downscale projections
- 52 J.A. Chun, et al. (2016) Assessing rice productivity and adaptation strategies for Southeast Asia under climate change through multi-scale crop modelling, *Agricultural Systems* 143 (2016), p.17
- 53 MacKinnon and MacKinnon (1986), cited in Delta Alliance, p.36

# 2016 | Capacity of the population to have access to transport services

The number of people having access to transportation services in 2016, is calculated by assuming the percentage of households possessing transportation assets (as per categories defined in Census 2014) is able to use the current system of transportation (roads and water facilities) as a result of the protection provided by the vegetation cover and type of soils.



**Vegetation cover**  
The predominant land use in Labutta Township, based on custom classification of 2015 Landsat Imagery using Google Earth Engine, is agriculture, covering 45% of the land, followed by mangroves (28%) mainly located in the southern areas, scrubland (15%) and forests (12%) located in northern areas.

- Scrubland
- Agriculture
- Mangrove
- Open forest
- Forest



**Soil types**  
Soil classification concerns the grouping of soils with a similar range of properties (chemical, physical and biological) into units that can be geo-referenced and mapped. The classification has generally been based on the distribution of the important land resources for agriculture

- Dune forest & beach sand
- Mangrove forest soil
- Swampy soil
- Gley & gley swampy
- Saline swampy & meadow gley

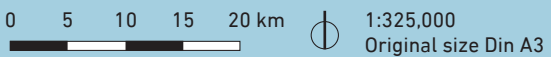
- Households (%)**
- 0-25
  - 25-50
  - 50-75
  - 75-100

- Salinity intrusion**
- Level end of hot season
  - Level end of wet season

- Transport infrastructure**
- Main road
  - Secondary road
  - Tertiary road

- Road bridges**
- Concrete bridge
  - Wooden bridge

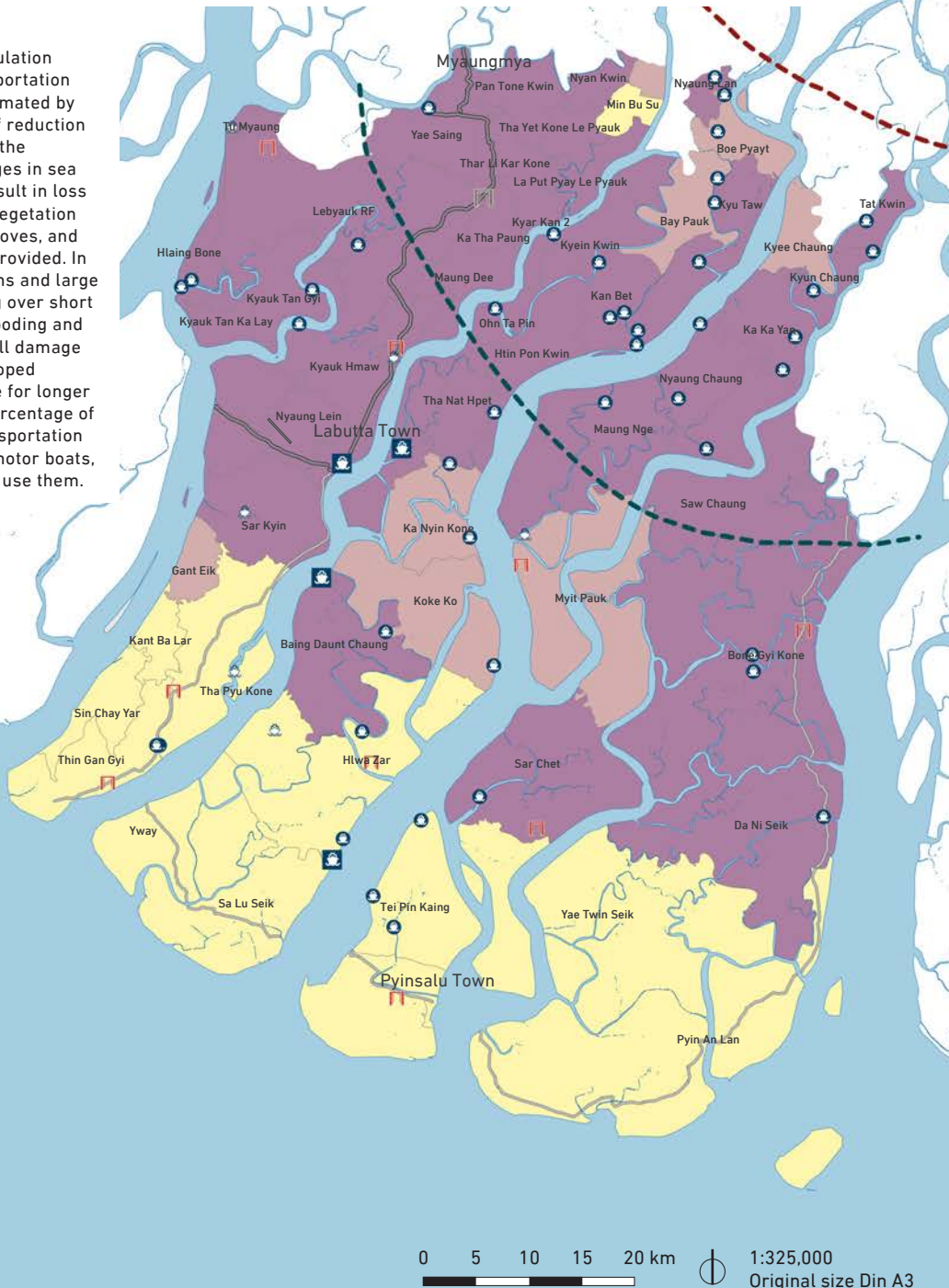
- Water transport facilities**
- Harbour / Port
  - Renovated jetty (LPD)
  - Jetty
  - Water canals



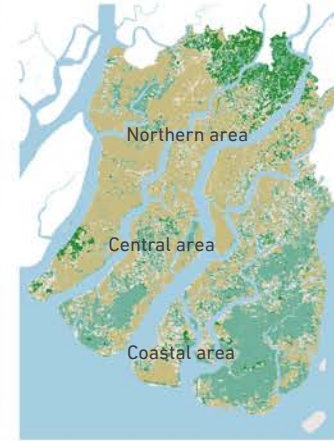
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Data Source: MIMU, FAO, WWF, UN HABITAT

# 2050 | Capacity of the population to have access to transport services

The capacity of the population to have access to transportation services in 2050, is estimated by applying a coefficient of reduction on 2016 baseline given the projected climate changes in sea level rise, which will result in loss of land destroying the vegetation cover, especially mangroves, and the coastal protection provided. In addition, stronger storms and large quantities of rain falling over short periods will result in flooding and erosion of soils. This will damage the already underdeveloped transport infrastructure for longer periods reducing the percentage of households having transportation assets (cars, bicycles, motor boats, canoes,...) being able to use them.



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**Vegetation cover**  
The predominant land use in Labutta Township, based on custom classification of 2015 Landsat Imagery using Google Earth Engine, is agriculture, covering 45% of the land, followed by mangroves (28%) mainly located in the southern areas, scrubland (15%) and forests (12%) located in northern areas.

- Scrubland
- Agriculture
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- Forest



**Soil types**  
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- Dune forest & beach sand
- Mangrove forest soil
- Swampy soil
- Gley & gley swampy
- Saline swampy & meadow gley

**Households (%)**

- 0-25
- 25-50
- 50-75
- 75-100

**Salinity intrusion**

- Level end of hot season
- Level end of wet season

**Transport infrastructure**

- Main road
- Secondary road
- Tertiary road

**Road bridges**

- Concrete bridge
- Wooden bridge

**Water transport facilities**

- Harbour / Port
- Renovated jetty (LPD)
- Jetty
- Water canals

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# 5

## OVERALL FINDINGS

The assessment concludes that, at present, Labutta does not possess the basic conditions and attributes of a resilient township, given the current and future climatic features.

Climate change will have great impact, unless resilience is prioritized and built overtime. Climate change will test and increase the current social, economic, ecological, infrastructural vulnerabilities.

The assessment presents here three broad scenarios for the future, ordered by descending probability, which inversely proportional to their desirability. Scenario A, or Business As Usual, has the most negative impact and is currently also the most probable considering the current conditions of the township. It is, evidently, the least desirable scenario.

Scenario B, describes a minimum standard of resilience to be achieved to protect people's life, assets and production means. It is much less likely than Scenario A, but also one that the Township and national authorities should strive to obtain as a bare minimum standard.

Finally, Scenario C is the most desirable future, but unfortunately also the least likely in the conditions studied at present. In this scenario, Healthy Eco-Systems, Resilient and Sustainable Infrastructure and a Diversified Economy are achieved, so that the Township can thrive. The Township and the regional and national authorities should aspire to materialize this scenario. A local resilience and adaptation plan would be the first tool to this end.

## 5.1 DEFINING SCENARIOS

This assessment presents three broad scenarios of the future;

A. Business as usual: no specific adaptation effort;

B. Resilience is built to maintain current living standards;

C. Resilient, sustainable economic development for Labutta.

These scenarios can help local and national government to plan for actions that will increase Labutta's resilience to the impacts of climate change.

Planning actions based on scenarios is a good practice, also in-line with the IPCC pathways approach, which is defined in the IPCC 5th Assessment Report. It is a common way that governments and industries use to plan for the future<sup>54</sup>. This report offers also a spatial analysis to inform the decision-maker about future 'suitability' of certain areas, geolocalized.

However, it is important to note the difference between a scenario and a forecast:

- A forecast suggests one reality in the present, which will lead to one reality in the future. This means that there is one pathway by which we can reach the future reality. So, for example, if a storm is developing in the Bay of Bengal, and we know the speed and direction in which the storm is moving, we can forecast when the storm will make landfall in Myanmar.
- Scenario planning is more complex, because it involves considering how multiple variables could lead to multiple futures. However, when considering the complex interaction of several variables, it is less likely to lead to error than forecasting, and is therefore a more effective way for governments to plan so-called 'no-regret' actions. Unlike forecasting, scenario planning acknowledges uncertainty, and allows for unforeseen developments.



Figure 69. Graphic representations of forecast



Figure 70. Graphic representation of scenarios





Figure 71. Potential Scenarios for Labutta in 2050

SCENARIO A

Business as usual: no specific adaptation effort.

In scenario A, authorities and communities even recognizing the need to address different aspects of vulnerability, do not take significant action. Changes in climate have an exponential effect on the three systems analysed in this report; socio-economic, infrastructure, ecological. Under this scenario, the spatial structure of Labutta, challenged by sea-level rise and salinization, and heightened risks of rapid on-set disasters, causing a loss of productivity, will undergo radical changes. This seems to be the current trajectory, represented by a larger arrow on the left.

SCENARIO B

Resilience is built to maintain current living standards

Under scenario B, the township, district, and national authorities, together with development partners work to build a minimum standard of resilience that ensures at least maintenance of current living standards and reduce the vulnerability of Labutta's people. This scenario is the minimum required to prevent increased vulnerability, and to enable continued development. The thinner arrow, signifies that this trajectory is less likely to materialize, currently.

SCENARIO C

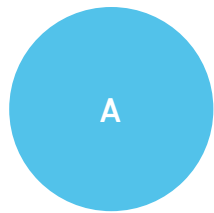
Resilient, sustainable economic development for Labutta

Under scenario C, Labutta in 2050 sustains and continues people's socio-economic development through a diversified economy, improved infrastructure and healthy ecosystems that is less dependent on paddy cultivation and capture fisheries. This is the scenario Labutta should aspire to materialize. The tiny arrow does not mean that this is impossible, but signifies the need for political, technical and financial commitment



## 5.2. SCENARIOS FOR LABUTTA 2050

Scenario



### BUSINESS AS USUAL SCENARIO (BAU)

- In this scenario authorities and communities do not recognize the urgent need to address different aspects of vulnerability and therefore changes in climate have an exponential effect on the three systems analysed in this report; socio-economic, infrastructure, ecological.
- Ultimately, this increasingly affects people's life, livelihoods, health and safety until 2050 and beyond.
- Under this scenario, the spatial structure of Labutta, challenged by sea-level rise and salinization, and heightened risks of rapid on-set disasters, causing a loss of productivity, will undergo radical changes.
- In this scenario, insufficient planning capacities and governance hamper mid to long-term planning: decisions fail to consider the heightened risks occurring because of climate change. Short-term measures, such as allowing cutting mangroves without replanting; constructing infrastructure where inundation may occur; or failing to construct houses with wind-resistant techniques; carry long-term negative consequences.
- In the business as usual scenario, livelihoods, infrastructure and environmental conditions will not allow people to improve living conditions in the township, given the current and future projected vulnerabilities to climate change.
- In addition, projected changes in the climate will interact with and exacerbate the existing vulnerabilities and as they do, new, unforeseen vulnerabilities may also emerge.

If business is conducted as usual, meaning that adaptation measures are not implemented and unsustainable use of environmental resources continues, Labutta is unlikely to be able to support current and expected population growth at the same living standard as in 2016, as vulnerabilities will grow further, and less and less people will be adequately sheltered, will make a decent livelihood and will access opportunities for development and self-realization.

Under a business as usual scenario, people in Labutta will experience lower incomes because of salinity, inundation, inundation of land, storm surges affecting coastal villages, strong winds affecting the whole township, loss of habitat for fishery, and a decrease of industrial and agricultural capacities.

Consequently, people will likely be displaced from the southern area to the central and northern area, Yangon and abroad are likely. Migration will be characterised by low skill levels and limited employability, which will restrict people to labour intensive, low remuneration jobs. This will particularly affect the youth population, who make up the overwhelming majority of migrants, and will result in remittance being the dominant income for increasingly female-headed households. If present trends continue, this migration would be

gender imbalanced, as more men will migrate than women, increasing the number of female-headed households.

Infrastructure functionality will be increasingly compromised as it is exposed to cyclones, strong winds and floods. This will translate into loss of assets such as houses, schools, public buildings and will cause increasing loss of life. Transport will become more difficult as the limited road infrastructure will be recurrently inundated, while bridges could be destroyed and the main waterways will be increasingly impassable as they are impacted by higher waves.

The impacts of climate change hazards and unsustainable resource use will reduce people's ability to benefit from the ecosystem. Deforestation will expose the coastal areas to extreme weather, while declining mangrove coverage will cause a continued depletion of fish stock. It will also affect soil regulation and quality, while also reducing the availability of building materials and cooking fuels. Soil quality issues will be exacerbated by salinity and a shorter but more intense monsoon season, which will have an impact on agricultural production. Water availability will continue to decline as a longer dry season will mean greater time for water to evaporate, while being more difficult to store.



Under these circumstances, analysis using the matrix of functions helps to design the future spatial structure in 2050, by assuming some eco-system services, socio-economics and infrastructure functions that support the current spatial structure of the township won't be available<sup>55</sup>. This is crucial to support planning and direct interventions for adaptation but also, and most importantly, to understand how the projected changes in one part of the township or the region may affect the current spatial and socio-economic linkages.

The new spatial analysis considers the following functions won't be available in each area:

	ECO-SYSTEMS SERVICES	SOCIO-ECONOMIC FUNCTIONS	INFRASTRUCTURE FACILITIES
Coastal Areas	Mangrove; Forest/Open forest; Roof/wall material (leaves); Rice; Vegetables; Livestock; freshwater from water channel	Livestock Market; Fish market; Fishermen; Wood for charcoal; Street sellers; Retail shop/supermarket; Groceries shop	Rain water harvest pond; Unpaved roads; Paved road; Port/Harbour; Boat transport on daily basis (two ways same day); Boat transport every two days (one way per day)
Central Areas	Mangrove; Forest/Open forest; Rice; Vegetables; Livestock; freshwater from Rivers	Livestock Market; Fish market; Fishermen; Wood for charcoal	Rain water harvest pond; Port/Harbour; Boat transport on daily basis (two ways same day)
Northern areas	Mangrove; Forest/Open forest; Livestock	Livestock Market; Fish market; Fishermen; Wood for charcoal	

The analysis of the matrix of functions in 2050 (refer to the Figure in the next page, where red squares show functions not available in 2050 in each village tract) under a business as usual scenario, shows Labutta's level of socio-economic and infrastructure development would decrease across the township. Around 75 per cent of the population, mainly from coastal and central areas, would be living in village tracts classified as local village tracts, being the lowest developed.







At the regional level, Myaungmya would provide main socio-economic functions to the whole township, while Pathein would provide the highest level of education and health facilities and represents the main local and regional market for agricultural products and provisioning needs of the township.

At township level, the future spatial structure would rely on (map LBT16) the following:

- Two main “clusters” of settlements located in northern areas;

- Despite potential changes in Pyinsalu Town, would still have the highest level of physical and socio-economic development in the southern area (saved its total inundation, however), the expected decline in agriculture and fisheries, would result in the loss of trade and economic opportunities increasing dependency on Labutta Town and most probably more people migrating to other areas;
- Pyinsalu’s main transportation route to Labutta through the Pya Ma Law and Yway rivers and to Kan Bet and further Wakema Township and

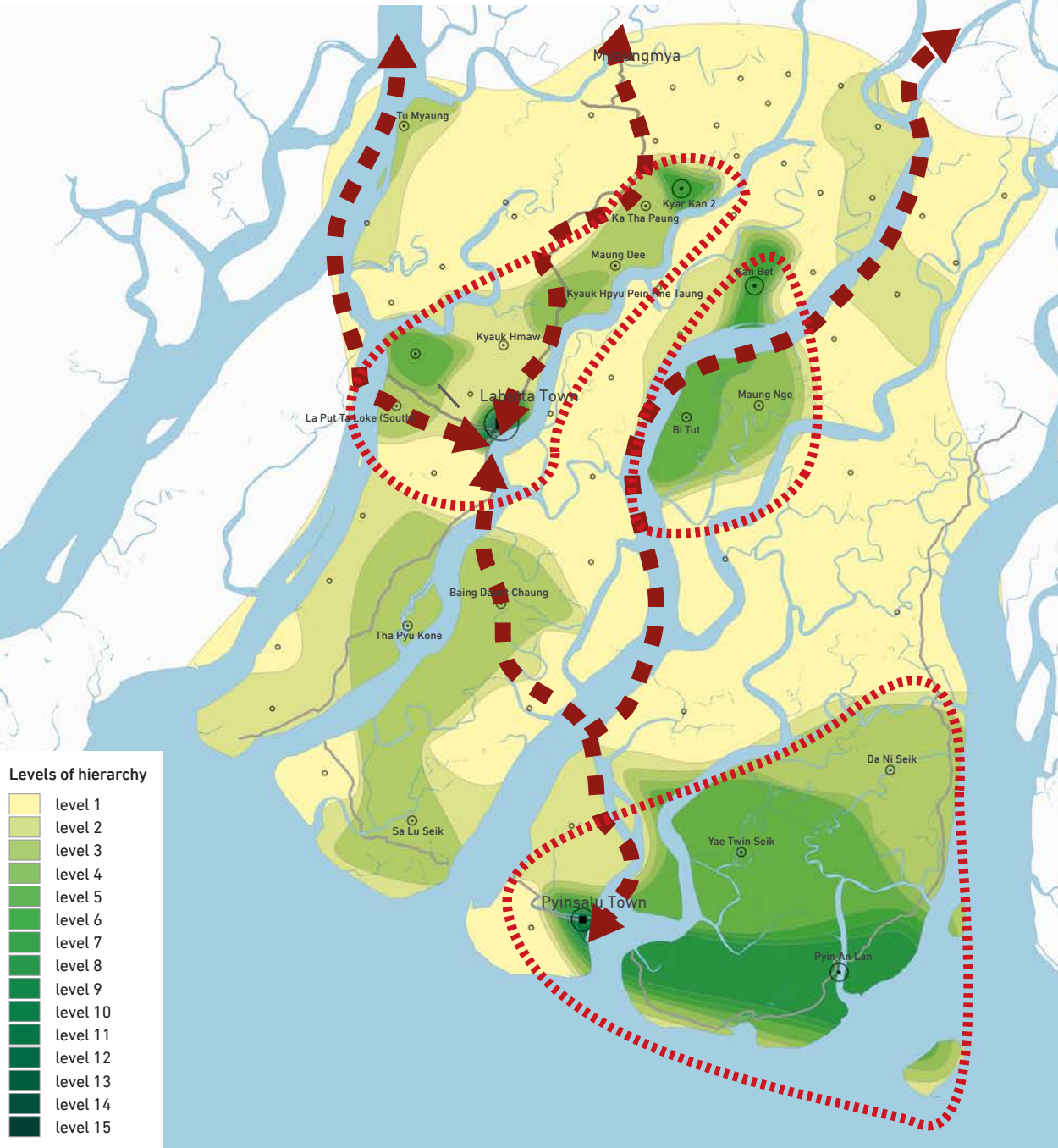
Yangon through Pya Ma Law river is also likely to be more dangerous and less able to pass because of high waves leaving these areas isolated, or even constantly under water, with obvious consequences;

- Labutta Town would still be connected with Pathein through the main paved road and the Thet Ke Thaug River, while Kan Bet would be connected to Wakema Township and Yangon through Pya Ma Law river. These two corridors would remain crucial to support the economy of the township in 2050.

LOCATION	North western area	North-Central area
<b>TERRITORIAL INFLUENCE</b>	Labutta Town would still be considered the main urban and trade centre of the township, extending its “territorial influence” along the main road to Myangmya and along the secondary road to Laputta Loke (Thet Ke Thaug River).	Kan Bet and the surrounding village tracts located at the centre of the township along the Pya Ma Law river would configure the second cluster of the township.
<b>VILLAGE TRACTS</b>	Labutta Town, La Put Ta Loke (South), Kyauk Hmaw, Nyaung Lein, La Put Ta Loke (North), Ka Tha Paung, Kyar Kan, Kyauk Hpyu Pein Hne Taung, Maung Dee.	Kan Bet, Bi Tut, Maung Nge, Htin Pon Kwin.
<b>TOTAL POPULATION</b>	62,327 inhabitants (20% of the total population of the township).	26,409 inhabitants (9% of the total population of the township).
<b>FUNCTIONAL COMPLEXITY</b>	This “cluster” would have the highest levels of physical development allowing the more number of economic activities of the township.	These four village tracts would configure a cluster strategically located at the centre of the township. They would maintain access to public utilities (wells and irrigation channels) and transportation infrastructure (paved road, harbour) allowing more crops (beans) and more types of economic activities (restaurant, salt production).



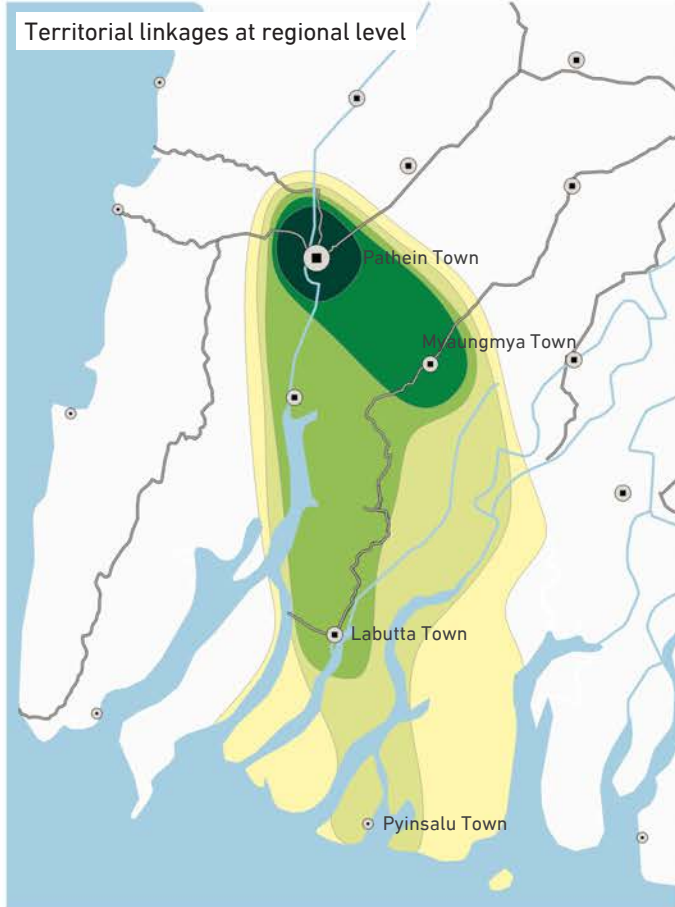
# 2016 | Spatial structure and territorial linkages



**Levels of hierarchy**

- level 1
- level 2
- level 3
- level 4
- level 5
- level 6
- level 7
- level 8
- level 9
- level 10
- level 11
- level 12
- level 13
- level 14
- level 15

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**Type of settlement**

- Local Village Tract (LVT)
- Intermediate Village Tract (IVT)
- Main Village Tract (MVT)
- Local Urban Centre (LUC)
- Main Urban Centre (MUC)
- Sub-township
- Township
- State Capital

**Main communication routes**

- Major road
- Secondary road
- Water canal

**Spatial Structure**

- Main clusters of settlements
- Primary corridors

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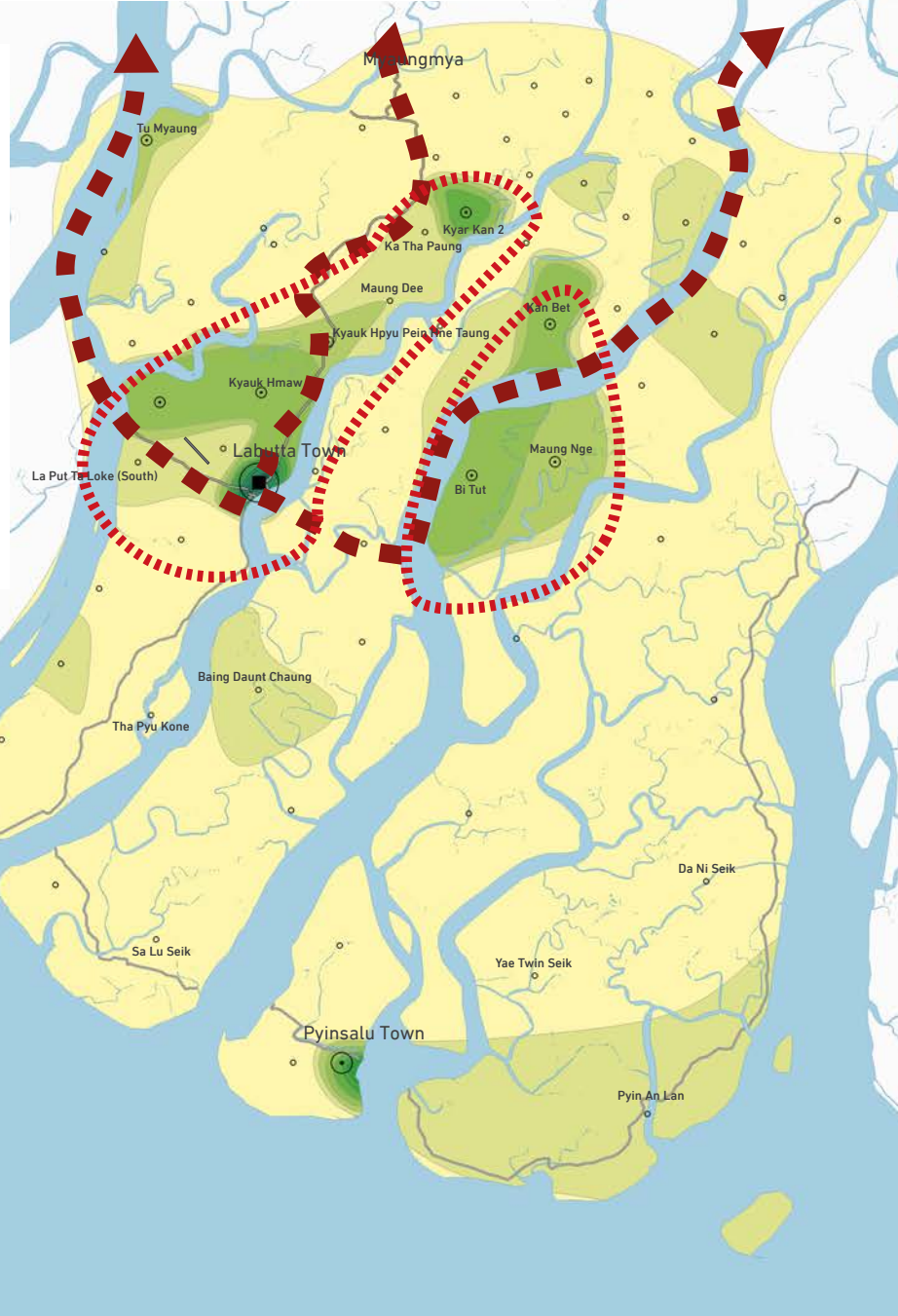
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Data Source: MIMU, UN HABITAT



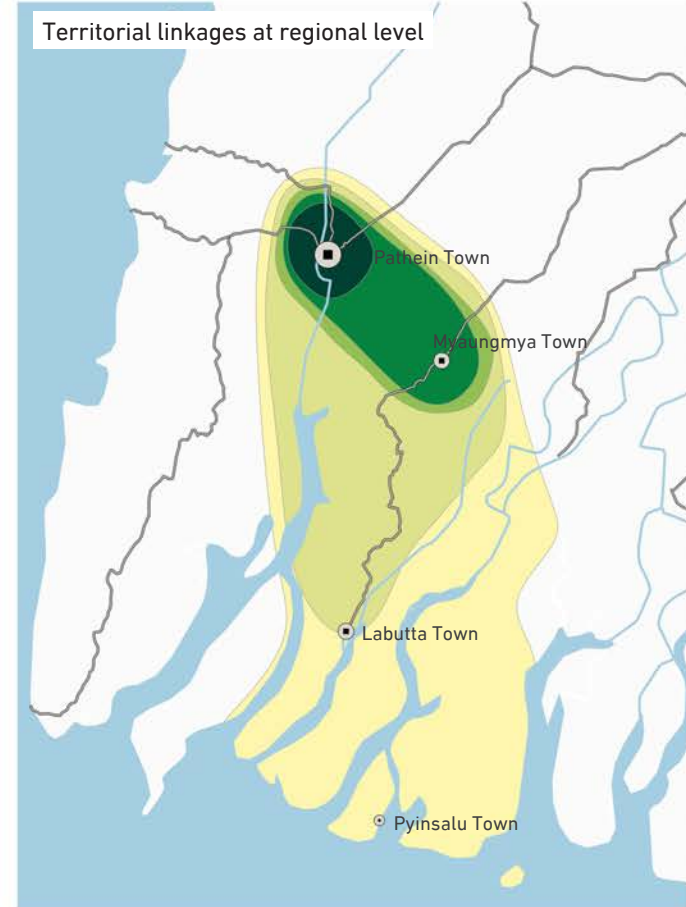
# 2050 | Future spatial structure and territorial linkages

Under a business as usual scenario, Labutta's level of socio-economic and infrastructure development may decrease across the township, as 75% of the population, mainly located in coastal and central areas, would be living in villages where only basic health and education services are available. Road and water infrastructure (roads and piers) would be either completely or partially unusable or unsuited resulting in isolation of coastal and central areas. Northern areas, especially Labutta Town, would be severely affected by the loss of agricultural production in southern areas and specialized markets would not be available to the local population.



**Levels of hierarchy**

- level 1
- level 2
- level 3
- level 4
- level 5
- level 6
- level 7
- level 8
- level 9
- level 10
- level 11
- level 12
- level 13
- level 14
- level 15



**Type of settlement**

- Local Village Tract (LVT)
- Intermediate Village Tract (IVT)
- Main Village Tract (MVT)
- Local Urban Centre (LUC)
- Main Urban Centre (MUC)

**Main communication routes**

- Major road
- Secondary road
- Water canal

**Spatial Structure**

- Main clusters of settlements
- Primary corridors

In 2050, at regional level, Myaungmya would likely provide main socio-economic functions to the whole township, while Patheingyi may provide the highest level of education and health facilities and represents the main local and regional market for the agricultural products and provisioning needs of the township.

**Type of settlement**

- Sub-township
- Township
- State Capital

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**Overall Findings**

## B

## RESILIENCE IS BUILT TO MAINTAIN CURRENT LIVING STANDARDS BY 2050

- Under this scenario, recognizing the future challenges, the township, district, and national authorities, together with development partners, work to build a minimum standard of resilience that ensures at least maintenance of current living standards and reduce the vulnerability of Labutta's people.
- However, investment, time, economic, technical and skill constraints are recognized, an adaptation plan is adopted, and activities that can be implemented without large investment are consistently undertaken, such as the protection of the environment, strengthening of economic associations to create a more resilient livelihoods and income, the integration of measures for strong winds in housing and schools, the improvement of water-harvesting, among others.
- Decisions on land-use and town-planning increasingly take into account current and projected climate risks, to prevent hazardous situations, such as infrastructure being constructed near flood-prone areas and the need to clean drainage infrastructure, inter alia.
- The township and communities are able to plan their needs considering climate constraints, and communicate them to the district, state, and region, NGOs and development partners.
- This scenario is the minimum required to prevent increased vulnerability, and to enable continued development, although overtime Townships can find

that, because of the cumulative effects of climate change, and its exponential consequences, the actual actions required are greater than anticipated.

Labutta in 2050 maintains current living standards by undertaking some adaptation measures. However, it broadly continues its present development trajectory.

To enable this scenario, current observed deforestation trends would need to halt to maintain current living standards, especially in mangroves, which are being cut at a highly unsustainable rate. If this deforestation is not halted, fishery livelihoods especially are very likely to decline. Deforestation also reduces soil quality and absorption capacity and therefore preventing it will also be beneficial to agriculture.

In order to prevent further deforestation, alternative energy sources would be required, as household scale cutting for energy and fuel wood is one of the primary drivers of deforestation. Without such an action, it will be very difficult to reverse the decline in mangroves and forests.

Alternative practices would need to be developed and implemented in agriculture. In some areas, land will be inundated, while in others, the salt line will mean that either agriculture is not viable, or only one crop is possible. To adapt to this situation, a variety of measures would be required; salt resistant



varieties and improved cropping techniques would be needed, with appropriate safety net features in case of failures. Meanwhile, provisions and plans should be made to enable farmers in the inundated area to move to other areas that are not saline; a process that will be complicated and take a considerable amount of time.

There would need to be some investment in infrastructure to ensure that functionality is maintained to present levels. In particular, water capture, storage and distribution would need to be improved. This means that the current network of water ponds would have to be enhanced, and systems put in place to prevent free-rider problems.

Transport infrastructure would also require improvements; the network of boats and piers would have to be strengthened to maintain present functionality in the face of stronger winds, storms and possible inundation. Meanwhile, improvements in road transport and power infrastructure would also contribute to maintaining current levels of development.



## RESILIENCE IS BUILT THAT ENABLES ECONOMIC AND SOCIAL DEVELOPMENT DESPITE CHANGES IN CLIMATE BY 2050, CONSIDERING THE DIFFERENT VULNERABILITIES OF BOTH MEN AND WOMEN,

Labutta in 2050 sustains and continues people's socio-economic development through a diversified economy, improved infrastructure and healthy ecosystems that is less dependent on paddy cultivation and capture fisheries.

Agriculture needs to be made resilient to the new climatic features through a combination of resistant crop varieties, better irrigation, and improved storage and distribution of water. To generate wealth from agriculture, some value addition, such as milling and processing, should take place in the township. To enable this, investment is required in energy and transport infrastructure that will protect people, add greater connectivity and allow for energy intensive industries in a sustainable and low carbon manner. Investment in renewables would also be an important consideration, in this case.

Investment in education and skills, coupled with infrastructure and agro-industrial development will enable young people to stay in the township and find more remunerative employment. It will also create a virtuous cycle, because people will be less likely to migrate, and less likely to work in highly climate-sensitive sectors such as capture fisheries and paddy cultivation. In the fishery sector, a shift in the model would be needed. At present, fishermen receive well below the market price for their catch because of the imbalance in the market. If fishermen were to work collectively, or could travel themselves to larger markets in Labutta and beyond, they would be less exposed to low prices offered by middlemen who buy their catch. This model would also make it easier to prevent overfishing and other environmentally damaging actions.

Deforestation trends would have to completely reverse, with reforestation of both inland forests and mangroves essential for the healthy functioning of ecosystems in the township. This is required to ensure that coastal settlements continue to be inhabitable, as well as preventing the salt line from moving further north. Preventing deforestation is a challenge, and the root causes of it are complex. An essential set of measures would be needed around moving away from dependence on wood for energy towards renewable sources, as while people are dependent on wood for their essential energy requirements, it will be very difficult to prevent mangrove cutting.

Improvements in the transport network and infrastructure will be required to ensure resilient and sustainable development. In particular, improvements would be needed in road transport; improving the resilience of small roads and increasing the number of village they access year-round, while also ensuring that public river transport also functions year-round, improving ports and harbours and boat safety. These measures would prevent remote areas, especially in the south of the township, from becoming isolated during the monsoon season.

Climate sensitive planning represents a group of actions that would be essential for resilient economic and social development. Cyclone shelters could be more effectively planned to provide dual purpose functions so they can also serve as schools of other public buildings. Improvements in the transportation network could also link up more effectively high schools – which are still inaccessible for many people – and health facilities.



## CONCLUSIONS & RECOMMENDATIONS: PLANNING FOR ADAPTATION IN LABUTTA

Building resilience to climate change in Labutta township is a great and urgent challenge, on which the life and welfare of thousands of people depend.

The devastating and long-lasting effects of Cyclone Nargis in 2008 were a tragic reminder of the sensitivity of Labutta area to severe, sudden, natural events. However, this assessment calls the attention of authorities and development partners to the fact that the effects of changes in climate on productive, social, ecological, and infrastructural systems of the township will greatly affect liveability and viability of Labutta over the next years, as well as increase the risk of further disasters. In these conditions, the vulnerability of people – particularly women, children, and disabled people – will greatly increase.

### KEY FINDINGS

The study has three main findings:

1. In addition to the need to reduce disaster risks from severe weather events, which will increase in intensity, decision-makers in Labutta Township urgently need to devise adaptation measures to protect productive systems, such as agriculture, from increased coastal flooding, warmer temperatures, more frequent extreme heat days, greater amounts of monsoon rainfall over a shorter monsoon season, and unknown rainfall changes during other seasons;

Despite communities enhancing their preparedness to disasters after Cyclone Nargis in 2008, Labutta Township remains insufficiently resilient to the present climate conditions, and its vulnerability will increase greatly because of the projected future changes in climate, if no adaptation actions are taken. Stronger storms and unusually heavy rainfall has already affected crops, basic services, housing and people's mobility in recent years. Storm surges and erosion are seriously affecting the coastal areas of the township, making a greater area saline – a problem being exacerbated by deforestation of both terrestrial and mangrove forests. A shorter monsoon season, coupled with higher temperatures in a longer dry season makes it difficult to collect water and results in shortages for both drinking and agricultural use.



2. Severe and wide-ranging underlying vulnerabilities exacerbate these climate-related threats, and are deeply interrelated with them. Labutta relies on a fragile and fast degrading ecosystem that communities are heavily dependent on; an economic and productive structure largely based on climate-sensitive agriculture and fisheries with insufficient technical skills to diversify production and employment; and transport and basic infrastructure (housing, schools, health-posts, roads, bridges) not adapted to the increased risks deriving from climate change, and a protective network of cyclones-shelter that is not sufficiently broad.

While the Ayeyawady Delta is a highly productive and resilient ecosystem, these qualities have been severely diminished due to decades of deforestation and degradation. Mangrove forests are particularly critical for maintaining ecosystem services but could be lost entirely within the next ten years without measures to prevent their loss. The low-lying topography of the township makes it especially vulnerable to salinity, especially in conjunction with reducing upstream river flows; allowing salt water to move further in-land. This directly contributes to a worsening situation in terms of access to fresh water, which is exacerbated by minimal infrastructure for storing and distributing water. Added to this, housing is usually constructed using

local materials in a way that can't easily withstand storms and floods, disaster resilient basic services are limited despite efforts to reduce disaster risks after Cyclone Nargis. Meanwhile, transport infrastructure is very limited, reducing mobility and increasing the risk of isolation of the people and communities of Labutta, especially the most vulnerable.

The socio-economic structure of Labutta is also a key underlying vulnerability. Agriculture and fisheries are the primary employment sectors but provide only low incomes, and are highly climate sensitive. The high number of informal workers means that livelihoods are often seasonal and unstable, and there are significant gender disparities in wages, which are higher for men; migration, which is male dominated; and in reporting of economic activity, where women are far more likely to be considered economically inactive despite having central roles in activities relating to the value chains in the fishery sector and agricultural commodities, and daily wages in construction. Production is not diverse, and value addition takes place outside the township. This means there is little capacity to create value-chains in-township that will help to create wealth, raise incomes, and reduce poverty, an issue, which is caused and exacerbated by a lack of skills resulting from minimal vocational training.

3. These vulnerabilities must be tackled as a whole, to generate co-benefits and enable adaptation. However, this requires effective strategic planning, resources, coordination, and time. This vulnerability assessment, the first of its kind in Labutta, and the planning work that follows it, represents a step towards achieving resilience and sustainable development, but the efforts should be sustained over a long period of time and by a number of actors, in particular local and national government. Increased planning capacity, supported by effective governance, and long-term programming and

budgeting are required for Labutta to develop along the third scenario identified in this report; in which resilience is built that enables economic and social development, despite changes in climate. At the very minimum, as a matter of mitigating risks, an action plan should be adopted that aspires to build resilience in accordance with along the Scenario B. As of now, the study finds that if no actions are taken, Scenario A, business as usual, is likely to unfold, which will make life and livelihoods very challenging in the township, especially for those living close to the coast.

Based on these findings, the study concludes that urgent adaptation planning is required to avoid Scenario A, and strive to achieve at the very least Scenario B, while aspiring to create the conditions for Scenario C.

An adaptation plan offers the best starting point for effective governance instrument to organize efforts and mobilize resources.





## POLICY RECOMMENDATIONS

The assessment issues the following recommendation for policy and decision-makers:

### 1. ECOSYSTEM

**It is crucial that healthy Eco-Systems are maintained and enhanced in Labutta. Ecosystem services - or the natural capital - represent an important source of livelihood, cultural, spiritual, physical health and safety for the vast majority of people in Labutta. They provide a variety of services to communities, without which the vulnerabilities of households will increase greatly from both rapid and slow on-set disasters from changes in climate. Actions must focus, among others, on:**

- a. Environmental conservation and restoration. In particular, mangrove and other multi-benefit services must be protected, restored and enhanced and environmental degradation stopped urgently, otherwise communities will not be able to adapt the adverse effects of climate change;
- b. Protection and enhancement of biodiversity habitat, especially for fish, while providing protection from unsustainable techniques;

- c. Innovate in agricultural production with salt and temperature resistant crops, to protect and enhance productivity in a context of climate change;

- d. Reducing the over-exploitation of natural resources, especially mangrove, through the widespread use of alternative energy sources, such as solar panels, efficient cook-stoves and other technology, and strengthening the capacity to manage water resources responsibly and durably, as increased temperatures and erratic rainfall will reduce fresh-water availability.

### 2. SOCIO ECONOMIC

**It is essential that productive capacities in agriculture and fishery are protected from the effects of the changing climate, such as crop-failure from increased temperatures, salinization as these sectors will continue to provide employment and occupation to most of the economically active population. However, given the potential extent of climate change impacts, including inundation, massive crop failure, potential conflict over land, it is also extremely important that productive means are diversified, to reduce dependency on these climate-sensitive sectors. Thus, actions should be taken to:**

- a. Enhance and diversify skills of people, both men and women, and especially younger people,

to increase employability in different sectors in Labutta and elsewhere, as some migration can't be avoided. Vocational training is also important as levels of technical qualifications are extremely low at present;

- b. Strengthen the socio-economic productive system by promoting cooperatives of farmers and fishermen so to increase their capacity to withstand shocks from rapid and slow on-set disasters, and to recover more quickly from them

- c. Increase opportunities for new industries or enterprises and promote investment, including through loans and other incentive schemes. This is difficult to achieve, without increased overall investment and focus on Labutta. It involves a large involvement of national, regional and district authorities, as well as development partners, and requires careful planning to be feasible.

- d. Utilize the potential of women's contributions to household livelihoods. As this assessment demonstrates, women often use innovative adaptive measures, which will be central to the communities' resilience in the future. For more efficient and sustainable interventions, it is essential to enhance understanding of gender roles in relation to productive capacities;

### 3. INFRASTRUCTURE

It is crucial that all infrastructure - housing, basic services such as schools and health posts - is adapted to the heightened risks of disasters from cyclones, floods, and water shortages. This includes, on the one hand, preventing future impacts of climate change on essential infrastructure such as roads, bridges, and settlements in general through climate-sensitive spatial planning. On the other hand, it includes the retrofitting of existing basic infrastructure, such as schools and health-posts, and ensuring that housing integrates basic disaster-resistant measures. More specifically, it is recommended that:

- a. Spatial planning in any new infrastructure, settlement expansion or any other infrastructure and development is climate-sensitive. This means that planning should consider current and future risks related to floods, cyclones and fresh-water shortages;
- b. Housing and basic infrastructure, including schools, health-posts is progressively retrofitted and reinforced, and new structures are built using disaster-resistant techniques;
- c. Housing safety also includes improved sanitation, and, crucially, the capacity to harvest water safely with improved techniques;

d. A network of life-line buildings is established, which includes not only dedicated cyclone shelters built from conventional materials, but also a network of resistant schools and health-posts that can greatly increase the resilience of communities to disasters;

e. Transport and connectivity is planned and protected from heightened risks related to climate change, such as storm-surges and waves, floods and inundation;

f. Community capacities are improved to collect and manage water, in the context of increased water scarcity resulting from a shorter monsoon, variable and erratic rainfall, increased evaporation, and salinization of ground-water;

g. Early-warning systems, in connection with disaster-sensitive physical and town planning are greatly enhanced and their coverage increased and adapted to new or heightened risks, such as floods and inundation from sea-level rise.

### 4. PLANNING AND GOVERNANCE

**Planning for resilience building will require a strengthened local governance, which will require stronger planning capacities from local to national level and vice-versa.**

**Mangrove and other multi-benefit services must be protected, restored and enhanced and environmental degradation stopped urgently, otherwise communities will not be able to adapt the adverse effects of climate change.**

a. It will be also absolutely crucial that resilience building actions are designed at Township scale. Most of the adaptation measures will be ineffective if planned at village level, as they require spatial and economic scale.

b. This will include budgeting. The results of this report should be integrated in township planning

c. Awareness of climate change impacts is highly strategic, cost-effective and important, and it should therefore be a focus of any intervention in Labutta.

## ADAPTATION ACTION PLANNING

Based on the broad coverage of community consultations undertaken in this study, the assessment team also conducted participatory planning exercises with communities and local authorities to identify priority outcomes, outputs and specific actions to avoid Scenario A, and change Labutta's development trajectory towards Scenarios B and, ideally, C.

To achieve Scenario C, the following main outcomes should be achieved:

1. Healthy ecosystem is maintained and enhanced, to continue protecting and providing for people;
2. Diversified and resilient economy is promoted, to enhance the economic conditions of people in the township;
3. Resilient infrastructure and connectivity is achieved, which protects people and enables development.

These outcomes, defined during the consultations are not aspirational, but are backed by a series of possible expected results and actions to undertake with different degree of investment and partnerships. These priorities will need to

be implemented by the communities, and the townships, district and national authorities. The outcomes of the plan will also help to communicate priorities to development partners and the private sector. In 2016-2018, the MCCA programme will implement some of the activities prioritized by the communities, while supporting the township to develop the plan and adopt it officially. The summary of the actions prioritized are presented in Annex A1.

To conclude, the findings of the study strongly indicate that adopting such a plan, using it consistently to programme and budget interventions and interact with donors and development partners, will be essential to mitigate the current and future effects of climate change, and prevent other vulnerabilities from arising. Annex A1 is particularly important as it demonstrates that communities and the township, if correctly supported and having



established the basic conditions, have ideas and determination on how to mitigate climate change impacts and to enhance resilience. While the impacts and future threats of climate change outlined in this report are severe and solutions to these are long-term in nature and complex to implement; this report should offer hope and encouragement that solutions exist and, with the right support and sufficient resources, can be implemented to ensure that Labutta Township can develop along a resilient and sustainable pathway.

In this regard, it is the hope of UN-Habitat, UN-Environment, WWF, and the CCSR that the report will be of use to both national and sub-national government officials in other parts of Myanmar, and of inspiration to other countries in the region and beyond, to identify climate change vulnerabilities and form the basis for taking action.

Priority outcomes, outputs and specific actions are to avoid Scenario A, and change Labutta's development trajectory towards Scenarios B and, ideally, C.

To achieve Scenario C, the following main outcomes should be achieved:

**1**

Healthy ecosystem is maintained and enhanced, to continue protecting and providing for people.

**2**

Diversified and resilient economy is promoted, to enhance the economic conditions of people in the township.

**3**

Resilient infrastructure and connectivity is achieved, which protects people and enables development.



# ANNEX 1. CLIMATE CHANGE ADAPTATION PLANNING OUTPUTS (LABUTTA, 2016)



Figure 73. Township administration after discussing the potential impacts of climate change (background) identify with MCCA and the village administrators potential adaptation measures © MCCA

## PROCESS

Between April and August 2016, the MCCA team extensively studied the vulnerabilities to climate change in Labutta Township. Consultations were conducted in a participatory manner with one hundred percent attendance of village administrators, and covered the entire township with meetings clustering different villages in focus groups. In addition, the team conducted specific consultations on gender issues, and with the Township Administration.

Participatory mapping exercises were conducted to identify hotspots to natural disasters, environmental degradation and where protective infrastructure exists and is lacking.

In the process, potential adaptive measures were identified to counter, prevent and mitigate the current and future impact of climate change. These were grouped under the eco-system, the infrastructure and connectivity and socio-economic actions. An exercise of prioritization was conducted. The activities prioritized were organized as follows:

1. Outcomes to be achieved by 2050 or before. These outcomes are systemic and therefore interconnected, and recognize that ecological, socio-economic and infrastructure and connectivity systems must be addressed together, to be beneficial and ensure adaptation. This means that improving infrastructure, without protecting and enhancing the eco-system services deriving from mangroves, for instance, will not generate resilient communities.
2. Expected Results. Under each of the three outcomes, specific expected results are to be achieved that will contribute to achieve the overall three systemic outcomes
3. Activities. Each of these outputs contain a set of activities. As they are prioritized, they are ranked for their adaptation capacity value, the difficulty and cost involved and time involved.



Figure 74. Village administrators and township authorities with the MCCA technical team ©Capizzi/MCCA

A SWOT analysis was also conducted to initiate the prioritization exercise.

During the consultations, potential activities were also co-designed and discussed. For example improved water tanks for more durable rainwater harvesting; cyclone shelters; mangrove replantation.

Based on the long-list of adaptive measures discussed with authorities and village members, a short-list was prepared and prioritized.

In the following pages, the activities are reported as the communities have prioritized them, under the three main outcomes.

This work forms the basis for an Adaptation Plan, to be adopted by Labutta Township, which the MCCA supports as part of its programme.



Figure 75. Participants to adaptation prioritization workshops in Labutta, July 2016 ©Capizzi/MCCA



Figure 76. Village adaptation committee established on the basis of this report in Da Mya Chaung Village ©MCCA 2016

SWOT ANALYSIS OF LABUTTA TOWNSHIP (JULY 2016)

SR	ISSUE	STRENGTH	WEAKNESS	OPPORTUNITY	THREAT
1	<b>SOCIO-ECONOMIC</b>	Agriculture	Laborers shortage	Can build industry or workshop	Land problem
		Fishery (river & stream/ crab & prawn)	Can use Waterway	Can improve production enterprises	Investment
		Livestock breeding (chicken, duck and pig)	Mechanism or technical know-how	Can increase job opportunities	Exposed location (due to the sea)
		Raw salt production (salinization area)	Investment	Can improve living standard	
		Rice mill (paddy)	Shortage of industry & workshop	Can improve educational and health care services	
		Trading (paddy, rice and aquaculture product/ transportation)	No marketing	Improve building infrastructure	
			Collaboration		
			Communication (transportation)		
	Electricity				
	Education/ health (human resources)				
2	<b>ENVIRONMENTAL</b>	Former or existing mangrove forest can expand	Increase firewood cutting due to livelihood difficulty of local people	Can have better weather condition and can withstand disasters	Increasing firewood cutting
		Land for agriculture and mangrove	Cost for transportation and transplantation of mangrove	Economic of fishermen also improved	Soil of ponds cannot retain water
		Preservation of existing forest	Less interest (negligence) of local people	Agriculture can be improved	Brick baking enterprise use the mangrove
		Can drill tube-wells in some costal area	No technical know-how or devices to dig ponds, wells, tube-wells	Long life span of mangrove can be used	Do not practice agricultural mechanism
			Salinization resisting paddy seeds and technical know-how	Mangrove forest can prevent from the increasing salinization	
3	<b>COMMUNITY INFRASTRUCURE</b>	Clinics in each village tract for health care	Limited numbers of staff for health care	Can increase numbers of brick ponds	Cost for construction and labor charges increase
		State primary, middle and high schools	Limited numbers of teaching staff, need of school repair and need of teaching facilities	Buildings to be constructed on the hills	Implementation slow as waterway-transportation
		Monasteries	Shortage of vehicles for transportation	Ponds to be constructed close to the banks of river or stream	Technical know-how
		Car road and waterway	Shortage of cyclone shelters		
		Phone services for communication	Need of technicians		
		Using both ponds and creek for water access (upper part)	Need of building renovation (some building are very old, some are not qualified since built)		
		Brick ponds	Safety of ponds (low banks)		
		Forming water committees in the lower part	Dry very fast due to rising temperature		
		Close to the towns (for minority)	The whole community have to rely on the same pond		
		Hill or higher ground level			



## OUTCOME 1: ECO-SYSTEM

OUTCOME	EXPECTED RESULT	ACTIVITIES	TYPE	COST	FEASABILITY	COMMUNITY ACCEPTANCE	ADAPTATION/EFFECTIVENESS	BENEFIT ANYWAY/NO REGRET	SPEED	SCORE	STRATEGIC VALUE
To protect and enhance environment so that it can continue supporting and improving the living standards of people in Laputta	ER1 Forestry coverage is restored (to 1980 levels), enhanced and protected so to continue providing services as protection from hazard, eco-system for biodiversity (fishery), construction materials, soil regulation	Protecting existing mangrove/forestry areas by enforcing laws and regulations on protected forestry areas		5	4	5	4	5	2	25	100
		Protecting existing mangrove/forestry areas by creating community awareness on the need to maintain forestry		5	4	5	4	5	2	25	100
		Enhancing and restoring mangrove/forestry coverage in areas exposed to natural hazards and in areas with soil		1	4	4	5	5	1	20	100
		Enhancing access to renewable energy sources as cookstoves, Solar Power to reduce weight on mangrove		1	5	4	4	5	3	22	100
		Implementing Community Forestry (Integrated Management and Livelihoods) to provide for construction,		3	4	5	4	5	1	22	75
ER2 Natural resources and in particular the soil and the sea/river biodiversity are protected and enhanced so to continue supporting agriculture, fishery and people		Enhancing knowledge and capacities for Sustainable Soil Management (sustainable organic fertilizer, rotational)		3	3	5	3	4	3	21	50
		Testing integrated soil management techniques to maintain soil productivity/fertility, including in salt		3	3	5	3	4	3	21	50
		Raising awareness on sustainable fishery and illegal chemical fishery		4	4	4	4	5	2	23	75
		Enhancing and restoring mangroves to (re) create eco- systems for fishery		3	4	5	4	5	2	23	100
ER3 The salinization process effects are mitigated by means of adaptive crops, regulating services (mangroves), and infrastructure		Protecting paddy fields/fields from salinization by constructing small community embankements		3	4	5	5	4	3	24	25
		Protecting fields by constructing constructing large embankements		1	5	4	5	5	2	22	50
		Protecting fields by constructing dykes systems structing dykes		1	5	4	5	5	2	22	75
		Testing crops resistant to salt to maintain and increase agricultural productivity		3	3	5	5	3	4	23	100
		Enhancing forestry and mangroves to control salinization		3	4	5	4	5	3	24	75
		Changing to livestock		1	3	4	3	4	3	18	75
		Training in agriculture adaptive techniques		3	5	5	5	4	3	25	100

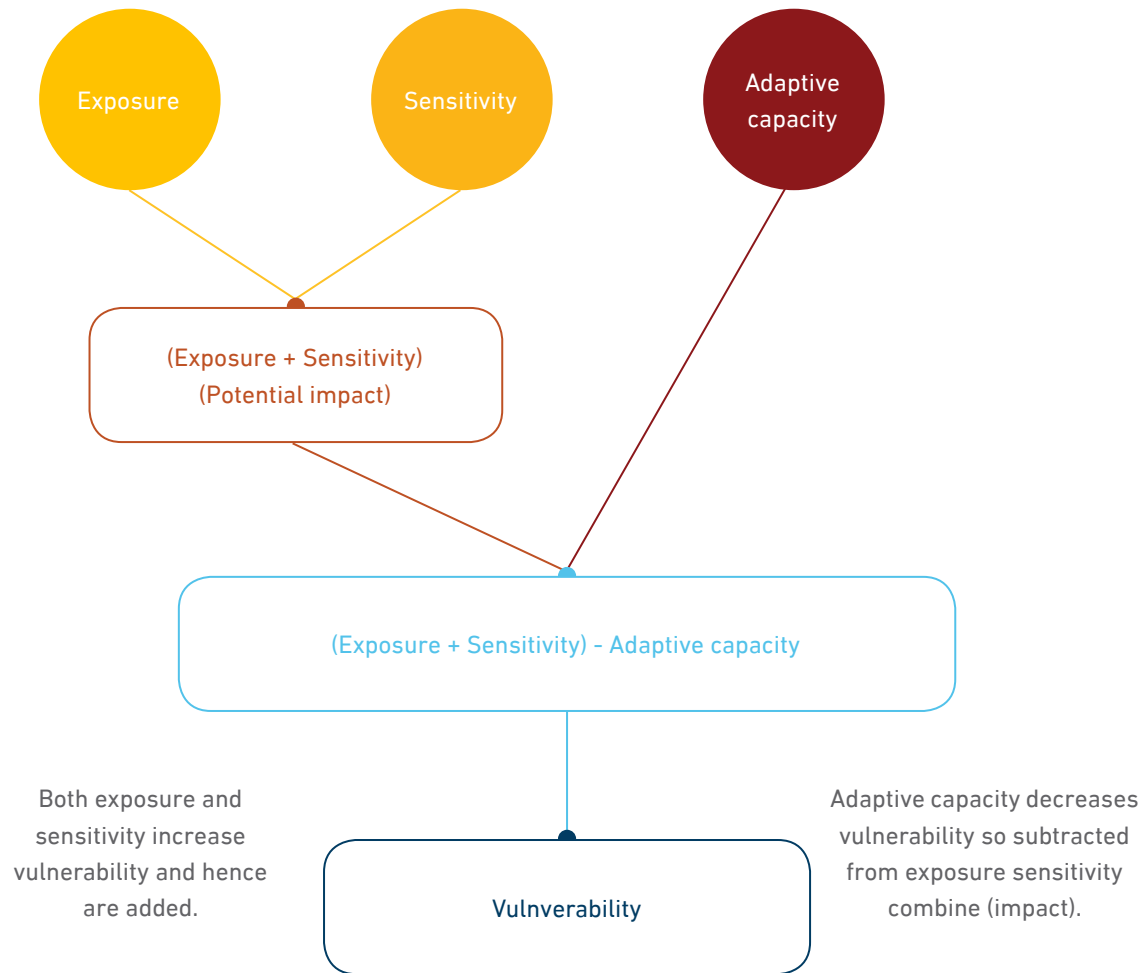
## OUTCOME 2: SOCIO-ECONOMIC

OUTCOME	EXPECTED RESULT	ACTIVITIES	TYPE	COST	FEASIBILITY	COMMUNITY ACCEPTANCE	ADAPTATION/EFFECTIVENESS	BENEFIT ANYWAY/NO REGRET	SPEED	SCORE	STRATEGIC VALUE
Diversified and Resilient Economy is Promoted, to Enhance the Economic Conditions of People in the Township;	ER1 Enhanced Skills for People Increase Employability in Different Productive Sectors	Climate information for farmers + fishers		5	4	5	5	5	3	27	75
		Knowledge sharing + training on agriculture and fisheries		3	4	3	4	5	3	22	75
		Training on mechanised farming		3	3	4	4	5	2	21	25
		Vocational training (new employability) inc build new training centres (5 if on the job training is more useful --- with earnings, less if not)		3	3	5	5	5	3	24	100
		More access to primary and secondary education		3	3	5	5	5	3	24	100
		IT Training		3	4	5	5	5	3	25	100
		Training on irrigation systems		4	5	3	5	3	5	25	75
	ER2 Increased investment and access to finance to maintain and improve production in existing industries - namely agriculture and fisheries	Loans for fishery activities		1	3	2	3	4	2	15	50
		Willingness to pay for retrofitting		5	3	3	4	5	4	24	100
		Mechanised farming		1	2	3	4	5	4	19	25
		Form cooperatives (It was 2 now is 4---requires more discussion)		5	3	4	4	5	3	24	75
		Irrigation schemes (Infrastructure)		1	1	5	4	5	1	17	50
	ER3 Investment in new industries has increased	Loans for small medium enterprises		2	3	5	5	4	4	23	100
Aquaculture			1	2	4	4	5	2	18	75	
Job guarantee scheme			1	1	5	4	5	1	17	50	
Provide access to agriland for landless people (Climate Justice)			1	1		3	5	2	12	25	
Loans/microfinance			4	3	5	5	5	4	26	100	

### OUTCOME 3: INFRASTRUCTURE AND CONNECTIVITY

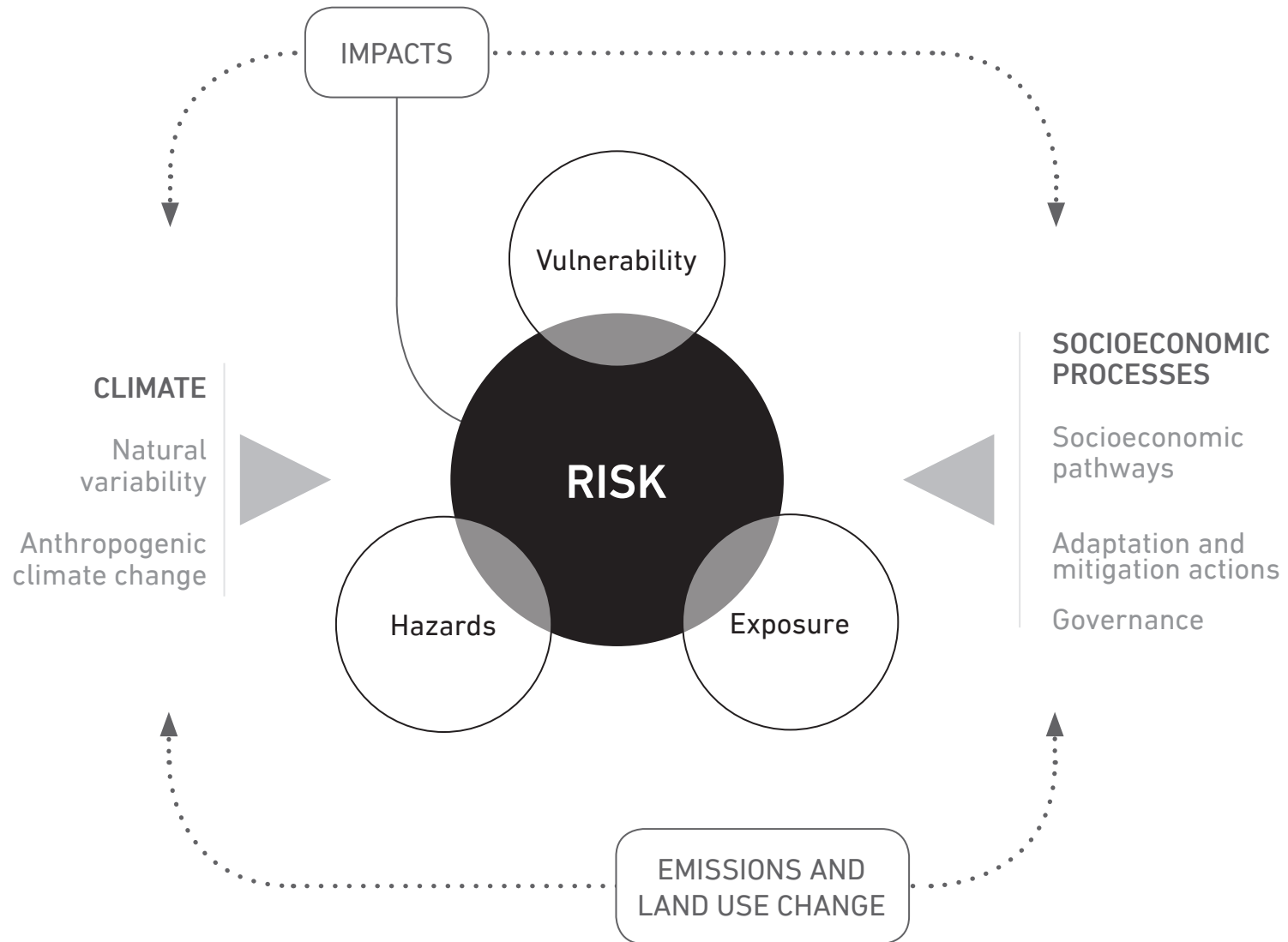
OUTCOME	EXPECTED RESULT	ACTIVITIES	TYPE	COST	FEASABILITY	COMMUNITY ACCEPTANCE	ADAPTATION/EFFECTIVENESS	BENEFIT ANYWAY/NO REGRET	SPEED	SCORE	STRATEGIC VALUE
Diversified and Resilient Economy is Promoted, to Enhance the Economic Conditions of People in the Township;	ER1 All people in Labutta is protected to natural hazards	Participatory planning (Disaster Preparedness, Disaster Sen		5	5	5	5	5	5	30	100
		Disaster drills in schools		5	5	5	5	5	5	30	100
		Improve radio access and broadcast		5	5	5	5	5	5	30	100
		Flood maps at village tract/urban ward level		5	5	5	5	5	5	30	100
		Early warning system		5	5	5	5	5	5	30	100
		Hospitals and health post safety/security plans		5	5	5	5	5	5	30	100
		Emergency preparedness		4	5	5	5	5	5	29	100
		Sand banks for protection in coastal areas		3	4	5	5	5	4	26	50
		Local material shelter		2	5	5	5	5	3	25	75
		Other small infrastructure resilient to hazards		2	3	5	5	5	3	23	75
		Evacuation routes		2	3	5	5	5	2	23	75
		Flood and erosion control plans		2	3	5	5	5	3	22	50
		Building cyclone shelters than can also be used as schools/community centres (local materials, double-use etc.)		1	2	5	5	5	1	19	75
		ER2 Public and private facilities and services are protected		Network of water harvesting at household level		5	5	5	5	5	5
Improve storage for food , crops and animals				4	5	5	5	5	5	29	75
Improve management of infrastructure				3	5	5	5	5	4	27	100
Improve construction techniques for resilient architecture				3	5	5	5	5	4	27	100
Strategic water networking				3	4	5	5	5	4	26	100
Improve water capture and storage at community level				3	4	5	5	5	4	26	100
Local/conventional material resistant housing				2	5	5	5	5	3	25	100
Large energy infrastructure, E.g. flood control, tidal energy generation etc.				1	3	5	3	5	2	19	25
River basin management (National relevance)				1	2	3	4	4	1	15	100
ER3 Network of transport and communication is enhanced		Sustainable urban drainage in Labutta town		5	5	5	5	5	5	30	50
		Concrete or wooden jetty to maintain access		2	4	5	5	5	3	24	75
		Improve boat and bus transport, adapted to sea-level rise, floods and recurrent hazards		1	3	5	5	5	3	22	100
		Roads and bridges to improve rapid/effective access in case of hazards/sea-level rise		1	3	5	5	5	2	21	100

# ANNEX 2. VULNERABILITY FRAMEWORK



## DEFINITIONS OF KEY COMPONENTS OF VULNERABILITY<sup>56</sup>

TERM	IPCC AR5 DEFINITION
<b>HAZARD</b>	The potential occurrence of a natural or human-induced physical event or trend or physical impact that may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, ecosystems, and environmental resources. In this report, the term hazard usually refers to climate-related physical events or trends or their physical impacts.
<b>EXPOSURE</b>	The presence of people, livelihoods, species or ecosystems, environmental functions, services, and resources, infrastructure, or economic, social, or cultural assets in places and settings that could be adversely affected.
<b>VULNERABILITY</b>	The propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt.
<b>IMPACTS</b>	Effects on natural and human systems. In this report, the term impacts is used primarily to refer to the effects on natural and human systems of extreme weather and climate events and of climate change. Impacts generally refer to effects on lives, livelihoods, health, ecosystems, economies, societies, cultures, services, and infrastructure due to the interaction of climate changes or hazardous climate events occurring within a specific time period and the vulnerability of an exposed society or system. Impacts are also referred to as consequences and outcomes. The impacts of climate change on geophysical systems, including floods, droughts, and sea level rise, are a subset of impacts called physical impacts.
<b>RISK</b>	The potential for consequences where something of value is at stake and where the outcome is uncertain, recognizing the diversity of values. Risk is often represented as probability of occurrence of hazardous events or trends multiplied by the impacts if these events or trends occur. Risk results from the interaction of vulnerability, exposure, and hazard (see Figure SPM.1). In this report, the term risk is used primarily to refer to the risks of climate-change impacts.



56 Ibid, p.3  
57 Ibid, p.5

## ANNEX 3. METHODOLOGY OF THE MATRIX OF FUNCTIONS

The Matrix of Function (MoF) is used to identify the linkages between the existing human settlements by classifying the human settlements considering its functional complexity and the role and importance in a given territory under a regional perspective. The main purpose is to allow each settlement to perform their potential and existing functions more effectively.

A well-articulated and integrated system of human settlements of different sizes and functional characteristics can play an important role in facilitating more widespread regional socio-economic development.

The assumption, in this assessment, is that those human settlements where fewer functions are present are more vulnerable, and their vulnerability would be reduced by providing the services that are largely missing, these already give some indications of the “local sensitivity” of a certain village to climate change or hazards. At the township level, we can visualise the linkages between villages,

for example we could determine the degree of dependency in terms of health or education services. This is very important to map and quantify the villages affected if something happens to the village providing the health or education service; hence it helps to determine a “regional sensitivity”.

The analysis using the MoF produces a set of hypotheses and assumptions about the existing network of human settlements and its organisation by:

- Determining a preliminary functional hierarchy of human settlements, which provides a baseline of conditions within the region and establishes a hierarchy of settlements (functional classification) based on its combination and diversity of physical infrastructure, social and economic activities located in them.
- Defining the current spatial structure of the township based on the “territorial influence” and socio- economic linkages between settlements

## STEP 1: FILLING THE QUESTIONNAIRE

The analysis is based on the data collected at Village Tract Level (basic administrative unit of reference that identify a human settlement) through the distribution of a questionnaire filled by village representatives for inventorying

the presence or absence of 82 functions– as exhaustively as possible - existing services, activities, equipment and infrastructure - with an economic, administrative, social or cultural function - for each Village Tract and Ward.

Figure 77. Questionnaire for inventorying the functions in each Village Tract

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The Matrix of Functions (MoF) is used to determine a hierarchy of settlements based upon availability of physical infrastructures and socio-economic key functions and its territorial linkages of a given territory.

Within the framework of the "Climate Change Adaptation Pilot Project at Labutta and Pakoku Townships" data will be collected at the Village Tract and Ward level, considered the basic administrative units of reference that identifies a human settlement in each Township. The following questionnaire has been prepared for inventorying (as exhaustively as possible) the existing services, activities, equipment and infrastructure with an economic, administrative, social or cultural function.

Please check the box (x) whenever a function exists in the Village Tract or Ward (e.g. if a school building is destroyed the function does not exist).

Township		
Name of Village tract/Ward		
Total Population of Village tract/Ward		
Category	Name of function	Presence
1. Public Utilities and facilities	1.1. Telecommunication Transmitter (Mobile Phone repeater)	
	1.2. Radio station	
	1.3. Post office	
	1.4. Rain water harvest pond	
	1.5. Well with hand pump	
	1.6. Public Water Network On Grid (piped water)	
	1.7. Irrigation system	
	1.8. Private solar panel electricity supply	
	1.9. Public Electricity Network On Grid	
	1.10. Sewerage drainage system	
	1.11. Storm water drainage system	
2. Road Connection and Transportation Infrastructure	2.1. Paved roads	
	2.2. Unpaved roads	
	2.3. Bus transport on daily basis	
	2.4. Bus Station	
	2.5. Boat transport on daily basis (two ways same day)	
	2.6. Boat transport every two days (one way per day)	
	2.7. Port/Harbour	

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3. Markets	3.8. Petrol Supply Station	
	3.1. General Market	
	3.2. Livestock Market	
4. Industries and Commercial Establishments	3.3. Fish market	
	4.1. Small basic needs stall	
	4.2. Groceries shop	
	4.3. Retail shop	
	4.4. Restaurant	
	4.5. Hotel	
	4.6. Bicycle Repair garage	
	4.7. Motor Vehicle Repair garage (motorbike /car)	
	4.8. Factory	
	4.9. Salt production	
	4.10. Aquaculture (Crabs / Shrimps)	
4.11. Banks/ western union		
5. Provisioning eco-systems services	5.1. Rice	
	5.2. Grains	
	5.3. Groundnuts	
	5.4. Maize	
	5.5. Beans	
	5.6. Powers	
	5.7. Tobacco	
	5.8. Vegetables	
	5.9. Livestock	
	5.10. Roof/wall material	
	5.11. Wood for charcoal	
	5.12. Oil extraction	
	5.13. Natural medicines (i.e. spirulina)	
6. Health Facility <sup>1</sup>	6.1. Public Rural Health Centre	
	6.2. Public Rural Health Centre	

<sup>1</sup> <http://www.moh.gov.mm/files/HEALTH/ROSERVICES/2016/2016%20RHMAR.pdf>

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သက်တောင့်တစားသော နယ်ပယ်တစ်ခုတွင် အခြေခံ အဆောက် အအုံများ တည်ရှိနေမှု၊ သမီးကလေးကလေး လူမှု နည်း လုပ်ဆောင်ချက်များနှင့် နယ်ပယ် ဆက်စပ်မှုများ အပေါ် မူတည်၍ ဓနတို့ကို အဆင့်အတန်းတို့ သို့မဟုတ် ဆုံးဖြတ်ရန်အတွက် လုပ်ဆောင်ချက်များပေးထား (Matrix of Functions) တစ်ခုကို တည်ဆောက် အပ်နှံပြုပါသည်။

လူထုအဖွဲ့အစည်းများနှင့် ပူးပေါင်း၍ အဆောက်အအုံများနှင့် ဆက်စပ်၍ ရှိမရှိ စစ်ဆေးရန်အတွက် မူတည်မှုများအရ ရှိမရှိကိစ္စများ၊ ကျေးဇူးများနှင့် ကျေးဇူးအပ်နှံမှုများ အခွင့်အလမ်းများကို ကောက်ယူပါသည်။ ထိုအခွင့်အလမ်းများကို ဖြည့်စွက်ရန်အတွက် ဖြည့်စွက်ရန် လိုအပ်သည့် အချက်အလက်များကို ဖြည့်စွက်ရန်အတွက် လူမှု ဓနတို့ကို ဖြည့်စွက်ပါသည်။ ရှိမရှိ အခြေခံ အဆောက်အအုံများကို ဖြည့်စွက်ရန်အတွက် သတ်မှတ်ပါသည်။

ဧည့်သည်များ အုပ်စုများနှင့် လူထုအဖွဲ့များ လုပ်ဆောင်ချက်များနှင့်အညီ ယခုလက်ရှိ တည်ရှိနေသော နယ်ပယ်များမှာ လုပ်ဆောင်မှုများ စတင်လုပ်ဆောင်မှုများနှင့် အခြေခံ အဆောက်အအုံများ အတိုင်းကို ကောက်ယူရန်အတွက် အောက်ပါ ဓနတို့ကို ဖြည့်စွက်ရန်အတွက် ဖြည့်စွက်ပါသည်။

**ရက်စွဲကို ဖြည့်စွက်ရန် အတွက် ရက်စွဲများကို လုပ်ဆောင်ချက်/ ဝန်ဆောင်မှု/ ဓနတို့ဖြင့် ဖြည့်စွက်ပါ။**  
(ဥပမာ- ဓနတို့ကို ဖြည့်စွက်ရန်အတွက် လုပ်ဆောင်ချက်/ ဝန်ဆောင်မှု/ ဝန်ဆောင်မှု ဖြည့်စွက်ပါ။) (လုပ်ဆောင်မှု/ ဓနတို့ကို ဖြည့်စွက်ရန်အတွက် ဖြည့်စွက်ပါ။)

မြို့နယ် - ကျေးရွာ		ရက်စွဲ	
ကျေးရွာ	ရက်စွဲ	ကျေးရွာ	ရက်စွဲ
၁.၁ နယ်ပယ်တစ်ခုတွင် ဓနတို့ (ရက်စွဲများ ထည့်သွင်းရန်) (ဥပမာ- ဝိုင်ဆိုင်)		၁.၂ ဓနတို့ ထည့်သွင်းရန် ဓနတို့	
၁.၃ နယ်ပယ်တစ်ခုတွင် ဓနတို့ (ရက်စွဲများ ထည့်သွင်းရန်) (ဥပမာ- ဝိုင်ဆိုင်)		၁.၄ ဓနတို့	
၁.၅ နယ်ပယ်တစ်ခုတွင် ဓနတို့ (ရက်စွဲများ ထည့်သွင်းရန်) (ဥပမာ- ဝိုင်ဆိုင်)		၁.၆ ဓနတို့	
၁.၇ နယ်ပယ်တစ်ခုတွင် ဓနတို့ (ရက်စွဲများ ထည့်သွင်းရန်) (ဥပမာ- ဝိုင်ဆိုင်)		၁.၈ ဓနတို့	
၁.၉ နယ်ပယ်တစ်ခုတွင် ဓနတို့ (ရက်စွဲများ ထည့်သွင်းရန်) (ဥပမာ- ဝိုင်ဆိုင်)		၁.၁၀ ဓနတို့	
၁.၁၁ နယ်ပယ်တစ်ခုတွင် ဓနတို့ (ရက်စွဲများ ထည့်သွင်းရန်) (ဥပမာ- ဝိုင်ဆိုင်)		၁.၁၂ ဓနတို့	

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၂. ရက်စွဲများ ထည့်သွင်းရန် အဆောက် အအုံများ	၂.၁ ဓနတို့ ထည့်သွင်းရန်	
	၂.၂ ဓနတို့ ထည့်သွင်းရန်	
	၂.၃ ဓနတို့ ထည့်သွင်းရန်	
၃. ကျေးရွာ	၃.၁ ကျေးရွာ	
	၃.၂ ကျေးရွာ	
	၃.၃ ကျေးရွာ	
၄. ကျေးရွာ/ နယ်ပယ် ဆက်စပ်မှုများ	၄.၁ ဓနတို့ ထည့်သွင်းရန်	
	၄.၂ ဓနတို့ ထည့်သွင်းရန်	
	၄.၃ ဓနတို့ ထည့်သွင်းရန်	
	၄.၄ ဓနတို့ ထည့်သွင်းရန်	
	၄.၅ ဓနတို့ ထည့်သွင်းရန်	
	၄.၆ ဓနတို့ ထည့်သွင်းရန်	
	၄.၇ ဓနတို့ ထည့်သွင်းရန်	
	၄.၈ ဓနတို့ ထည့်သွင်းရန်	
	၄.၉ ဓနတို့ ထည့်သွင်းရန်	
	၄.၁၀ ဓနတို့ ထည့်သွင်းရန်	
	၄.၁၁ ဓနတို့ ထည့်သွင်းရန်	
၅. ကျေးရွာ/ နယ်ပယ် ဆက်စပ်မှုများ	၅.၁ ဓနတို့ ထည့်သွင်းရန်	
	၅.၂ ဓနတို့ ထည့်သွင်းရန်	
	၅.၃ ဓနတို့ ထည့်သွင်းရန်	
	၅.၄ ဓနတို့ ထည့်သွင်းရန်	
	၅.၅ ဓနတို့ ထည့်သွင်းရန်	

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### STEP 3: SPATIAL ANALYSIS OF THE MATRIX OF FUNCTIONS

#### A. Determining a preliminary functional hierarchy of human settlements

The analysis of the MoF allows to establish a functional hierarchy of settlements based on their “Total Centrality Score”. Three types of Rural Village Tracts (local village tracts, intermediate village tracts and main village tracts) and two

types of Urban Wards (local urban centre and main urban centre) are identified. Furthermore, a “set of functions” that should be covered is derived considering the highest presence of a function for each typology. Considering the Local Village Tract (LVT) as the basic level, an implicit assumption is that in a “regular/standard distribution” any higher hierarchical level contains the number of functions of the precedent level(s) plus their own specific functions.

Figure 79. Typologies of Rural Village Tracts & Urban Wards

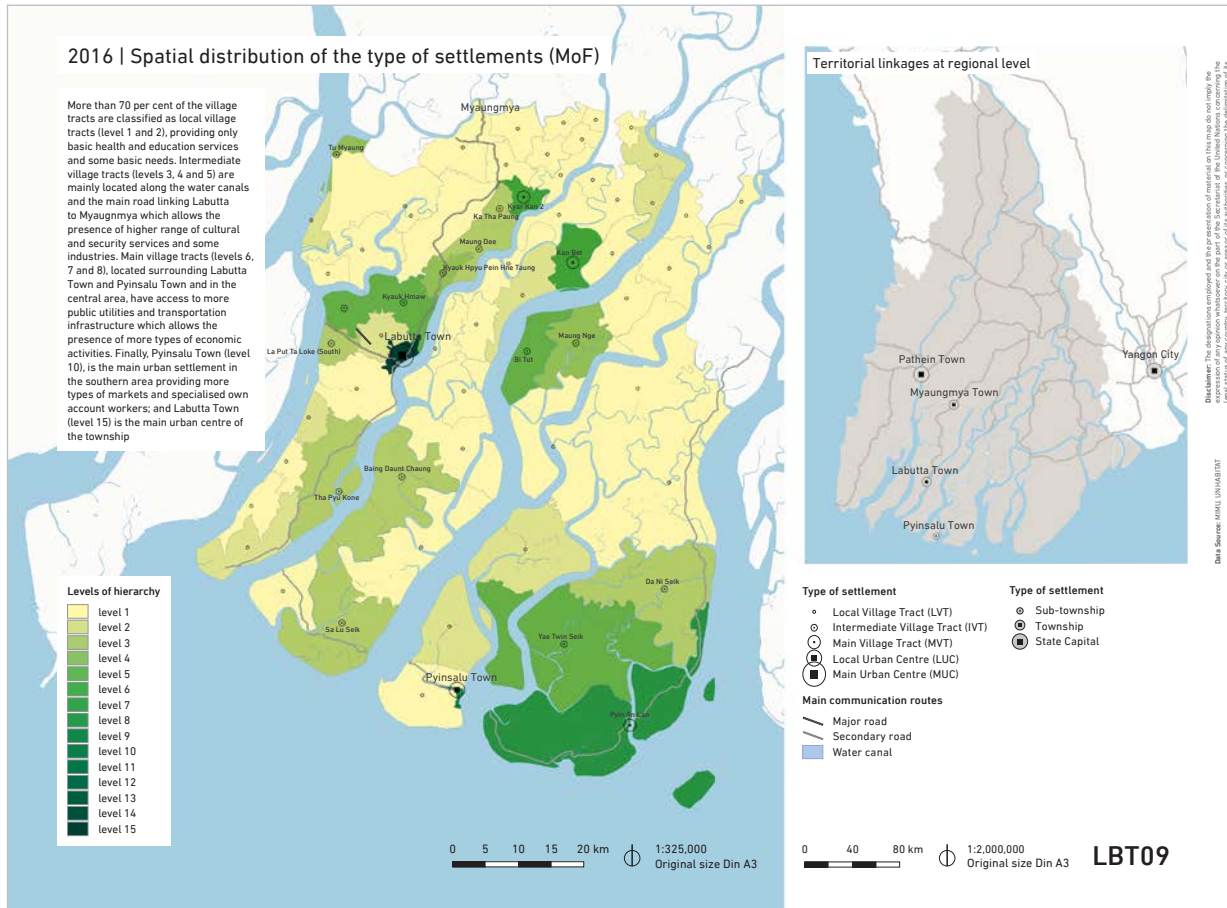
TYPE	Local village tract (LVT)	Intermediate village tracts (IVT)	Main village tracts (MVT)	Local urban centres (LUC)	Main urban centres (MUC)
<b>CENTRALITY SCORE</b>	38.97 – 118.73	131.39- 187.66	219.01- 308.05	523.62	835.17
<b>LEVEL OF HIERARCHY</b>	1 2	3 4 5	6 7 8	9 10 11	15
<b>LEVEL OF DEVELOPMENT</b>	Is considered the lowest level of infrastructure and socio-economic development, rain fed water and solar panels is the main energy source, while boats are the main mean of transportation. Only basic health and education coverage is provided, and the basic needs are provided through small groceries and street sellers. Agriculture is the main economic activity (mainly rice and vegetables) together with fishermen mainly in communities in coastal areas.	Is considered the second to the lowest level of infrastructure and socio-economic development. More transportation facilities, security services and industries (mainly aquaculture) are provided.	Is considered the highest level of rural settlements. Access to more public utilities and transportation infrastructure allows the presence of more types of economic activities	Lowest level of urban settlement. Presence of more types of markets and specialised own account workers.	Highest level of physical and socio-economic development, covering the highest number of functions and the most unique ones across the Township.w
<b>NUMBER AND TYPE OF FUNCTIONS THAT SHOULD BE COVERED</b>	23 functions  Eco-system services: Mangrove, Rice, Small streams, Roof/wall material (leaves), Vegetables, Livestock  Infrastructure: Rain water harvest pond, Boat transport on daily basis (two ways same day), Private solar panel electricity supply, Unpaved roads  Socio-economic services: Basic Education Primary Schools, Basic Education Post-Primary Schools, Midwife, Public Sub Rural Health Centre, Religious Organization/Monastery, Civil Society Organisation, Disaster management committee, NGOs, Carpenters, Fishermen, Street sellers, Weaving/sewing, Groceries shop	33 functions (23 from previous category +10)  Infrastructure: Port/Harbour, Cyclone Shelter, Boat transport every two days (one way per day)  Socio-economic services: Kindergarten, Basic Education Middle Schools, Cultural Centre, Cooperative Union, Bicycle Repair garage, Plumbers, Aquaculture (Crabs / Shrimps)	50 functions (33 from previous category +17)  Eco-system services: Rivers, Beans Infrastructure: Telecommunication Transmitter (Mobile Phone repeater), Paved road, Well with hand pump, Irrigation system, Petrol Supply Station, Bus transport on daily basis  Socio-economic services: Basic Education High Schools, Public Rural Health Centre, Motor Vehicle Repair garage (motorbike /car), Salt production, Pharmacy, General Market, Fire Station, Police Check Point	61 functions (50 from previous category +11)  Eco-system services: Flowers, Wood for charcoal  Infrastructure: Storm water drainage system  Socio-economic services: Private Clinic, Public Station Hospital, Fish market, Post office, Police Station, Electricians, Livestock Market, Lawyers	72 functions (61 from previous category +11)  Eco-system services: Maize, Groundnuts Infrastructure: Bus Station, Public Electricity Network On Grid, Radio station  Socio-economic services: Public Township Hospital, Dentist, Accountants, Banks/ western union, Hotel, Eye specialist

Labutta Township shows low levels of socio-economic and infrastructure development. It is observed that the number of functions belonging to socio-economic activities, health, education, security, welfare and other professional services tend to increase as settlement's centrality grow.

The mapping the typologies of village tracts helps visualising the spatial distribution of the levels of infrastructure and socio-economic development of the township:

- More than 70 per cent of the village tracts are classified as local village tracts (LVT), providing only basic health and education services and some basic needs;

- Intermediate village tracts (IVT) are mainly located along the water canals and the main road linking Labutta to Myaungmya which allows the presence of higher range of cultural and security services and some industries (mainly aquaculture);
- Main village tracts (MVT), located surrounding Labutta town and Pyinsalu town and in the central area, have access to more public utilities and transportation infrastructure which allows the presence of more types of economic activities;
- Pyinsalu Town has the highest level of physical and socio-economic development in the southern area, with more types of markets and specialised own account workers;
- Labutta Town is the main urban centre, covering the highest number of functions and the most unique ones across the Township.
- The assumption, in this assessment, is that human settlements that have fewer functions available are more vulnerable, and their vulnerability would be reduced by providing the services that are largely missing. Eastern areas of the township are the most vulnerable to climate change and hazards.



B. Define the current spatial structure of the township:

Under a regional planning perspective, where a region is not only a system of functionally diversified settlements but also a network of social, economic, and physical interactions, the analysis of the spatial linkages among the Village Tracts and Wards helps to, for example, determine the degree of dependency in terms of health or education services. This is very important to map and quantify the villages affected if something happens to the village providing the health or education service.

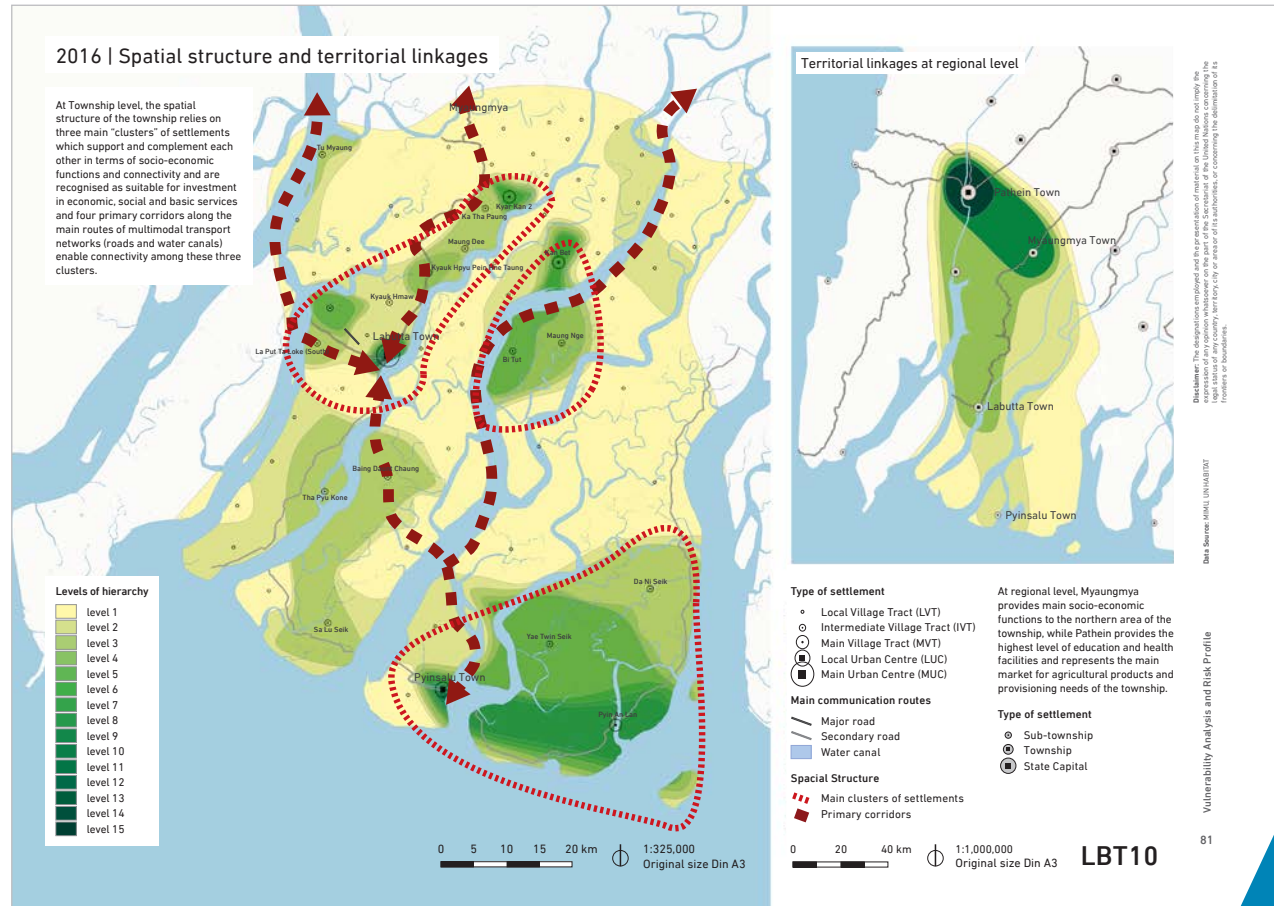
The cartographic representation of the “condensed levels of hierarchy” by using isopleths<sup>58</sup> allows visualising the level of “territorial influence” (or not) of each Village Tract over its neighbouring Village Tracts at Township and Regional level and, identifying “clusters” of settlements (or areas of concentration of settlements) which are strongly interconnected and work cooperatively in terms of socio-economic activities. The current spatial structure of the township relies on:

- At regional level, Myaungmya provides main socio-economic functions to the northern area of the township, while Patheingyi provides the highest level

of education and health facilities and represents the main market for the agricultural products and provisioning needs of the township

- At township, three main “Clusters” of settlements or priority areas of economic, social and basic

services development, composed of a network of human settlements which support and complement each other in terms of socio-economic functions and road connectivity and are recognised as suitable for investment in economic, social and basic services.



58 NB: In meteorology an isopleth indicates a geographical line connecting points showing an equal level of incidence of a specific meteorological feature. In the case of the MoF, the term is used to indicate a geographical line representing a specific condensed level of hierarchy.

- Four Primary Corridors along main (existing and proposed) routes of multimodal transport networks which enable connectivity among the “Clusters” of settlements and/or human settlements adjoining

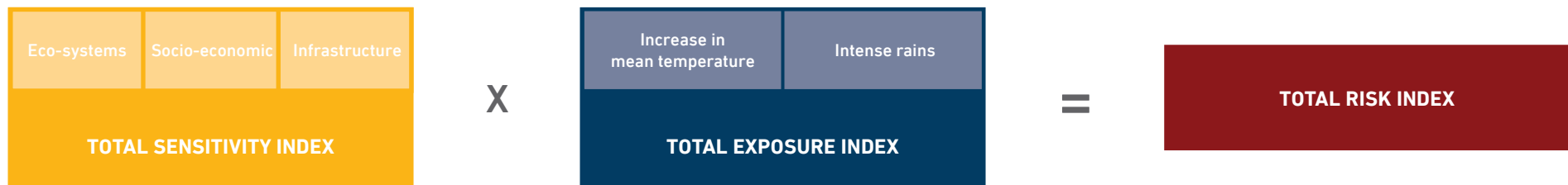
townships and regions. Labutta Town is well connected with Pathein through the main paved road and the Thet Ke Thuang river, while Pyinsalu’s main transportation route to Labutta is through the Pya

Ma Law and Yway rivers and to Kan Bet and further Wakema Township and Yangon through Pya Ma Law river. These corridors remain crucial to support the economy of the southern areas of the township.

LOCATION	North western area			Southern area			North-Central area		
<b>TERRITORIAL INFLUENCE</b>	The “territorial influence” of Labutta Town, considered the main urban and trade centre of the township, is observed along the main road to Myangmya and along the secondary road to Laputta Loke (Thet Ke Thuang River).			The “territorial influence” of Pynsalu Town, considered the main urban and trade centre of the southernmost part of the township, is observed towards the west, along the secondary road to Pyn An Lah.			Centred in Kan Bet includes the surrounding village tracts located at the centre of the township along the Pya Ma Law river		
<b>VILLAGE TRACTS</b>	Name	Level of hierarchy	Typology	Name	Level of hierarchy	Typology	Name	Level of hierarchy	Typology
	Labutta Town	15	MUC	Pyinsalu Town	10	LUC	Kan Bet	6	MVT
	Kyar Kan	6	MVT	Pyin Ah Lan	8	MVT	BiTut	5	IVT
	Kyauk Hmaw	5	IVT	Yae Twin Seik	5	IVT	Maung Nge	4	IVT
	La Put Ta Loke (North)	5	IVT	Da Ni Seik	3	IVT	Htin Pon Kwin	2	LVT
	Kyauk Hpyu Pein Hne Taung	4	IVT						
	La Put Ta Loke (South)	3	MUC						
	Ka Tha Paung	3	MUC						
	Maung Dee	3	MUC						
	Nyaung Lein	2	MUC						
<b>TOTAL POPULATION</b>	62,327 inhabitants (20% of the total population of the township)			24,907 inhabitants (8% of the total population of the township)			26,409 inhabitants (9% of the total population of the township)		
<b>FUNCTIONAL COMPLEXITY</b>	This “cluster” has the highest levels of physical development which allows the presence of more types of economic activities.			Despite Pyinsalu Town being the economic centre of this cluster, it only provides local markets (fish and livestock) and some specialised own account workers (lawyers and electricians), which, at township level, shows the economic dependency with Labutta Town. Pyin Ah Lan is the most important village tract in terms of health services (Station Hospital) and provisioning, supporting and regulating eco-system services, mangroves			These four village tracts configure a cluster strategically located at the centre of the township, their access to more public utilities (wells and irrigation channels) and transportation infrastructure (paved road, harbour) allows higher yields and more crops (beans) and more types of economic activities (general market, restaurant, salt production)		

## ANNEX 4. VULNERABILITY INDEX CALCULATION

The vulnerability index is calculated by village tract to identify locations where risk levels are higher under the eco-system, socio-economic and infrastructure components.



## SENSITIVITY INDEX

The sensitivity index considers three indicators for each of the three components, in total nine indicators. Data used is from Census 2014 and spatial data sets from MIMU and WWF. The ranking criteria defines 1 as the lowest and 4 the highest level of sensitivity.

**Ecosystems indicators:** The three indicators under the ecosystems component assess people's dependency on freshwater sources and forestry sources.

	11. Access to drinking water	12. Quality of the forest	13. Access to irrigation water
1	50% HHs having access to surface water and 50% having access to groundwater	All village tracts are ranked 4 as scrubland is the only type of vegetation cover	50% HHs having access to surface water and 50% having access to groundwater
2	0-25% HHs having access to surface water		0-25% HHs having access to surface water
3	50-75% HHs having access to surface water		50-75% HHs having access to surface water
4	75-100% HHs having access to surface water		75-100% HHs having access to surface water

**Socio-economic indicators:** The three indicators under the socio-economic component assess people's livelihoods

	11. Level of education completed	12. Income per capita	13. Labour force participation rate
1	75-100% population 25 years and over with high school, diploma or vocational training completed	Labutta town is the main trade centre	75-100% labour force participation rate population 10 years and over
2	50-75% population 25 years and over with high school, diploma or vocational training completed	Northern area is a mix of agri and industry	50-75% labour force participation rate population 10 years and over
3	25-50% population 25 years and over with high school, diploma or vocational training completed	Next lowest incomes are in fisheries, which we assume dominates in the coast	25-50% labour force participation rate population 10 years and over
4	0-25% population 25 years and over with high school, diploma or vocational training completed	Lowest incomes in agriculture, which is the dominant livelihood in the central area	0-25% labour force participation rate population 10 years and over

**Infrastructure indicators:** The three indicators under the infrastructure component assess people's access to shelter and mobility

	11. Type of housing units	12. Access to transport services	13. Access to protection services
1	0-25% houses built with local materials	50-100% HHs having transport items in rainfed areas	All village tracts are considered 4 as there are no adequate protection shelters rather than monasteries
2	25-50% houses built with local materials	0-50% HHs having transport items in rainfed areas	
3	50-75% houses built with local materials	50-100% HHs having transport items in riverbank areas	
4	75-100% houses built with local materials	0-25% 0-50% HHs having transport items in riverbank areas	

## EXPOSURE INDEX

### Intense rainfall

	Strong winds	Flooding
1		rainfed areas (lowest)
2	All areas	close to seasonal streams (medium)
3		riverbank areas (highest)

### Increase in temperature

	Drought	Heat waves
1		
2	riverbank areas (medium)	
3	rainfed areas (highest)	All areas

Village Tract	SENSITIVITY INDEX									Total Sensitivity Index	HAZARD INTENSITY (frequency/magnitude)					Total Exposure Index	Total Risk Index
	ECO-SYSTEMS			SOCIO-ECONOMIC			INFRASTRUCTURE				SEA-LEVEL RISE		INTENSE RAINS	INCREASE IN MEAN TEMPERATURE			
	I1. Access to drinking water	I2. Quality of the forest	I3. Access to irrigation water	I1. Level of education completed	I2. Income per capita	I3. Labour force participation rate	I1. Type of housing units	I2. Access to transport services	I3. Access to cyclone shelters		Storm surge	Salinization	Flooding	Cyclone	Drought/ Heat Waves		
Nyaung Lain	2	4	2	4	2	2	4	1	4	25	0	1	1	4	1	7	175
Kyauk Tan Gyi	1	4	2	4	2	2	4	2	4	25	0	1	1	4	1	7	175
Ye Sai	2	3	2	4	2	2	4	2	4	25	0	1	1	4	1	7	175
Tha Li Kar Kone	2	3	2	4	2	2	4	2	4	25	0	1	1	4	1	7	175
Pan Toon Kween	2	4	2	4	2	2	4	2	4	26	0	1	1	4	1	7	182
Myoay Hauk	2	3	2	4	2	3	4	2	4	26	0	1	1	4	1	7	180
Kyauk Phyu	3	4	3	4	2	1	4	1	4	26	0	1	1	4	1	7	182
Laputta Loap Myauk	3	3	3	4	2	2	4	1	4	26	0	1	1	4	1	7	184
Kyein Kone Gyi	4	2	4	4	2	1	4	1	4	26	0	1	1	4	1	7	184
Ta Yet Kone Le Pyauk	2	3	1	4	2	4	4	2	4	26	0	1	1	4	1	7	184
Urban Labutta	4	3	4	4	1	2	4	1	4	27	0	1	1	4	1	7	186
Maung Nge	4	3	4	4	2	2	4	1	4	28	0	1	1	4	1	7	193
Kyauk Tan Ka Lay	4	2	4	4	2	2	4	2	4	28	0	1	1	4	1	7	193
Tha Nup Phat	4	2	4	4	2	2	4	2	4	28	0	1	1	4	1	7	194
Lebyauk	4	3	4	4	2	2	4	1	4	28	0	1	1	4	1	7	194
Hlai Bone	4	3	3	4	2	3	4	1	4	28	0	1	1	4	1	7	194
Kyauk Mhaw	4	3	4	4	2	2	4	1	4	28	0	1	1	4	1	7	196
Htin Pon Kwin	4	2	4	4	2	2	4	2	4	28	0	1	1	4	1	7	196
Too Myaung	4	3	3	4	2	2	4	2	4	28	0	1	1	4	1	7	198
Ka Ta Paung	4	3	4	4	2	2	4	1	4	28	0	1	1	4	1	7	198
A Mat	4	2	4	4	2	2	4	2	4	28	0	1	1	4	1	7	198
Bar Thar Kone	4	2	4	4	2	1	4	3	4	28	0	1	1	4	1	7	198
Nyaung Lan	4	4	4	4	2	1	4	2	4	29	0	1	1	4	1	7	200
Bee Toot	4	3	4	4	2	2	4	2	4	29	0	1	1	4	1	7	200
Bo Pyay	4	3	4	4	2	2	4	2	4	29	0	1	1	4	1	7	201
Ka Ka Yan	4	4	4	4	2	1	4	2	4	29	0	1	1	4	1	7	203
Kan Bet	4	3	4	4	2	2	4	2	4	29	0	1	1	4	1	7	201
Nyaung Chaung	4	3	4	4	2	2	4	2	4	29	0	1	1	4	1	7	201
Ohn Ta Pin	4	2	4	4	2	3	4	2	4	29	0	1	1	4	1	7	203
Kyein Kween	4	3	4	4	2	2	4	2	4	29	0	1	1	4	1	7	203
Gon Hmyin Tan	4	3	4	4	2	2	4	2	4	29	0	1	1	4	1	7	203
Shaw Chaung	4	3	4	4	2	2	4	2	4	29	0	1	1	4	1	7	203
Kyun Chaung	4	3	4	4	2	2	4	2	4	29	0	1	1	4	1	7	203
Tap Kween	4	3	4	4	2	2	4	2	4	29	0	1	1	4	1	7	203
Maung Tee	4	3	4	4	2	2	4	2	4	29	0	1	1	4	1	7	203
Bay Pauk	4	2	4	4	2	2	4	3	4	29	0	1	1	4	1	7	205
Nyan Kween (Kan Yar)	4	3	4	4	2	2	4	2	4	29	0	1	1	4	1	7	205
Kyu Taw	4	4	4	4	2	2	4	2	4	30	0	1	1	4	1	7	210
Laput Pyay Le Pyauk	4	4	4	4	2	2	4	2	4	30	0	1	1	4	1	7	210
Kyee Chaung	4	3	4	4	2	2	4	3	4	30	0	1	1	4	1	7	208
Kya Kan	4	4	4	4	2	2	4	2	4	30	0	1	1	4	1	7	210
Min Boo Su	4	3	3	4	2	2	4	4	4	30	0	1	1	4	1	7	210
Laputta Loap Taungww	2	2	2	4	4	2	4	1	4	25	0	2	2	4	1	9	228
Tai Daunt Chaung	3	3	1	4	4	2	4	1	4	26	0	2	2	4	1	9	232
Sar Check	2	3	2	4	4	2	4	1	4	26	0	2	2	4	1	9	232
Da Ni Seip	3	3	1	4	4	2	4	1	4	26	0	2	2	4	1	9	232
Phone Gyi Kone	1	3	3	4	4	2	4	1	4	26	0	2	2	4	1	9	232
Gant Eiat	4	3	4	4	4	2	4	2	4	31	0	1	2	4	1	8	244
Kone Gyi	3	2	2	4	3	2	4	1	2	23	1	3	2	4	1	11	256
Po Laung	1	3	2	4	3	2	4	2	3	24	1	3	2	4	1	11	261
Sar Kyin	4	2	4	4	4	2	4	1	4	29	0	2	2	4	1	9	264
Myit Pauk	4	3	4	4	4	2	4	2	4	31	0	2	2	4	1	9	277
Kok Ko	4	3	4	4	4	2	4	2	4	31	0	2	2	4	1	9	277
Ka Nyin Kone	4	2	3	4	4	3	4	3	4	31	0	2	2	4	1	9	279
Urban Pynsalu	4	3	4	4	3	2	4	2	1	27	1	3	2	4	1	11	292
Sa Lu Seip	4	2	4	4	3	2	4	2	3	28	1	3	2	4	1	11	311
Tel Pin Kai	4	3	4	4	3	2	4	2	3	29	1	3	2	4	1	11	319
Yway	4	3	4	4	3	1	4	2	4	29	1	3	2	4	1	11	319
Hloa Zar	4	3	4	4	3	2	4	2	4	30	1	3	2	4	1	11	330
Tha Pyu Kone	4	3	3	4	3	3	4	2	4	30	1	3	2	4	1	11	330
Thin Gan Gyi	4	3	4	4	3	2	4	3	3	30	1	3	2	4	1	11	330
Yay Thwin Seip	4	3	4	4	3	2	4	2	4	30	1	3	2	4	1	11	330
Sin Chay Yar	4	2	4	4	3	2	4	3	4	30	1	3	2	4	1	11	333
Kan Ba Lar	4	2	4	4	3	3	4	3	4	31	1	3	2	4	1	11	341







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