Myanmar Climate Change Alliance

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CLIMATE CHANGE VULNERABILITY ASSESSMENT OF LABUTTA TOWNSHIP, AYEYAWADY REGION, 2016-2050: SCENARIOS FOR RESILIENCE BUILDING

SUMMARY FOR POLICY MAKERS

STUDY CONDUCTED BY

UN-HABITAT

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IN COLLABORATION WITH

WWF

Center for Climate Systems Research

'Climate Change Vulnerability Assessment of Labutta Township, Ayeyawady Region, Myanmar, 2016-2050: Scenarios for Resilience Building'

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Cover Photo: Crossing by boat to Oo Yi Kone village from Labutta:
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SUMMARY FOR POLICY MAKERS

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HIGHLIGHTS

In 2016 the Myanmar Climate Change Alliance (MCCA), implemented by UN-Habitat and UN-Environment, on behalf of the Ministry of Natural Resources and Environmental Conservation, conducted a detailed climate change vulnerability assessment of Labutta Township, in collaboration with WWF and Columbia University.

Labutta is located at the southern tip of the Ayeyawady Delta Area region in Myanmar and is home to approximately 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. Three scenarios for the future of Labutta are envisaged, taking into account the potential impact of climate change and the required adaptation and mitigation action. Recommendations are issued to avoid the worst case future scenario A, which is currently the most likely.

The study projects changes in climate for the township and concludes that temperatures may increase 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, over shorter periods of time. Strong winds and cyclones are also expected to increase, because of higher air and ocean temperatures, more evaporation and a greater moisture level in the atmosphere. Salinity already is and will continue to be 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 as the sea-level rises. The assessment projects up to 41 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 concludes that decision-makers in Labutta Township will need to plan for increased coastal flooding, warmer temperatures, more frequent extreme heat days, more intense cyclones, greater amounts of rain within a shorter monsoon season, and unknown rainfall changes during other seasons.

The study demonstrates that, in the current conditions 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 due to the current socio-economic; infrastructure and ecological system conditions, and the expected impact of climate change on these systems.

The interplay of these underlying vulnerabilities with on-going 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.

Three possible future scenarios by 2050 are envisaged:

A

Most likely / least desirable

The business as usual scenario, in which authorities and communities do not recognize the urgent need to address different aspects of vulnerability. Changes in climate have exponential effects on the three systems analysed in this report; socio-economic, infrastructure, ecological and ultimately affect people's life, livelihoods, health, and safety before and by 2050. In this scenario, insufficient planning capacities and governance affect the required 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

Currently unlikely / desirable

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 continue present development trends.

C

Currently very unlikely / very desirable

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 people and enables. 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.

PURPOSE, PRINCIPLES AND METHODS OF THE ASSESSMENT

The purpose of this assessment is to inform the Labutta Township, district, regional and national authorities, as well as the 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.

FIVE PRINCIPLES WERE APPLIED TO CONDUCT THE ASSESSMENT:

- **Simplicity**, to ensure ease of replication in other townships
- **Measurability** and availability of data, to ensure ease of update and replication
- **Inclusiveness**, to ensure participation of communities
- **Comprehensiveness**, to ensure relevance of the findings
- **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.
- Data available at either national or local level, which can be easily obtained upon written request. The assessment does not use high resolution satellite imagery, other than that free on-line. 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;
- Participatory approach, 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 iss 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 interventions for adaptation spatially
- Equal participation of men and women and, where possible, using gender disaggregated data
- Representative engagement of young and old people, and consideration poverty drivers such as a lack of access to educational opportunities
- Engagement of the national government and the township throughout the process, to ensure ownership of the results and replication

THE METHODOLOGY WORKS AS FOLLOWS:

A. It first describes the context and key socio-economic, ecological and infrastructure features and the spatial structure of the township, as basis for the analysis. 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;

B. It analyses, through both data analysis and community risk mapping, the exposure of people and assets to recurrent natural hazards and the potential for rapid and slow on-set disaster;

C. It then overlays downscaled projections of climate change up to 2050 on the current conditions analysed in the assessment and studies how these new climatic conditions will affect people and assets in the township;

D. It produces future scenarios that may materialize if adaptive action is not taken and contrast them with potential adaptive pathways, which inform adaptation planning

E. On this basis, it informs a long-term local adaptation and resilience building plan, with detailed adaptive measures for the infrastructure, environmental and socio-economic systems

1

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 diversied 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 Pathein. 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.

2016 | Topography

Digital Elevation Model (DEM) of Myanmar

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. The terrain is made up of central lowlands ringed by steep, rugged highlands.

Type of settlements

- Sub-village

Main communication routes

- Major road
- Secondary road
- Streams
- Water canals

0 200 400 km
1:13,000,000
Original size Din A3

LBT01

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: HNAI, FAO, IPMP, UN HABITAT

CLIMATIC FEATURES, NATURAL HAZARDS AND OBSERVED IMPACTS

In the last decades, meteorological and observational data confirm that

- Stronger storms, winds and unusually heavy rainfall affect people's mobility and access to basic services, destroy houses and lives, and destroy agriculture crops. The cyclone Nargis was extremely destructive and killed thousands of people. Its intensity was unprecedented in this region.
- Exposure to storm surges and erosion 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 resulting in water shortages for agriculture and drinking water
- Sea water infiltration increases salinization impacting nutrient cycling in soil and lowers rice yields

ECOSYSTEM CONDITIONS

- Labutta Township is characterised by a deltaic environment, with a flat topography, except for some low hills in the northern part of the township. Due to its location, the Ayeyawady Delta collects sediments and nutrients that support a highly productive surrounding ecosystem. These in turn provide critical ecosystem services – benefits that nature provides to people – that support livelihoods and the larger economy of the entire township.
- The Delta is a naturally highly productive and resilient ecosystem, but decades of deforestation and degradation have severely diminished. 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. The township can be divided in three main areas, depending on the level of salinity 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.

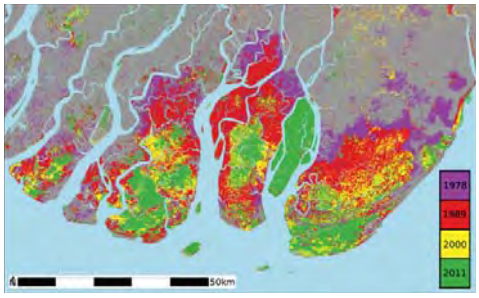


Figure 2. **From Webb et al. (2014). Historical forest coverage in the Ayeyarwaddy delta showing deforestation over time between 1978 and 2011**

INFRASTRUCTURE CONDITIONS

- Labutta is considerably less urbanised than the rest of Myanmar. Thirty per cent of Myanmar's population lives in urban areas whereas only 10.6 per cent of people living in Labutta Township live in the urban centres, almost all of whom in Labutta Town
- 97 per cent of the conventional housing units are made in non-durable materials in Labutta. Housing construction is vulnerable to strong winds and floods, because it is often poorly executed, or not adapted to increased frequency and intensity of the hazards and highly dependent on already degraded eco-systems provisioning service.
- 80 per cent of the population relies only on uncovered water sources (ponds, rivers and streams) for drinking water. 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.
- Freshwater availability will worsen due to the lack of infrastructure for water storage and management at community level. Salinization of freshwater challenges the current irrigation system.
- Disaster and climate resilient basic services coverage is very limited. Around 10 per cent of the total population of the township has access to cyclone shelters providing critical emergency shelter.
- 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.

Figure 3. **Conventional household by type of housing unit (Census 2014)**

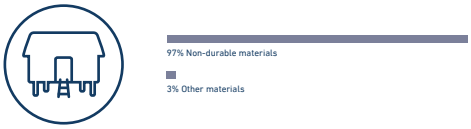
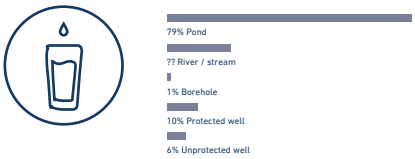
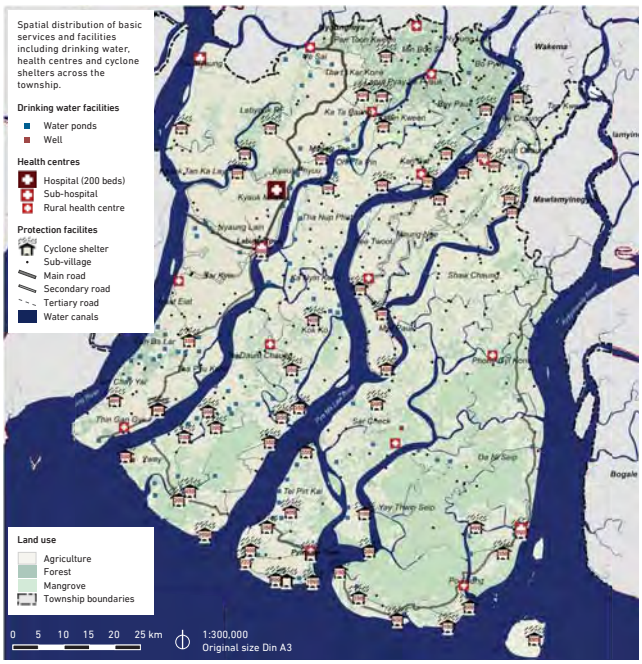


Figure 4. **Distribution of main sources of water for drinking use in Labutta Township (Census, 2014)**



2016 | Basic services and shelter



Main drinking water sources

Rain water harvest ponds are the only source of drinking water for more than 80% of the households, while some communities from the north-east and south-west areas have access to wells.

Rural health coverage

The majority of sub-rural health centres (SRHC) are located within a distance of 10km (2h walking) from a rural health centre (RHC), provide health services to a population between 2,500 and 5,000 inhabitants.

Cyclone shelter coverage

The spatial distribution shows a network of shelters every 5km (1 h walking) in coastal and northern areas, while in the central-east area there is a lack of shelters and distances are greater.

0 20 40 km

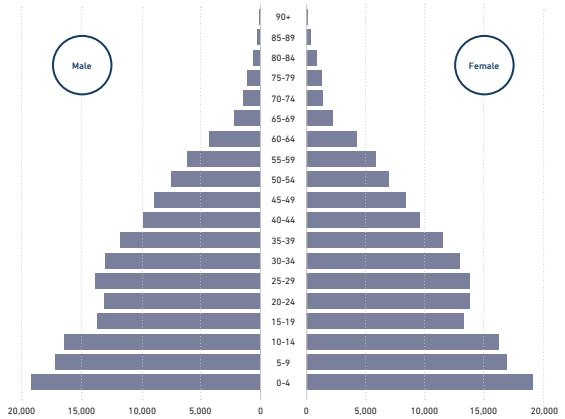
1:1,000,000
Original size Din A3

LBT08

SOCIO-ECONOMIC CONDITIONS

- Labutta's population pyramid shows an uneven distribution, with fewer than expected people in the 15-24 age group. This is indicative of relatively high outward migration and the disproportionate effect of cyclone Nargis on young people and children. Despite this, around 38 per cent of the population of Labutta is under 18.
- Infant mortality is much higher in Labutta than in the rest of Myanmar; 60 infants are lost per 1,000 live births compared to 40 per 1,000 on average in Myanmar.
- Agriculture and fisheries make up 50 per cent of value but provide the main source of livelihood for almost 72 per cent of the population, when economically inactive people are factored in. There is limited 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.

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



- 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. 71.8 per cent of the population has received either no education or only education up to the grade 5 level. This rises to almost 76 per cent for women.
- 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.

Figure 6. **Labutta's Economy by sector**

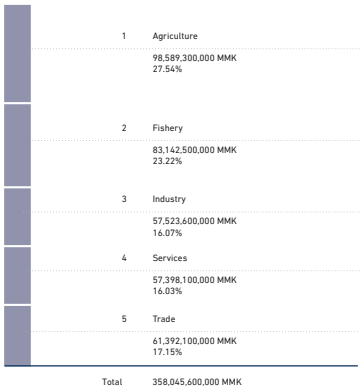
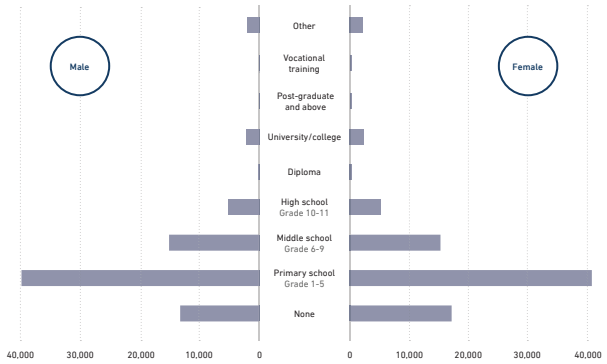
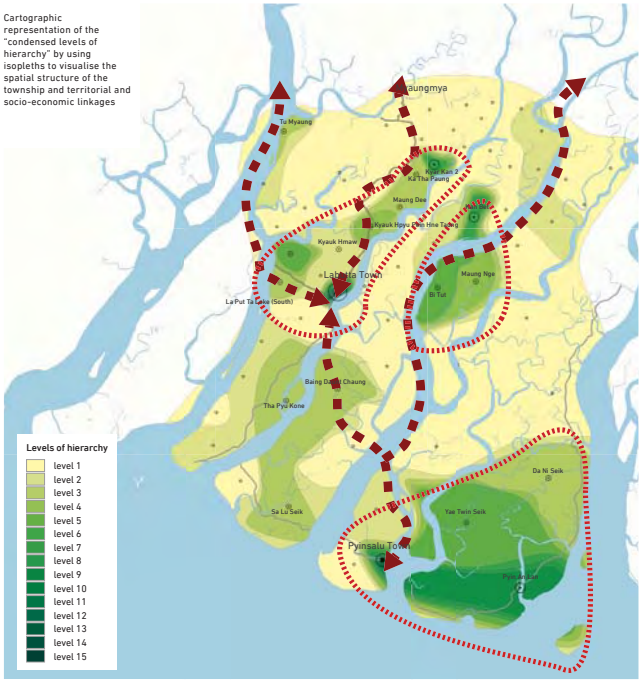


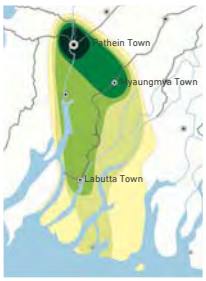
Figure 7. **Level of education completed people over 25 (Census, 2014)**



2016 | Spacial structure

Cartographic representation of the "condensed levels of hierarchy" by using isopleths to visualise the spatial structure of the township and territorial and socio-economic linkages





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

Spacial Structure

- Main clusters of settlements
- Primary corridors

At regional level, Myaungmya provides main 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 agricultural products and provisioning needs of the township.

Type of settlement

- Sub-township
- Township
- State Capital

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

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

LBT10

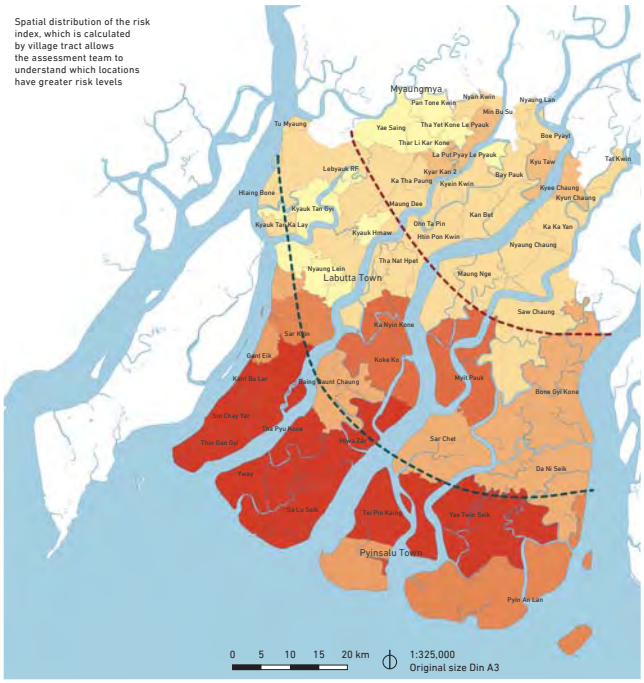
Data Source: MIMU, LAV-HABTAT

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 extremely vulnerable to weather conditions and natural hazards, with potential for disrupting both commerce, and access to critical services such as health from more remote areas.
- The spatial distribution of services and functions is not balanced across the township and is fragile by virtue of the poor connections and climatic present and projected conditions

2016 | Risk index

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



Data Source: MIMU, FAO, YHHP, UN HABITAT

Eco-systems | Socio-economic | Infrastructure

TOTAL SENSITIVITY INDEX

X

Sea-level rise | Increase in mean temperature | Intense rains

TOTAL EXPOSURE INDEX

=

TOTAL RISK INDEX

Risk rating

- 1 (lowest)
- 2
- 3
- 4
- 5
- 6
- 7
- 8
- 9
- 10 (highest)

Salinity intrusion

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

CURRENT VULNERABILITY INDEX

Indicators for infrastructure, ecological and socio-economic systems have been analysed against the observed climatic dominant features and natural hazard profile.

These indicators are: For infrastructure and transportation, the 1) type of housing units, 2) access to transport service, 3) access to cyclone shelter; for eco-system services: 1) access to drinking water; 2) access to irrigation water (other than rain) and 3) quality of the forest coverage. For the socio-economic system: 1) level of education achieved, 2) income per-capita, 3) labour-force participation rate.

Depending on the village tract, indicators were scored and then contrasted with the potential natural hazards. As a result, an index of vulnerabilities was established to show where they are spatially concentrated, given a certain natural hazard.

- The entirety of Labutta township is extremely vulnerable to a number of natural hazards, which have increased in intensity and likelihood over the last decades. This includes floods and inundations; strong winds, storms or cyclones and heavy rains; sea-level rise and salinization with increased storm-surge risks and erosion. Its economy is extremely risk-sensitive and non-diversified and the infrastructure unable to withstand the hazards. Its eco-system is seriously degraded;
- 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, storm surge, salinity and flooding are all likely to impact the coastal areas of the township more than the inland areas.
- The vulnerability index suggests that coastal areas of the township are currently facing greater threats from disaster risks. However, the rest of the township is nonetheless extremely vulnerable to the transformative effects of climate change (such as salinization, higher temperatures affecting crops and evaporation of harvested water) and require also attention.

2

CLIMATE CHANGE PROJECTIONS AND FUTURE RISKS AND VULNERABILITIES

CLIMATE CHANGE PROJECTIONS FOR LABUTTA

- Sea level for the coastal area closest to Labutta is projected to increase by 20 to 40 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 with possible peaks at 2.3°
- 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.

Figure 9. **Projected Sea Level Rise in Myanmar**

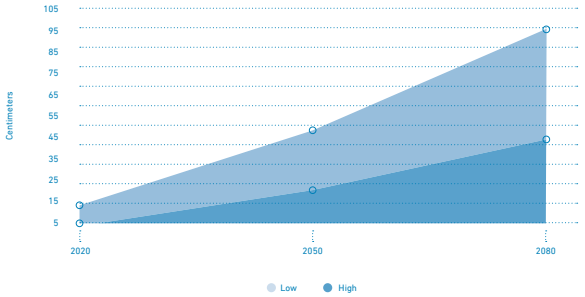


Figure 10. **Projected Change in Average Rainfall (%) in Labutta, Myanmar**

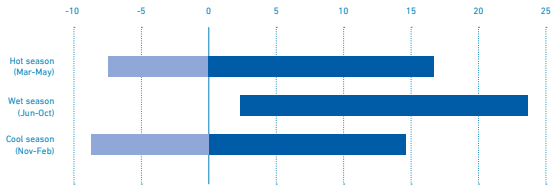
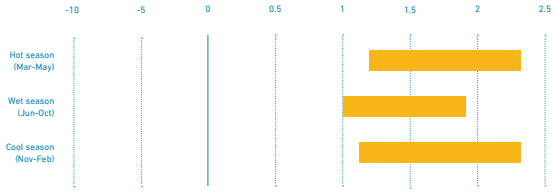


Figure 11. **Projected Change in Temperature (°C) in Labutta, Myanmar**



CLIMATE CHANGE IMPACT PATHWAY

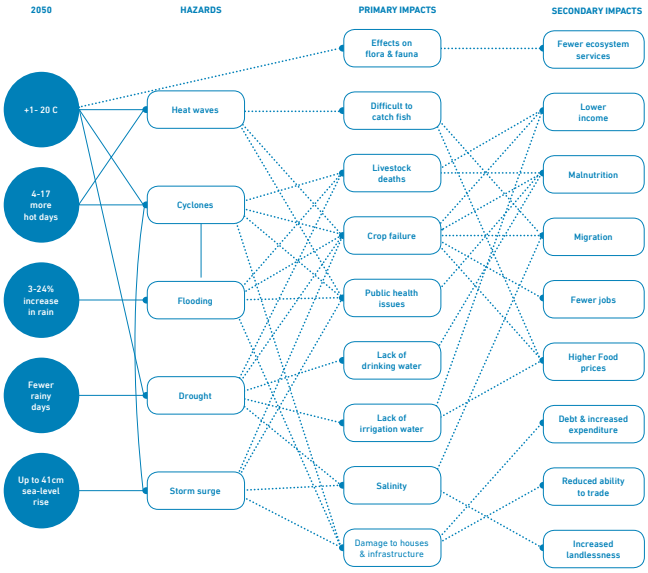
The projected changes in climate will increase the hazards intensity and possibly likelihood, and set in motion primary and secondary impacts before and by 2050.

Downscaled projections were discussed with communities and the chain of potential effects and impacts drawn participatorily.

There is a complex correlation between hazards and impacts: in particular a given primary impact resulting from one or more climatic features can cause multiple secondary impacts that are intertwinned and that feed mutually.

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; so, crop failure would cause worsening nutritional outcomes, because many farmers keep a substantial amount of their crops for household consumption.

Figure 12. **Pathways to potential climate change impact***



*Feel free to draw your own lines.

FUTURE RISK PROFILE AND VULNERABILITIES

This section of the assessment assumes that business will be conducted as usual, meaning that no adaptation actions will be taken. As such, the future vulnerabilities presented here are not a projection or a forecast of the situation in ecosystems, infrastructure, or socio-economics in 2050, but are a possible scenario if no actions are taken.

i. Increased risks of rapid on-set disasters

The changes in climate will result in increasingly intense hazardous events. 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.

+ 2°C Warmer

Increase in mean temperature of 1.1 to 2.0°C[1]

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 -7% to +17% in the hot season; and -8% to +13% in the cold season [2]

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 20-41cm in the 2050s[3]

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

1 According to Columbia University downscale climate projections for Ayeyawaddy 2011-2040, as compared to 1980-2005 average
2 According to Columbia University downscale climate projections for Ayeyawaddy 2011-2040, as compared to 1980-2005 average.
3 Middle range sea-level rise projections for coastal areas in Myanmar, in 2050s, according to Columbia University downscale projections

ii. Increased risks of slow on-set disasters, transformative climatic processes and negative effects on key sectors

Future vulnerabilities that are likely to emerge or worsen under projected future climate change under a 'business-as-usual' (BAU) scenario, which will have profound effects on the way communities benefit from eco- system services and this in turn will affect productive systems, particularly agricultural productivity, access to water, and mobility.

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

- A much greater proportion of Labutta's agricultural land will to 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.
- If we assume a 15 per cent reduction in output because of climate change and 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, output per capita would reduce to US$369 (442,800 Kyat) per year at constant prices, resulting in incomes of below US$1 (1,200 Kyat) per day.

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

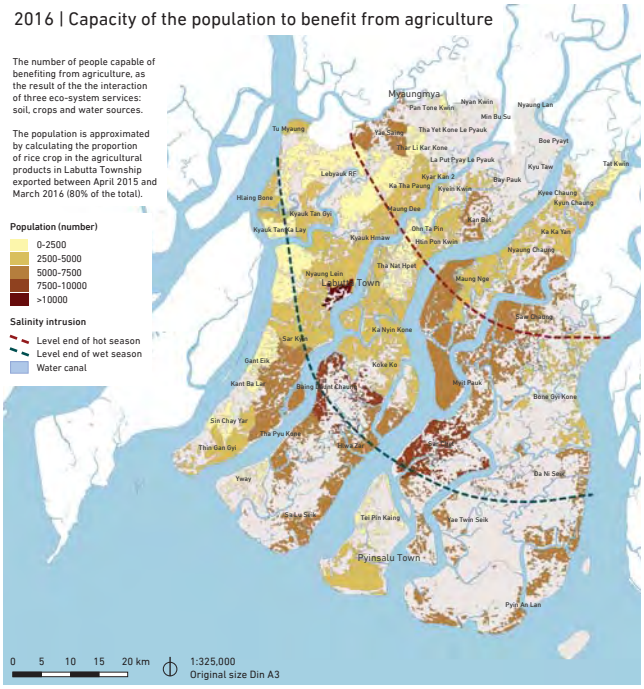
+ Sea Level

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.

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).



Crop types

Type of crops cultivated in each village tract in 2016.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

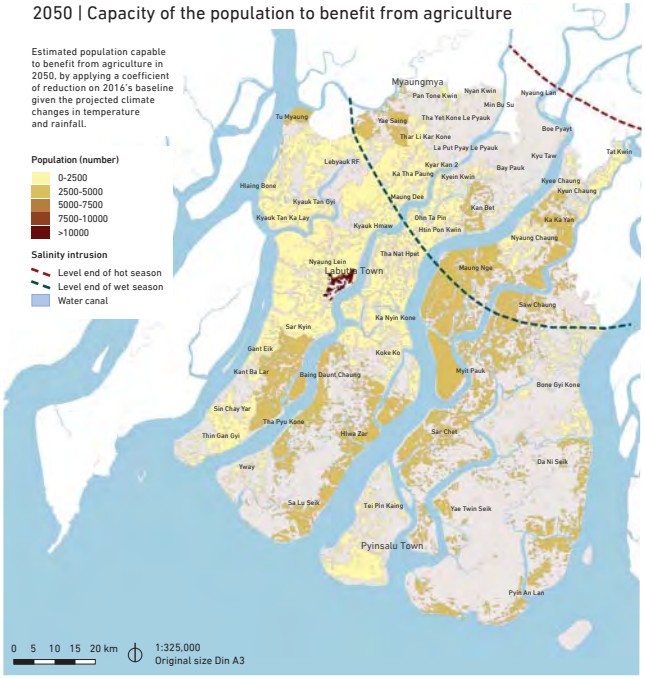
Rainfed agriculture is the main type of agriculture across the township. In some parts of the northern area, a system of irrigation canals and dykes allows two crops per year

LBT12a

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.



Crop types

Type of crops cultivated in each village tract in 2016.

Soil types

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LBT12b

Data Source: MIMU, FAO, WWF, UN HABITAT

Fewer people are expected to have access to freshwater for drinking water from surface sources specially in coastal and central areas by 2050

- 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.
- In addition, the level of salinization of rivers and streams is moving north, meaning that in the future, freshwater sources (ground-water and surface water) in northern areas could, experience saline intrusion.

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

+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 decliens as water availability for vegetation growth decreases

+/- Rainfall

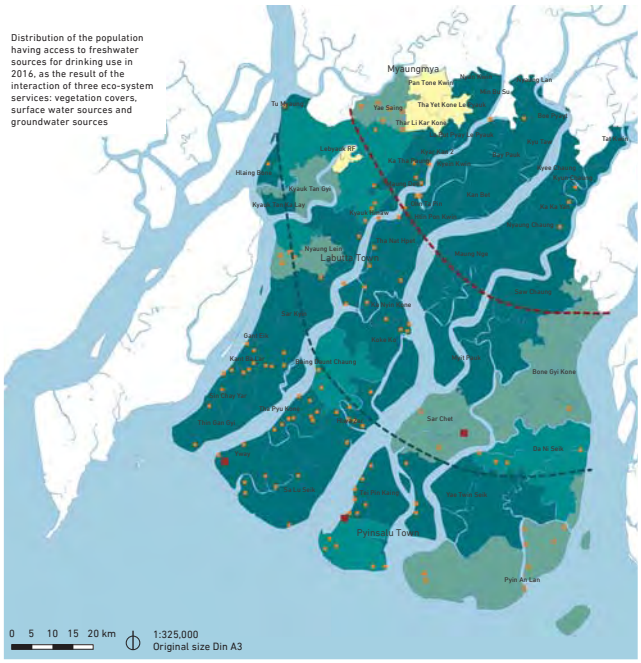
HAZARD	ECO-SYSTEM SERVICE	MAIN PROJECTED IMPACTS
More heavy rain, which is less useful and more damaging	Surface water	Strong tidal and storm surges create large-scale intrusion events, salinizing drinking water supplies, inundating fields, rivers, and streams with saline water
	Geology	Large quantities 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

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

Distribution of the population having access to freshwater sources for drinking use in 2016, as the result of the interaction of three eco-system services: vegetation covers, surface water sources and groundwater sources



Scrubland
Agriculture
Mangrove
Open forest
Forest

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

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.

Hydrology

The Geologial 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.

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

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

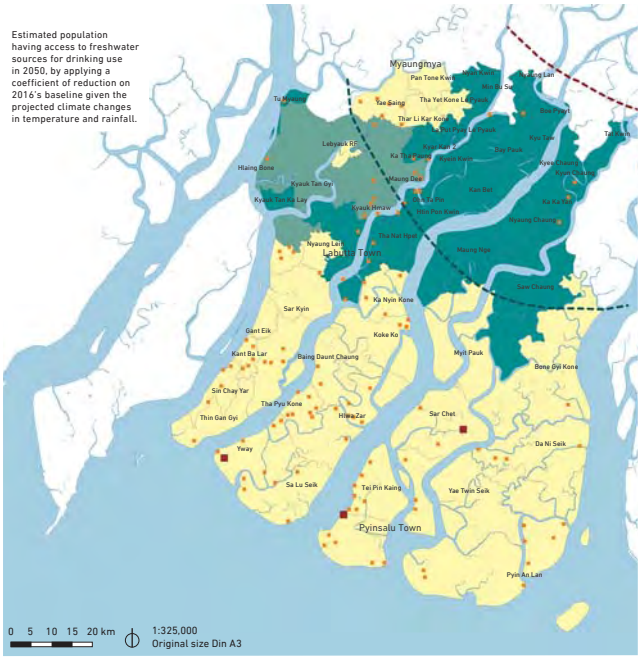
0 20 40 km
1:1,000,000
Original size Din A3

LBT13a

Data Source: MIMU, FAO, YAHY, UN HABITAT

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

Estimated population having access to freshwater sources for drinking use in 2050, by applying a coefficient of reduction on 2016's baseline given the projected climate changes in temperature and rainfall.



Scrubland
Agriculture
Mangrove
Open forest
Forest

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Main water 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

LBT13b

Data Source: MIMU, FAO, YAHY, UN HABITAT

Deforestation trends would increase mangrove degradation reducing people's capacity to depend on forestry sources and fisheries as a viable livelihood option by 2050

- As mangroves are cleared, the numerous basic ecosystems services they provide that support climate resilience – erosion control, defences against coastal storm, fisheries habitats - may also be lost.
- 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.
- Production may move away from capture fisheries towards aquaculture. This would have adaptation benefits, giving producers more control over their production in less exposed locations. However, evidence shows that aquaculture is a driver of deforestation (both mangrove and terrestrial forests).

+/- 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

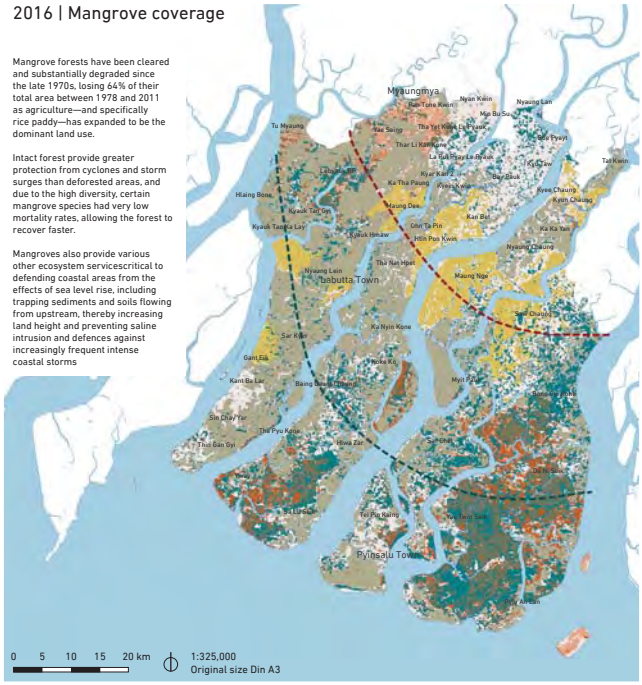
HAZARD	ECO-SYSTEM SERVICE	MAIN PROJECTED IMPACTS
More land inundated	Soils	Inundation will result in loss of land
	Vegetation cover	Inundation will result in loss of land, and protection of mangroves

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 servicescritical 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

- Degraded forest
- Deforestation areas
- Intact forest
- Irrigated agriculture
- Rainfed agriculture

Salinity intrusion

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

- -0.2
- 0
- 0.25
- 0.5

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

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

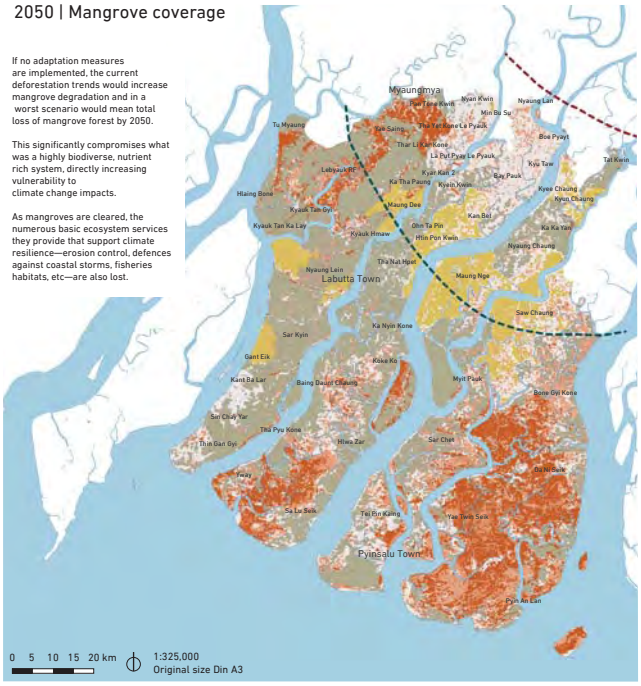
LBT14a

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.



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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

- Degraded forest
- Deforestation areas
- Intact forest
- Irrigated agriculture
- Rainfed agriculture

Salinity intrusion

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

- -0.2
- 0
- 0.25
- 0.5

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

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

LBT14b

Data Source: MIMU, FAO, WWF, 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.

Data Source: MIMU, FAO, WWF, UN HABITAT

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

- Some of the 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 areas will be either completely or partially unusable. This also means that the existing network of boat piers may become increasingly unusable or unsuited.
- Individual boats are likely to be more dangerous and 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.

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:

+/- Rainfall

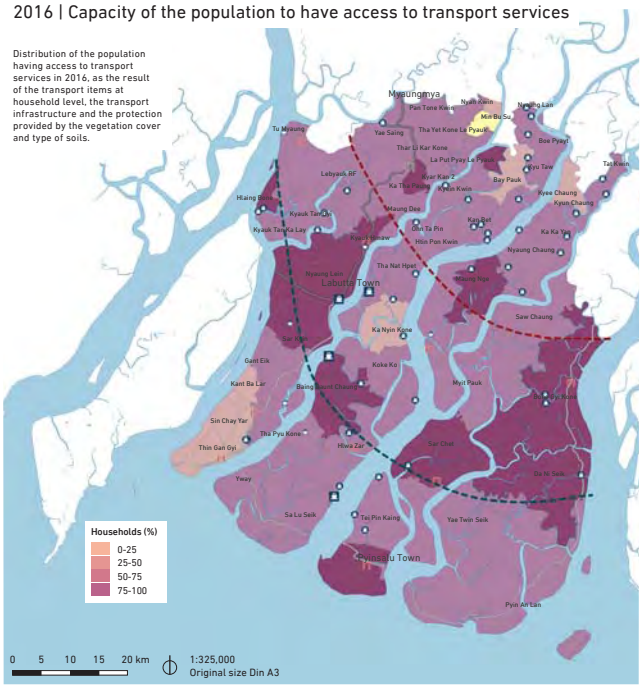
HAZARD	ECO-SYSTEM SERVICE	MAIN PROJECTED IMPACTS
More heavy rain, which is less useful and more damaging	Soils	Large quantities of rain falling over short periods will result in flooding and erosion
	Vegetation cover	More frequent cyclones and stronger winds will result in destruction of mangrove areas

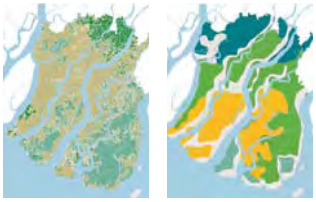
+ Sea Level

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

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

Distribution of the population having access to transport services in 2016, as the result of the transport items at household level, the transport infrastructure and the protection provided by the vegetation cover and type of soils.





Scrubland
Agriculture
Mangrove
Open forest
Forest

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

0 20 40 km
1:1,000,000
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 areas.

Soil types

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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

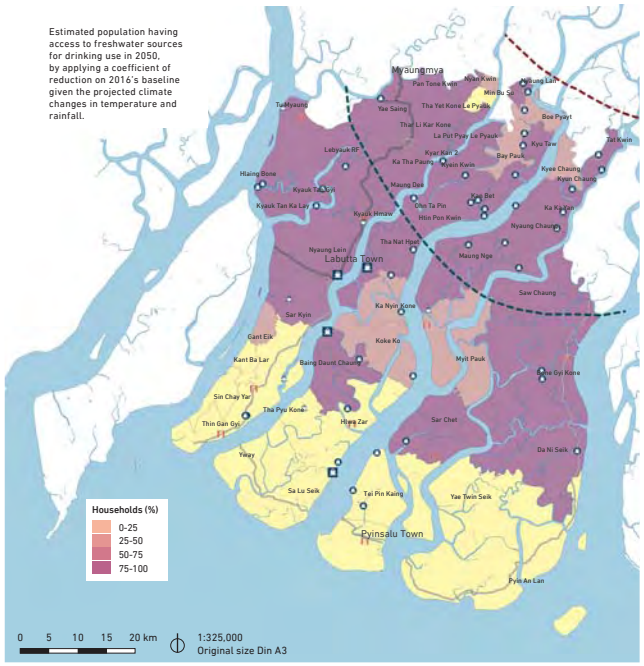
Water transport facilities
- Harbour / Port
- Renovated jetty (LPD)
- Jetty
- Water canals

LBT15a

Data Source: MIMU, FAO, WWF, UN HABITAT

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

Estimated population having access to freshwater sources for drinking use in 2050, by applying a coefficient of reduction on 2016's baseline given the projected climate changes in temperature and rainfall.



Scrubland
Agriculture
Mangrove
Open forest
Forest

Dune forest & beach sand
Mangrove forest soil
Swampy soil
Gley & gley swampy
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0 20 40 km
1:1,000,000
Original size Din A3

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

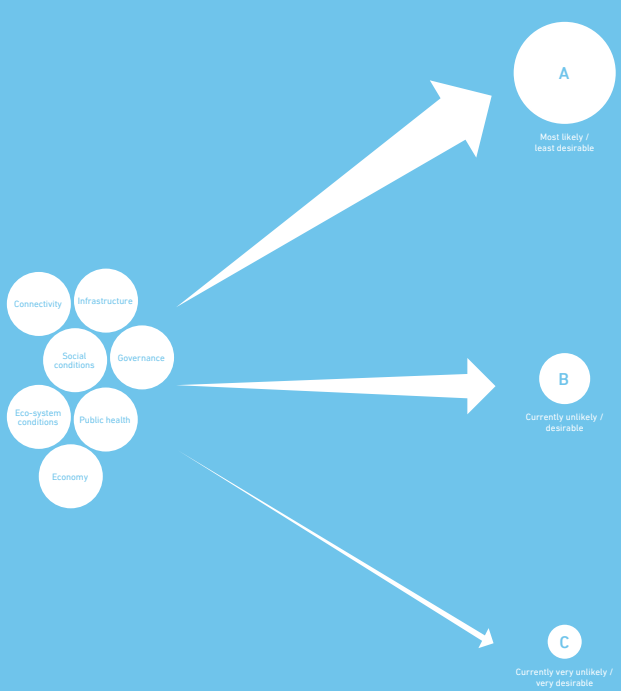
LBT15b

Data Source: MIMU, FAO, WWF, UN HABITAT

3

SCENARIOS FOR LABUTTA 2050

This assessment arrives at three broad scenarios of the future. 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 in-line with the IPCC pathways approach and is a common way that governments and industries use to plan for the future.



- SCENERIO A
  Business as usual: no specific adaptation effort.

In scenario A, 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. 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.

- SCENERIO B
  Resilience is built to maintain current living standards

Under scenario B, 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. This scenario is the minimum required to prevent increased vulnerability, and to enable continued development.

- SCENERIO 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.

Scenario

A

BUSINESS AS USUAL SCENARIO

- If business is conducted as usual, meaning that adaptation measures are not implemented, unsustainable use of environmental resources continues and resilience is not built across the systems, Labutta is unlikely to be able to support current and expected population growth at the same living standard as in 2016.

- 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, decrease of industrial and agricultural capacities, internal migration from south to north, a continued lack of skills and employability, continued labour intensive, low remuneration employment and outward migration.

- 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 higher waves impact them.

- 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.

Scenario

B

RESILIENCE IS BUILT TO MAINTAIN CURRENT LIVING STANDARDS

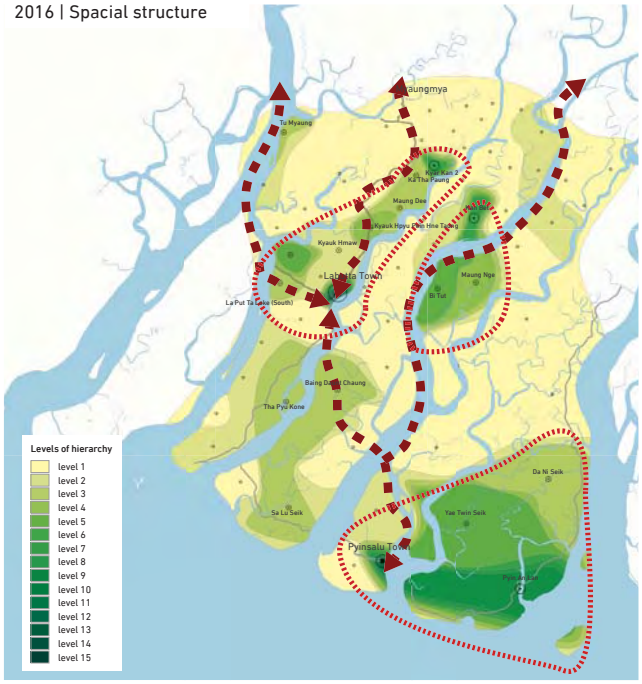
- Labutta in 2050 maintains current living standards by undertaking some adaptation measures, however, it broadly continues its present development trajectory.

  Deforestation trends would need to halt to maintain current living standards, especially in mangroves, which are being cut at a highly unsustainable rate. To do this, alternative – ideally renewable – energy sources would be required.

  To adapt in agriculture, 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.

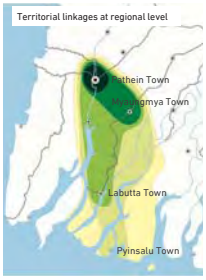
  The current network of water ponds would have to be enhanced, and systems put in place to prevent free-rider problems. Transport infrastructure would also require improvements; the network of boats and piers would have to be strengthened to maintain present functionality in the face of stronger winds, storms, and possible inundation. Meanwhile, improvements in road transport and power infrastructure would also contribute to maintaining current levels of development.

2016 | Spacial structure



Data Source: MIMU, UN HABITAT

Territorial linkages at regional level



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

Spacial Structure
- Main clusters of settlements
- Primary corridors

Type of settlement
- Sub-township
- Township
- State Capital

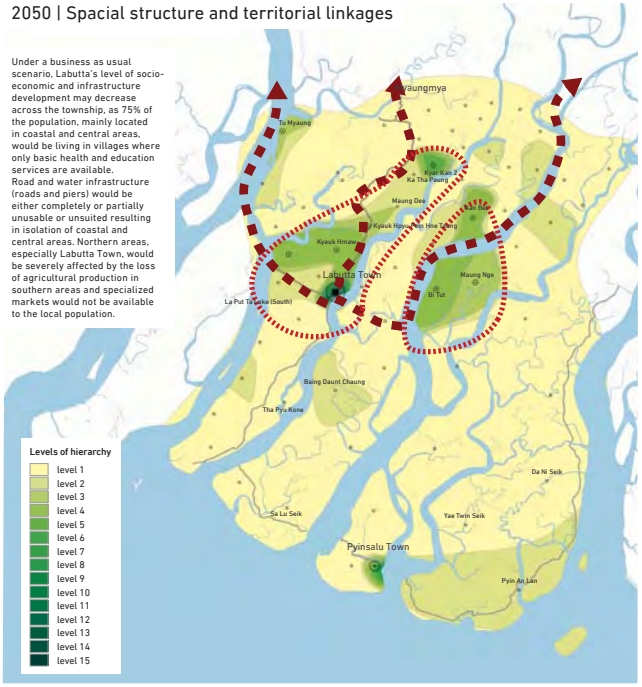
0 5 10 15 20 km — 1:325,000 Original size Din A3

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

LBT16a

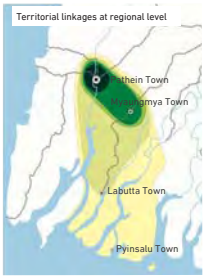
2050 | Spacial structure and territorial linkages

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.



Data Source: MIMU, UN HABITAT

Territorial linkages at regional level



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

Spacial 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 Pathein 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

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

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

LBT16b

Scenario

C RESILIENCE IS BUILT THAT ENABLES ECONOMIC AND SOCIAL DEVELOPMENT DESPITE CHANGES IN CLIMATE BY 2050, TAKING INTO ACCOUNT THE DIFFERENTIATED 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 both protect people, add greater connectivity, and allow for energy intensive industries. 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.

  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 required to ensure that coastal settlements continue to be inhabitable, as well as preventing the salt line from moving further north.

FINDINGS & RECOMMENDATIONS: PLANNING FOR ADAPTATION IN LABUTTA

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

The devastating and long-lasting effects of Cyclone Nargis in 2008 are 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.

KEY FINDINGS

The study unveils three main broad 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 plan for 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;

2. Severe and wide-ranging underlying vulnerabilities exacerbate these climate-related threats, and are deeply interrelated with them. This consists of a:

   • a fragile and fast degrading ecosystem that communities are heavily dependent on. 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;

   • an economic and productive structure largely based on climate-sensitive agriculture and fisheries with insufficient technical skills to diversify production and employment. 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;

   • and infrastructure (transport, housing, schools, health-posts, roads, bridges, cyclone shelters) that is not adapted to the increased risks deriving from climate change. 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.

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, 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. 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

Policy recommendations, derived from the findings of the assessment are as follows:

1. **It is crucial that healthy ecosystems are maintained and enhanced in Labutta. Ecosystems 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. Innovation 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. **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. **It is crucial that all infrastructure is adapted to the heightened risks of disasters from cyclones, floods and inundation, and water shortages. It is also important that transportation systems are improved to sustain development across the township. This implies, 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 requires retrofitting 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.

POLICY RECOMMENDATIONS

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

   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 and their implications is highly strategic, cost-effective and important, and it should therefore be a focus of any intervention in Labutta.

LOCAL ADAPTATION AND RESILIENCE PLANNING: PURSUING THE BEST SCENARIO

Based on the broad coverage of community consultations undertaken in this study, and ownership by the township authorities, the assessment also included participatory planning for long-term adaptation and resilience-building. This planning process identified priority outcomes, outputs and specific actions to prevent Scenario A from materializing, and change Labutta's development trajectory towards Scenarios B and, ideally, Scenario C.

Communities and township authorities agreed that, in order to achieve Scenario C, the following main outcomes should be obtained:

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 simply aspirational. They 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.

The summary of the actions prioritized are presented on the following pages..

OUTCOME 1: ECO-SYSTEM

OUTCOME	EXPECTED RESULT	ACTIVITIES	TYPE	COST	FEASA-BILITY	COMMUNITY ACCEPT-ANCE	ADAPTA-TION/ EFFEC-TIVENESS	BENEFIT ANYWAY/ NO REGRET	SPEED	SCORE	STRA-TEGIC 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 mantain 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 knoweldge and capacities for Sustainable Soil Management (sustainable organic fertilizer, rotational		3	3	5	3	4	3	21	50
		Testing integrated soil management techniques to mantain 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 infrastracture	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 mantain 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	FEASA-BILITY	COMMUNITY ACCEPT-ANCE	ADAPTA-TION/ EFFEC-TIVENESS	BENEFIT ANYWAY/ NO REGRET	SPEED	SCORE	STRA-TEGIC 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 imporve 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	FEASA-BILITY	COMMUNITY ACCEPT-ANCE	ADAPTA-TION/ EFFEC-TIVENESS	BENEFIT ANYWAY/ NO REGRET	SPEED	SCORE	STRA-TEGIC 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 Preparadness, 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	30	100
		Improve storage for food , crops and animals		4	5	5	5	5	5	29	75
		Improve management of infrastruture		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 commu-nication is enhanced	Suistainable 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

CONCLUSIONS

Labutta – and other townships in Myanmar – will have to officially adopt the local adaptation and resilience plan resulting from this analysis and use it consistently to programme and budget interventions and interact with donors and development partners

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.

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 to take action

Myanmar Climate Change Alliance

GCCA+
THE GLOBAL CLIMATE CHANGE ALLIANCE PLUS INITIATIVE

Funded by the European Union

UN HABITAT

UN environment

WWF

Center for Climate Systems Research
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