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**CLIMATE CHANGE VULNERABILITY
ASSESSMENT FOR PAKOKKU TOWNSHIP,
MAGWAY REGION, MYANMAR,
2016-2050,**
**MYANMAR: SCENARIOS FOR
RESILIENCE BUILDING**

STUDY CONDUCTED BY



IN COLLABORATION WITH



“Climate Change Vulnerability Assessment of Pakokku Township, Magway Region, Myanmar, 2016-2050: Scenarios for Resilience Building”

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NOTES ON THE STUDY

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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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EXECUTIVE SUMMARY

This assessment analyses the vulnerability of the ecological, infrastructure and socio-economic conditions of Pakokku in relation to the present and projected climatic conditions. It concludes that vulnerabilities in Pakokku are high and that changes in climate will require decision-makers of Pakokku to plan for greater amounts of rain within a shorter monsoon season, which will induce both destruction of crops and floods in the urban areas; much warmer average temperatures and more frequent extreme heat days with resulting water scarcity, risks of droughts, reduction in agricultural productivity and threats to human health. Based on these findings, required actions for building resilience over the mid to long-term is strongly recommended and potential action identified, as illustrated in Annex 1 of this report

In 2016 the Myanmar Climate Change Alliance (MCCA) financed by the European Union and implemented by the United Nations Human Settlements Programme (UN-Habitat) and the United Nations Environment Programme (UN-Environment) under the Ministry of Natural Resources and Environmental Conservation conducted a detailed climate change vulnerability assessment of Pakokku Township, in collaboration with the World Wide Fund for Nature (WWF) and the Center for Climate Systems Research of the Columbia University (CCSR). Pakokku is located in the western part of the central dry zone, on the west bank of the Ayeyawady River. 290,139 people live in Pakokku Township, just over 30 per cent of whom live in the town itself. Pakokku has a mostly flat topography, except for some low mountains in the western area of the township, and is characterized by a hot, dry climate. Vulnerability relating to water is the predominant challenge in the township. Areas by the river experience floods, while away from the river drought and access to water is a chronic problem.

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 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 2.7°C by 2050, with up to 17 more hot days per year. Although projected changes in rainfall are less

clear, it is likely that there will be a slight increase in rainfall, but concentrated in a shorter monsoon season (June – October) and a decrease in the cool season. It is likely that this increase will therefore result in heavy rains. As a consequence, the increase in rainfall is unlikely to alleviate the water scarcity challenges of the Dry Zone Area, and may rather aggravate crop destruction, erosion and run-off water and floods, already experienced frequently by communities living close to the Ayeyawady and seasonal streams. Conversely, a shorter monsoon season will produce longer dry-spells and therefore higher risks of droughts.

The assessment shows that decision-makers in Pakokku Township will need to plan for variable rain, with increases concentrated in the monsoon season, less groundwater availability in dry areas, greater flood risks near the Ayeyawady, and more frequent and more severe extreme heat events, with associated risk of droughts, loss of crops and livestock and risks for human health.

In current conditions, the study demonstrates, Pakokku Township is insufficiently resilient to the present climate conditions, and its vulnerability will increase because of the projected future changes in climate, if no adaptation and resilience building 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. Pakokku's economy is not well diversified: although comparative good capacities in urban areas for small industrial production and household based production of goods, over 46 per cent of people in the whole township depend on agriculture for their livelihood, despite agriculture generating only a relatively small share of the township's total economic output. Very few agricultural workers earn minimum wage, while landless people who provide casual labour are also unlikely to earn minimum wage – especially women, whose incomes can be half that of men. Agriculture in Pakokku is highly climate sensitive. In the dry area, access to water is an ongoing challenge as people do not have access to water to irrigate fields, while in fertile riverside areas, damage from seasonal floods is a serious problem. The effect of this, as well as a lack of other livelihood options, is a driver of migration, which is very high in Pakokku. Indeed, migration is sufficiently high that there is a shortage of productive age people. Migration also has a distinct gender aspect; male migrants outnumber females by three to one.
2. Pakokku has a dryland ecosystem, which is dependent on the Ayeyawady Dry Forests. However, a history of deforestation and resultant land degradation have caused increased run-off, poor soil quality and erosion. This problem is particularly acute in river-bank areas, which are also prone to flooding. Flooding is also being driven by upstream factors, including

deforestation, which has caused more severe and more frequent flooding in recent years. These issues result in highly variable, but generally low, crop yields. In turn, low yields drive low incomes and in-turn lead to high outward migration.

3. Infrastructure in Pakokku is insufficient in many places to protect from floods in urban areas or by the seasonal streams, and inadequate to guarantee continued access to water through either ground or surface rainwater harvesting. Insufficient infrastructure compounds the lack of ground and surface water that can be used for drinking. Only 15 per cent of households have access to piped water. Few households have access to household water harvesting which means that water storage is not being optimised. While there is irrigation infrastructure in the township, including 6 dams, these are either in disrepair, rely on seasonal streams that are not flowing in the dry season, or still require water to be pumped, which is prohibitively expensive. Sanitation facilities are still lacking in the township; 19 per cent of households do not currently have access to a safe sanitation facility in their home. Meanwhile, houses in Pakokku are often poorly constructed and vulnerable to strong winds and, in areas close to the river, floods.

The interplay of these vulnerabilities with ongoing and future changes in the climate will, if not urgently addressed, leave the people of Pakokku more vulnerable to both rapid on-set disasters and long-term climatic transformative effects. The impact

will be experienced through more frequent loss of assets, and potentially lives, lower incomes that will drive poverty, increased migration, worse outcomes for women and a declining public health situation. Housing and basic service conditions, especially in access to water, 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 Pakokku is not resilient at present.

THE ASSESSMENT PRESENTS THREE POSSIBLE ADAPTATION SCENARIOS BY 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 lives, 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 building infrastructure and houses in flood prone areas. 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; improving skills and access to credit for more resilient livelihoods and incomes; 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 can 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 Pakokku, 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) To achieve a greener healthy environment that supports the living standards of Pakokku in a sustainable manner despite changes in climate, 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 Pakokku 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 Pakokku Township.

Figure 1. MCCA facilitators describe the impact of climate change on eco-system services in Pakokku





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, eco-system, 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 thus to avoid the worst-case

future scenario, or '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 Data: the report therefore is also a baseline that can be updated on a regular basis, as part of the resilience building action.



1.1 BACKGROUND

Myanmar is one of the most vulnerable countries in the world to the negative effects of severe natural hazards. Many of its 51.4 million people¹ 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 projections² 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 percent of its GDP, and employment for up to 70 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 the United Nations Environment Programme (UN Environment) under the Ministry of Natural Resources and Environmental Conservation (MoNREC) and its Environmental Conservation Department (ECD). 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 expected 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, 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. In 2017, Hakha Township, in the Chin State, was also chosen as mountain eco-system to conduct an additional vulnerability assessment in collaboration with ICIMOD.

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.

¹ Census 2014
² Myanmar Initial National Communication to the UNFCCC (2012), pp.54-97
³ These projections have been prepared by DMH over the course of 2016 and will be publicly available after this document is published. The Columbia University Center for Climate System Research, along with WWF and MCCA has also published in 2017 the "Climate Risk Information" document for Myanmar, which contains new projections for the country, and informs this report.



1.2 OBJECTIVES OF THE ASSESSMENT

The main objective of this assessment is to inform the Pakokku Township, as well as the district, regional and national authorities, and 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. 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.

The vulnerability assessment illustrates how climate change will heighten risks and exacerbate already sizeable development challenges. Pakokku Township is characterised by several challenges; a poverty rate above the national average, and social development indicators such as child mortality that are well below those in the rest of Myanmar. Pre-existing and man-made environmental challenges also hamper development; water availability is a very pressing challenge throughout much of the township, for example. The location of the river combined with a lack of water distribution infrastructure means that the township is prone to both flooding and drought, and has highly productive, fertile areas that are prone to damage and unproductive areas that don't sustain adequate livelihoods.

At national level, there is increasing data and understanding of the observed impacts of climate change and projections on the expected changes^{3,4,5} and initial analyses on the risks and vulnerability to climate change in sectors such as agriculture and the natural environment. However, there is very little information on the expected effects of climate change on the ground. There are no studies that 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 Pakokku relating to the physical and natural environment, administrative and demographic features; infrastructure and socio-economic conditions.
2. Overlaying present and projected climate hazards onto Pakokku 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.

As a result, a comprehensive analysis of the present situation and future development is presented here 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.

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

1.3 PRINCIPLES & METHODOLOGY

Guiding principles

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 intervention**

To respect these principles, the assessment uses the following:

- Open-source or widely available software, such as Q-GIS, which reduces costs and enables national replication;
- Data available at either national or local level that is easily obtained upon written request. The assessment does not use satellite imagery, unless provided for free by the authorities or other sources. 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;
- Community involvement throughout the whole township through simple questionnaires, community focus groups and participatory mapping;
- Comprehensive analysis of the three main systems that define the township; ecological, socio-economic, and infrastructure. Climate change causes impacts on all three of these systems in Pakokku. 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 was 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, use of gender disaggregated data and women-only focus groups;
- 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 contrast 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.

METHODS AND TECHNIQUES APPLIED

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 .

To generate a comprehensive account of the township vulnerability, the following key methods and tools were applied:

Vulnerability Index: The assessment defines vulnerability as a function of exposure, sensitivity, and adaptive capacity . 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 for each village tract/urban ward.

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, process and mapped through GIS. More information can be found in Annex A3.

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 – the benefits nature provides to people and/or essential to natural processes – are analysed, i.e. provisioning, regulating, cultural and supporting services, to find which services or functions are most used by the township and how climate change is affecting their quality and availability. The assessment, through both local consultations and desk review, analyses their availability in the township and their role to sustain life, and the processes of overexploitation and degradation that threatens their quality. The key services are presented in this report..

Figure 2 Communities engage in participatory cartography pointing to flood-prone areas and long-listing adaptive measures in Pakokku during the vulnerability assessment © Sukun/MCCA UN-Habitat (2016)



Figure 3 Members of the MCCA Technical Working Group validate the preliminary results of the vulnerability assessment in Naypyitaw, October 2016 © Sukun MCCA UN-Habitat 2016



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 it will be affected by climate change, is key to understanding the resilience capacity of the township, and the required adaptation actions. Thorough understanding of the 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 is 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 new given 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

10 UNEP (2013) PROVIA Guidance on Assessing Vulnerability, Impacts and Adaptation to Climate Change, p.52
11 Where [Vulnerability V = (Exposure E + Sensitivity S) – Adaptive Capacity A]
12 Where Hazard H x vulnerability V = Risk R

truthing work, mixed with the analysis of recorded historic data, gives the assessment depth and accuracy.

Disaggregated Census 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 seeks to convey complex message in the simplest possible manner. Nevertheless, its development required diverse

national and international expertise: this assessment is therefore not a rapid tool, and 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 spatial analysis are needed, as well as scenario building.

The study also limits the use of flood modelling and the digital elevation models. Following the principle of replicability, the assessment team use 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) were sometime out-dated and could not be verified. Findings take this into account.



Figure 4 Community members in Pakokku participate in the vulnerability assessment conducted by MCCA (c) Sukun MCCA UN-Habitat 2016

2

TOWNSHIP PROFILE

Pakokku township is located in the western part of the dry central region of the country, in the Magway Region. The town of Pakokku, home to approximately 90,000 people and also hosting the Pakokku District administration, is built on the Ayeyawaddy River while the administrative boundaries extend north and southwest to include drier areas. The eco-system in within the administrative boundaries of the township is therefore predominantly dry. Processes of

deforestation from land-use change or over-exploitation also altered the landscape and regulating services of the eco-systems. For instance, more intense and unseasonal heavy rains experienced in the last decades, produce runoff water that transform into flash-floods, while in the urban areas, non-risk sensitive planning places several neighbourhoods at risk of floods in the town.

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 plains¹². The dry zone, including Pakokku Township, is located in the north-western part of the central basin.

The central basin and lowlands, lying between the Rakhine Mountains and the Shan Plateau, are structurally connected with the folding of the western ranges. The basin was deeply excavated by the predecessors of the Ayeyawady, Chindwin, and Sittaung Rivers; the valleys are now occupied by these rivers, which cover the ancient soft sandstones, shales, and clays with their alluvial deposits. Pakokku sits on the west bank of the Ayeyawady River at the western edge of the dry zone, just upstream of Bagan, a historic city and one of Myanmar's main tourist attractions, and downstream of the confluence of the Chindwin and the Ayeyawady Rivers, which flows south to the Delta and into Gulf of Martaban.

Climate and Ecology

The Ayeyawady Dry Forests are the primary ecoregion in the dry zone, defined by a harsh climate, with an average rainfall of approximately 650mm per year, which rarely falls in more than 15 days per year. When it does rain, it is often in torrential downpours that, due to limited vegetation, lead to rapid runoff and flash flooding, limiting groundwater recharge. Summer winds also occur in the dry zone. Where forests do still occur, they are defined by low stature, thorny trees, with common species including *Terminalia oliveri*, *Tectona homiltoniana*, and associated species *Acacia catechu* and *Bauhinia racemosa*.

Decades of intense pressure from land-use change or overexploitation and upstream logging, resulted in many of the forests in the dry zone to be converted to agriculture lands or severely degraded. As a result, biodiversity in the region has similarly declined. For example, tigers and other large mammals formerly inhabited the area, but these species are locally extinct. Some can still be found in protected areas to the

north, including populations of barking deer, sambar, and Eld's deer, primates like rhesus macaque, jungle cats, asiatic jackals, and potentially leopards, but these habitats are extremely isolated and limited in size, limiting the longer-term survival of these populations. The dry zone is also well known for snakes, including vipers like the Burmese python, lizards, and turtles like the yellow tortoise and soft-shelled turtles, which are under intense pressure as a food source.¹³

Ecosystem Services

While deforestation and land degradation have significantly impacted the ability of ecosystems in the dry zone to support livelihoods in the township, people still directly and highly depend on the land and benefits provided by nature. Unlike other naturally highly productive regions in Myanmar like the Ayeyawady Delta, however, these benefits and their ability to support local livelihoods are more limited due to the drier, less productive climate and ecology of the dry zone. While decades—and even centuries—of pressures on the land have further compromised many of these benefits, three in particular continue to support the primarily agriculturally based livelihoods of Pakokku: water, soils, and crops. Production statistics for the larger dry zone demonstrate the importance of agriculture in region nationally, which provides most of Myanmar's sesame, groundnuts, and pulses, 22 per cent of its rice, and more than two thirds of all sheep and goats.¹⁴ As is the case throughout Myanmar, the strong seasonality of the regional

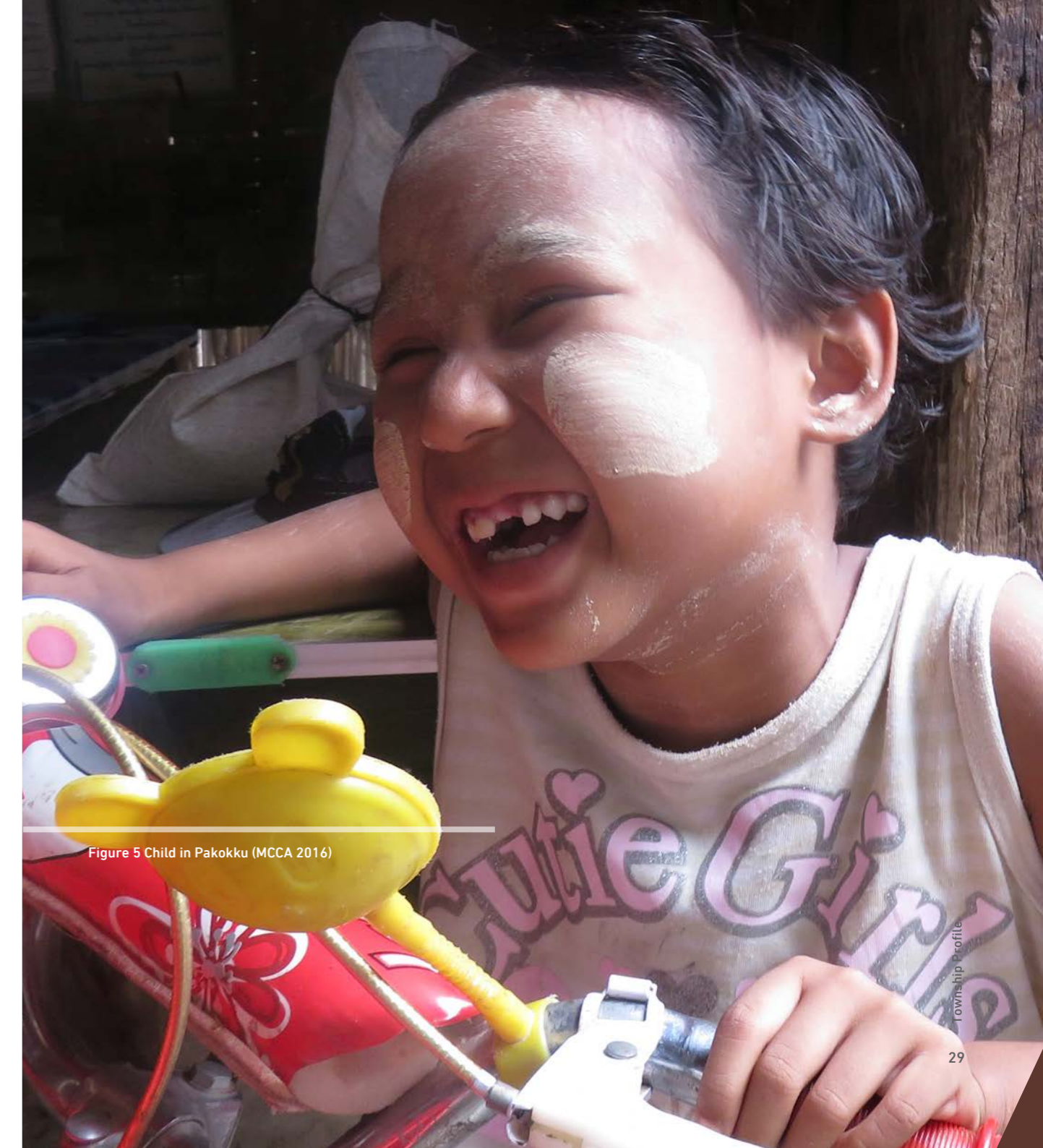


Figure 5 Child in Pakokku (MCCA 2016)

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

Figure 6. Seasonality of major river flows in the dry zone on the left, from IWMI (2015); and seasonal rainfall for the nearby Chauk weather station on the right. Rainfall data provided by DMH. Refers to baseline average from 1985-2010.

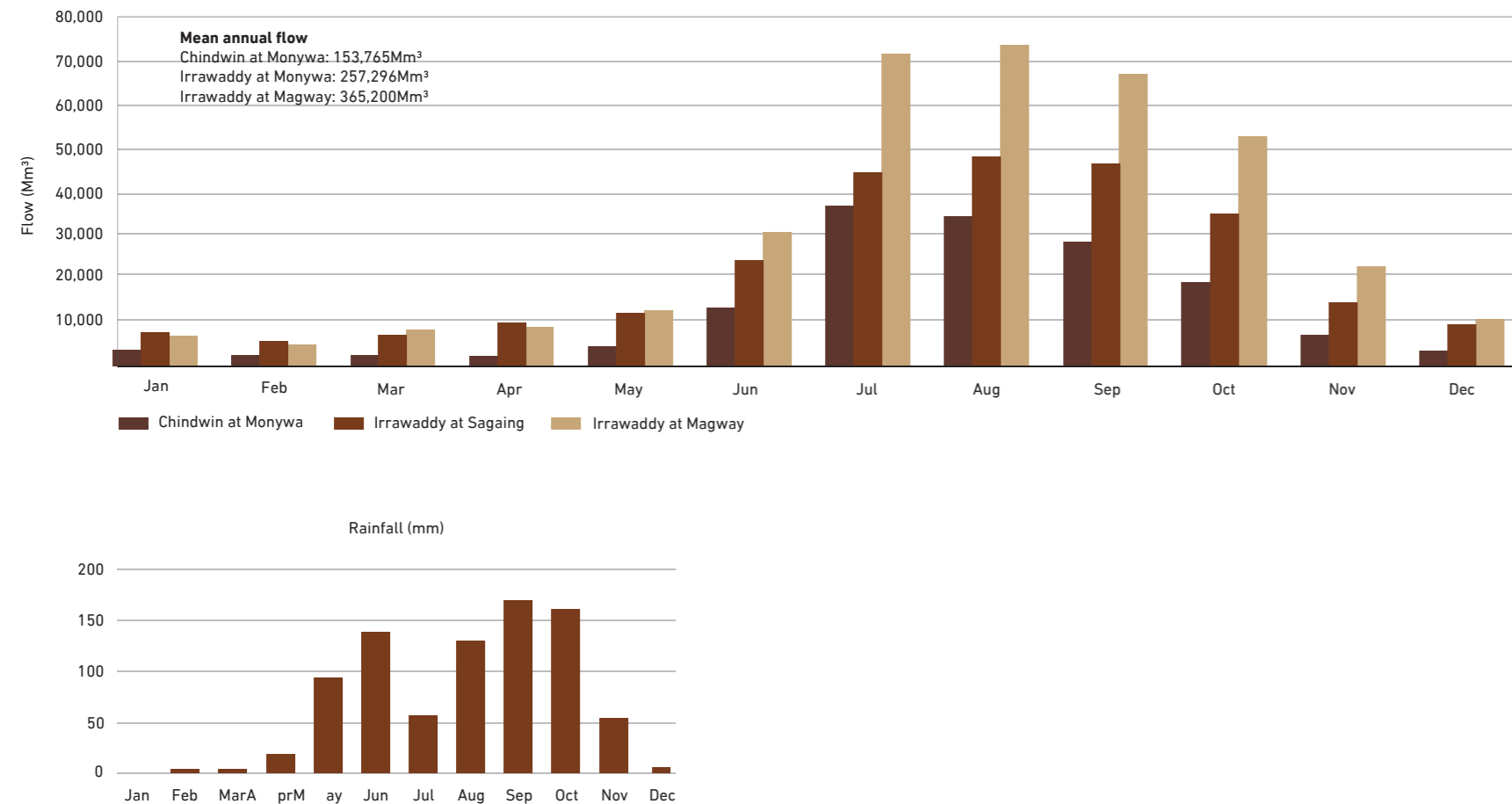
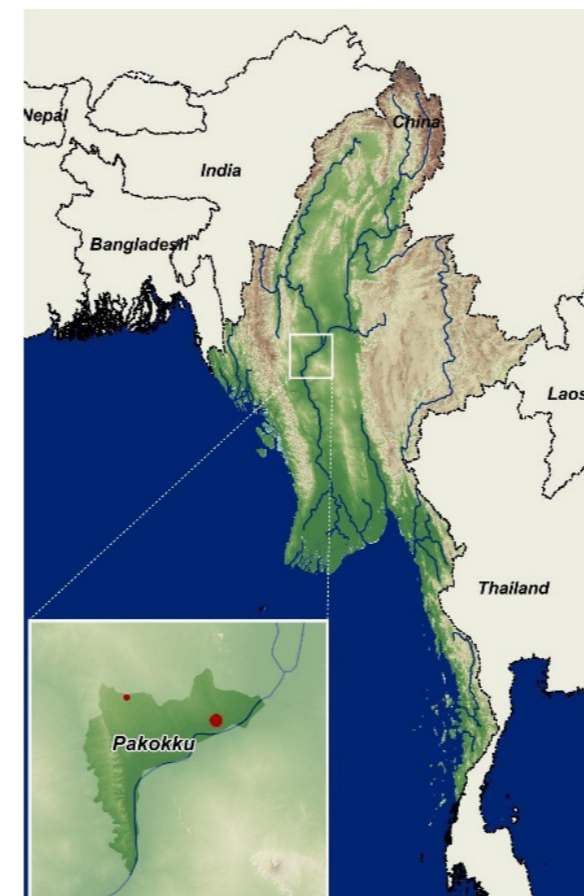


Figure 7. The location of Pakokku Township in Myanmar



climate directly influences these three services—with distinct wet and dry seasons—affecting how and where they most support local populations.

Water

With its location along the banks of the Ayeyawady, certain populations in the township are well positioned to exploit the enormous water resources provided by the river, particularly for agriculture. River flows are, however, also highly seasonally variable, with around 85 per cent of total annual flows occurring in the wet season between May and October (see Figure 5). While some of the population is more concentrated along the riverbank, and thus has easier access to water year-round, the majority is located in areas farther from the riverbank. This spatial and temporal variability means communities in the Township must rely on a variety of other sources for water throughout the year, including groundwater and rainwater harvesting, making other sources particularly important for livelihoods and domestic uses. Groundwater is one such critical additional source for more than 60 per cent of the township, but water quality varies considerably: some communities sit above the Pegu aquifer, which tends to be too saline or brackish for either domestic or agricultural use.¹⁶

Soils and Crops

The Ayeyawady River also has some of the naturally highest sediment rates of freshwater rivers in the world, which help provide rich alluvial soils that continue to serve as productive agricultural areas, especially in the floodplain that comprises 20 per cent of the land area in the township (see map below). These alluvial deposits support paddy rice in the wet season and a second crop of oilseeds, pulses, vegetables, and tobacco in the dry season. The dry zone ecoregion, however, in conjunction with decades of deforestation and land degradation has contributed to pervasive erosion and lower fertility soils that further limits the already low productivity. These soils and limited rainfall provide for only one wet season crop, which includes pulses, sesame, groundnuts, and results in even greater reliance on livestock. These lighter soils are also prone to erosion, from both intense rainfall and wind, requiring fertilizer inputs to ensure yields, which vary significantly from year to year.

¹³ WWF, 2016. Ecoregions of the World. Tropical and Subtropical Dry Broadleaf Forests. Southeastern Asia: Central Myanmar (formerly Burma). www.worldwildlifefund.org/ecoregions. Accessed 11/2016.

¹⁴ International Water Management Institute (IWMI). 2015. Improving water management in Myanmar's dry zone for food security, livelihoods and health. Colombo, Sri Lanka: International Water Management Institute (IWMI). 52p.

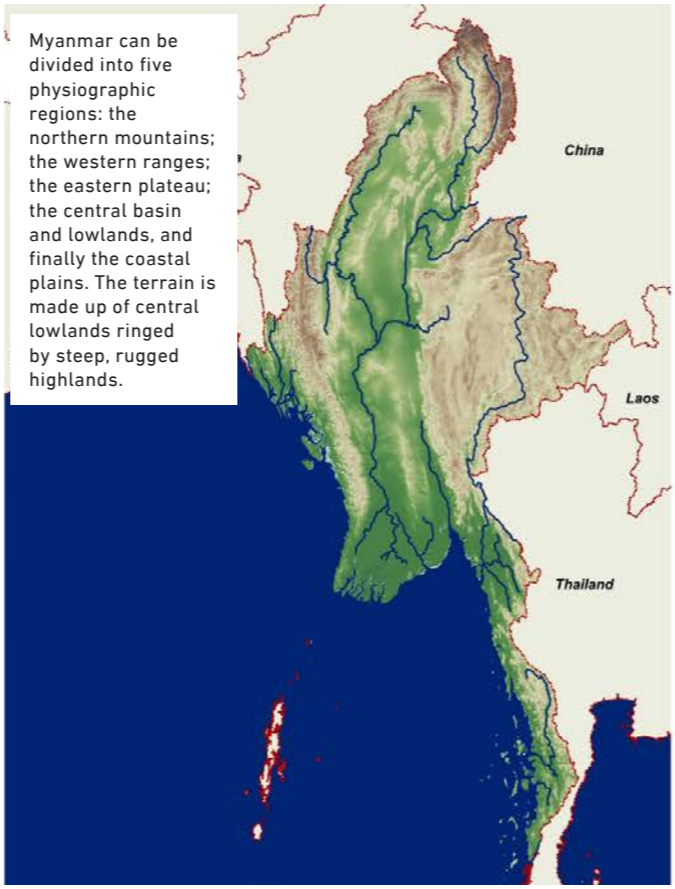
¹⁵ International Water Management Institute (IWMI). 2015. Improving water management in Myanmar's dry zone for food security, livelihoods and health. Colombo, Sri Lanka: International Water Management Institute (IWMI). 52p.

¹⁶ International Water Management Institute (IWMI). 2015. Improving water management in Myanmar's dry zone for food security, livelihoods and health. Colombo, Sri Lanka: International Water Management Institute (IWMI). 52p.



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

Digital Elevation Model (DEM) of Myanmar



Type of settlements
 ● Township
 • Sub-villages
 — Contour lines (100m)
 - - - Contour lines (20m)

Main communication routes
 — Main road
 - - - - - Railway
 ■ River
 ■ Seasonal stream

0 200 400 km 1:13,000,000 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 of its authorities, or concerning the delimitation of its frontiers or boundaries.

Data Source: MIMU, FAO, WWF, UN HABITAT

2.2. DEMOGRAPHIC OVERVIEW

In 2014, Myanmar conducted its Population and Housing Census, the first national census in 30 years. 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.

Pakokku is one of 26 townships in the Magway Region, and is also the centre of Pakokku District. The total population of Pakokku Township is 290,139, comprised of 130,741 males and 159,398 females, giving a highly unusual sex ratio of 82, which points to high levels of sex disparity among outward migrants. Of the total township population, 90,842 live in the urban area, meaning the urbanisation rate is 31.3 per cent. 31.5 per cent of Pakokku's population is under the age of 18.¹⁷

Pakokku's population pyramid is rather unusual. Notwithstanding the sex disparity it shows a normal distribution of people over the age of thirty. However, there are two unusual trends among people under thirty in the township; firstly, there is a very sharp drop from the number of people in the 10-14 age bracket to the 15-19 age bracket, with no increase or decrease up until the 30-34 age bracket. This points to high levels of outward migration, an issue that is explored further below and analysed later in the report. Secondly, there are fewer children in the 0-4 and 5-9 age brackets compared to the 10-14 age bracket. This supports the view that a high number of people of reproductive age are migrating away from the township, and are either not having children, are having children elsewhere, or are taking their children, born in the township, with them when they migrate.

¹⁷ Ministry of Immigration and Population (2015) The 2014 Myanmar Population and Housing Census, Magway Region, Census Report Volume 3-N

This change in the demographics is particularly noticeable in the rural areas, where the drop off in people between the ages of 15-30 is particularly marked. The sex disparity is also particularly noticeable in the age groups between 20 and 34. This would suggest a gender disparity in migration; that more men are migrating outward than women.

There is a comparatively high number of people who have migrated overseas. In total, 2,834 people have migrated outside of Myanmar, of which 2,248 are men, primarily to Thailand, Malaysia, Singapore and China. However, the census does not provide the figure for the number of people who have migrated internally – a number that is likely to be far higher.

The sex disparity is also particularly noticeable in the age groups between 20 and 34. This would suggest a gender disparity in migration; that significantly more men are migrating outward than women. The unusual sex ratio for the township – 82 – meaning there are 82 males for every 100 females, supports this view. The high number of female-headed households also evidences this; the census shows that 32 per cent of households are headed by women.

The infant mortality rate in Pakokku is considerably higher than the national average. In 2013-2014, 54 in every thousand live births died in infancy while the national average is 40, and the average for the

Figure 8. Population pyramid for Pakokku Township

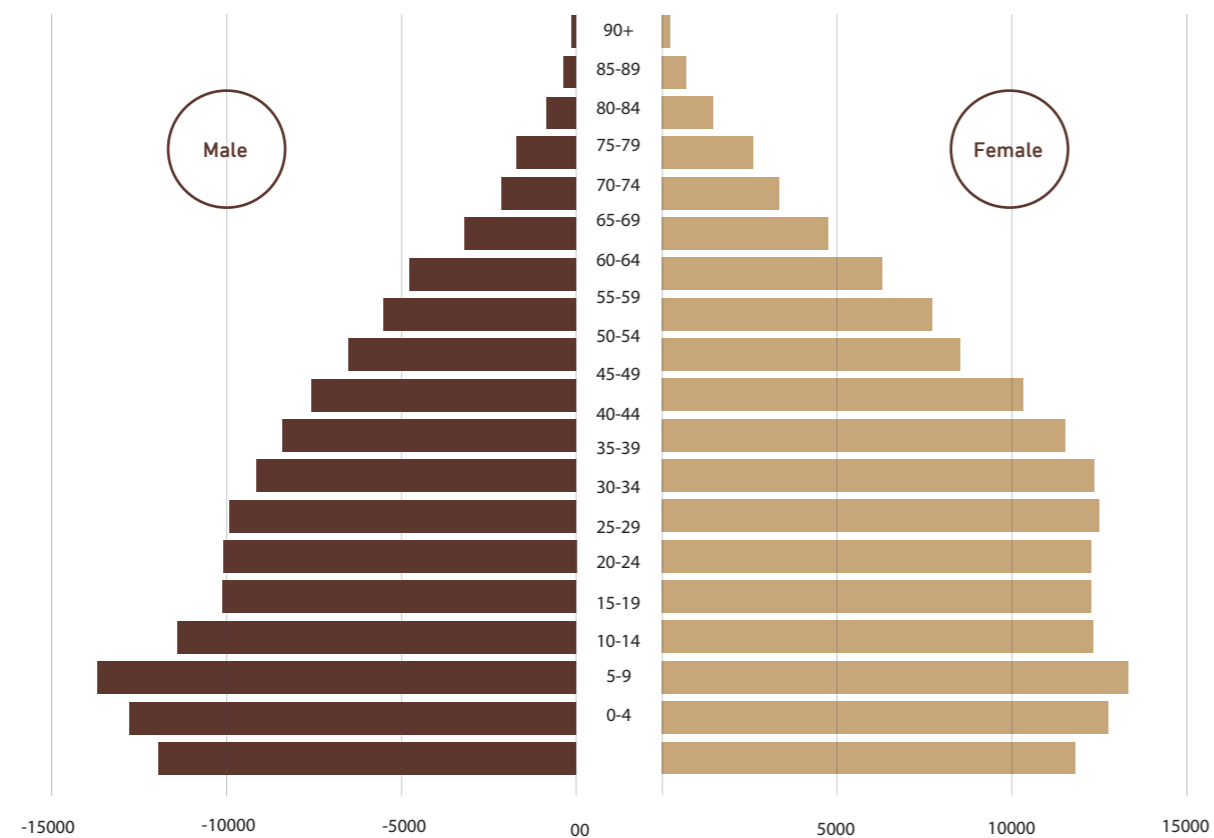
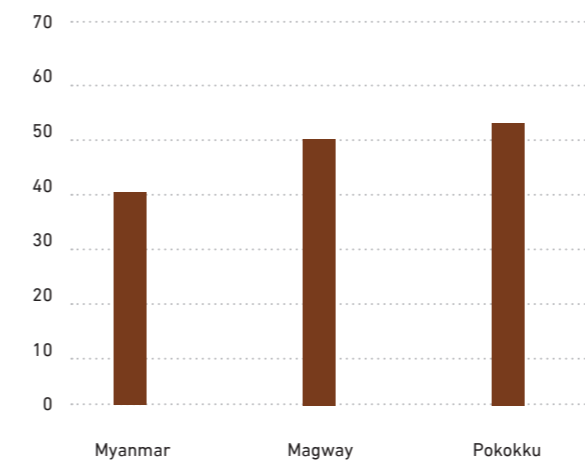


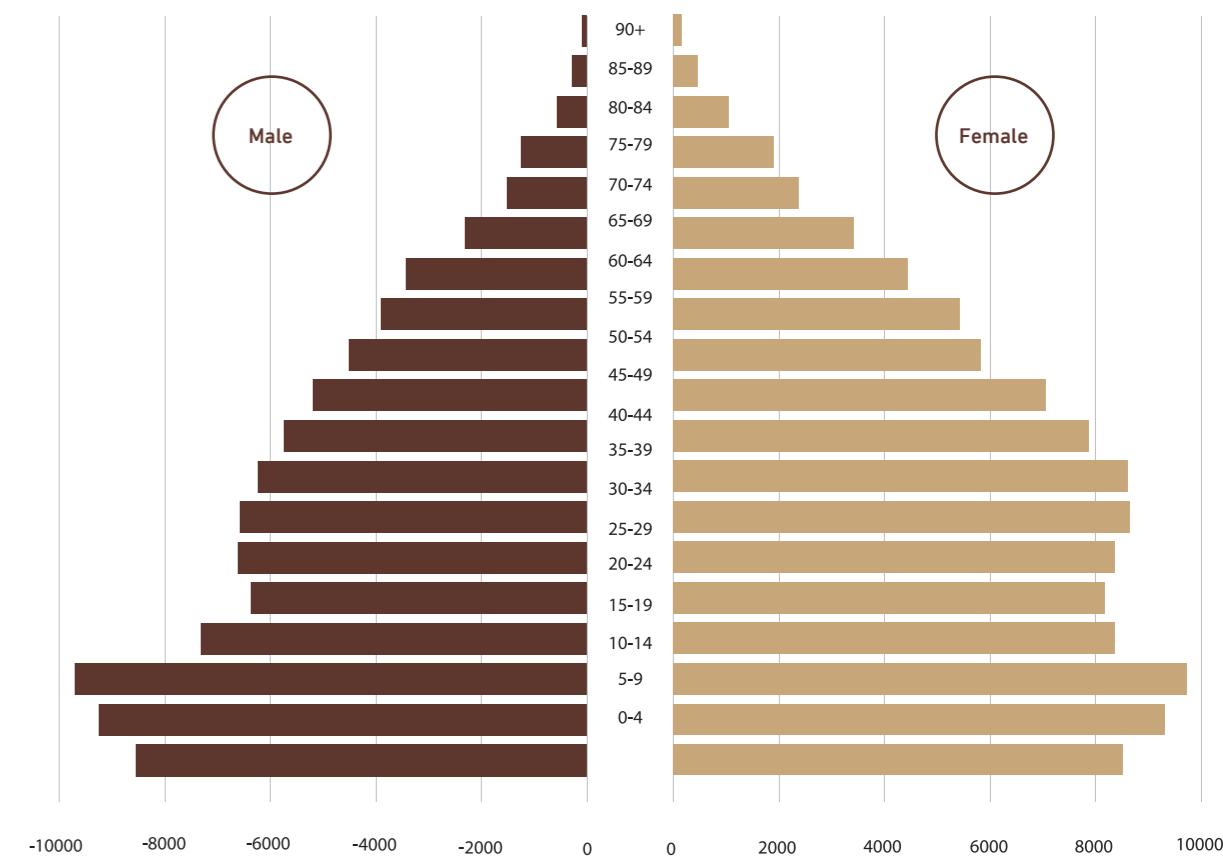
Figure 9. Infant mortality per 1,000 Live Births



Magway Region is 50. This initially signals a lack of health care facilities, post-natal care and nutritional problems, and is a subject to which the report will return later.

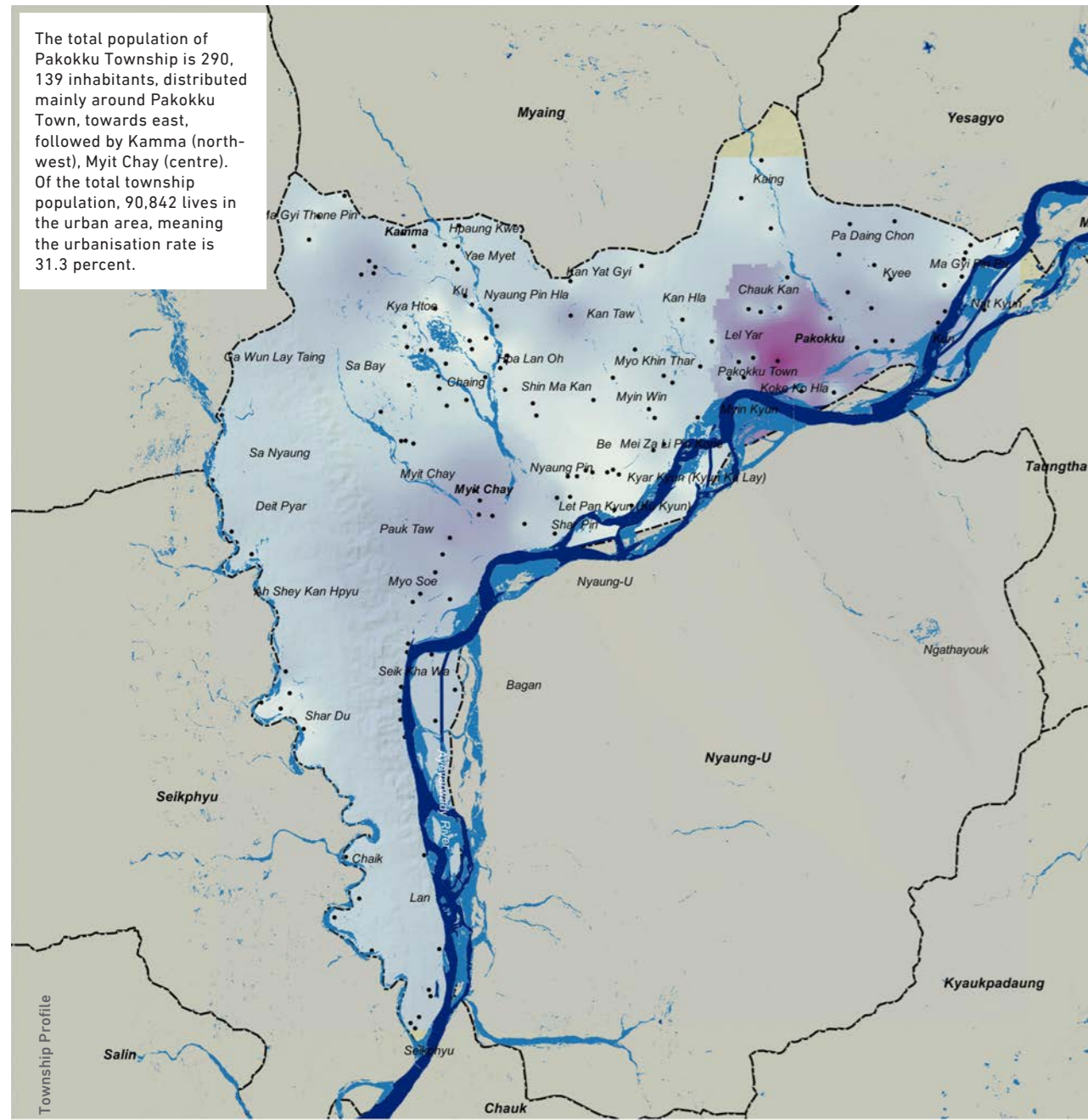
The census data also shows the infant mortality rate in recent years to be very high in Labutta; higher than both in the remainder of the Ayeyawady Region and in Myanmar. In 2013-2014 the infant mortality rate was around 60 per 1,000 live births, higher than the average for the Ayeyawady Region (53) and far higher than the national rate, which is 40 per 1,000 live births¹. 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.

Figure 10. Rural population pyramid for Pakokku Township

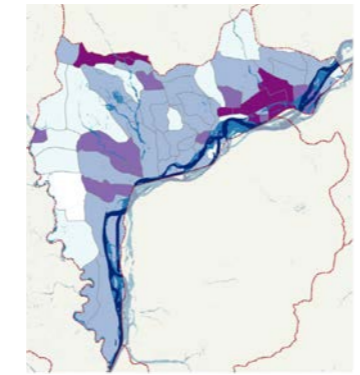


¹³ The Ministry of Immigration and Population of the Republic of the Union of Myanmar, The 2014 Population and Housing Census, The Union Report (Census Report Vol. II), Nay Pyi Taw, (May) 2015
¹⁴ UNFPA Census Thematic Report on Migration and Urbanization, 2016.
¹⁵ Ibid, Census 2014
¹⁶ World Bank (2015) data series. Available here - <http://data.worldbank.org/indicator/SP.DYN.IMRT.IN> - accessed 11-8-2016

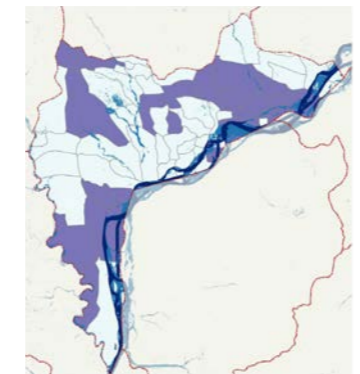
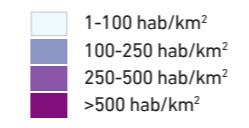
The total population of Pakokku Township is 290,139 inhabitants, distributed mainly around Pakokku Town, towards east, followed by Kamma (north-west), Myit Chay (centre). Of the total township population, 90,842 lives in the urban area, meaning the urbanisation rate is 31.3 percent.



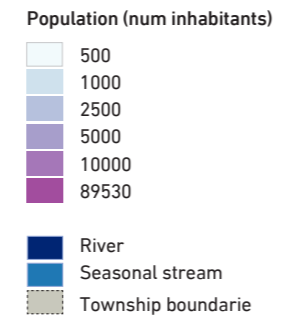
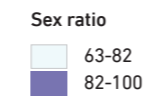
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Population density
The spatial distribution of the population density shows riverbank areas are more populated, being Pakokku and surrounding area the most densely populated. There is a significant difference between the population density in rural areas (215 hab/km² on average), and in Pakokku Town (4,000 hab/km²).



Distribution of population by sex
The total population of Pakokky Township is 290,139 comprised of 130,741 males and 159,398 females, giving a highly unusual sex ratio of 82, which points to high levels of sex disparity among outward migrants.



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

PKK02

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Data Source: MIMU, FAO, WWF, UN HABITAT



Figure 11. Community member in Pakokku © Sukun / MCCA 2016

2.3. ADMINISTRATION AND GOVERNANCE

Pakokku Town hosts both the Pakokku Township Administration and Pakokku District, one of five districts in the Magway Region. The regional government is located in Magway Town.

There are a number of important regional centres relatively close to Pakokku. The National Transport Development Plan considers Mandalay, 161 kilometres away by road, a national centre, and Monywa and Magway, 116 and 168 kilometres away respectively, as agro-industrial centres. All three of these towns are located on strategic transportation corridors. Additionally, Pakokku Town is 31 kilometres from Nyaung U, a major tourist centre because of the Bagan temples, which also has an airport with connections to Mandalay and Yangon.

Under the (National Spatial Development Framework (NSDF) typologies, Pakokku is a town with concentrations of population predominantly engaged in agrarian activities. District and township level administrative functions are provided here and services of health and education, and social and community services, as shown in the spatial structure below. Pakokku has 56 village tracts in total, with a land area of 1,312 square kilometres. However, the town of Pakokku is also comparatively large, with distinctive urban characteristics.

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.

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 programs/work plans and budgets .¹⁸

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 different actions, which are however depending on sectoral policies and programmes of national and regional ministries.

Municipal governance capacities are considered essential pre-conditions to ensure effective long-term adaptation to climate change at local level, 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 mid



Figure 12. A participant in consultations with township officials in Pakokku Township

Municipal governance capacities are considered essential pre-conditions to ensure effective long-term adaptation to climate change at local level, as it enables programming and budgeting across sectors, over the mid to long-term.

to long-term planning at the correct spatial scale that ensure, for example, that value chains are supported by the right connectivity and links to the markets, which require a scale that integrates the legitimate needs at the village level within a much broader scale. The current township governance system at local level harbours inherent weaknesses in this regard, and could be considered as a source of vulnerability. For instance, the lists of needs collected at village tract level in the township planning processes, or the community-driven development activities, may indeed benefit villages and communities. However, they do not ensure that adaptive actions are taken in a cross-sectoral and strategic manner, at the correct spatial and time scale. This issue is part of a broader debate on decentralization and local governance in the country, well beyond the scope of this report. However, the assessment is forced to highlight that local governance requires strengthening in order to face the long-term challenges of climate change. Resilience can be hardly achieved through village and community adaptation only.

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.

2016 | Administrative boundaries



Pakokku township in Magway region



Type of settlement
 • Sub-village
 Township boundaries
 River
 Seasonal stream



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

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.

Pakokku is exposed to climatic hazards that include droughts, inundation and flash-floods, extreme temperatures and heat-waves, and strong winds; these result frequently in loss of economic assets and productive means both in the rural and in the urban areas. Because of its location in the dry zone area of the country, Pakokku is also particularly exposed to the consequences that observed changes in climate have already had on agricultural productivity, with new pests and diseases appearing, water scarcity with greater evaporation in a context of late on-set and early withdrawal of the monsoon season.

The current conditions of its socio-economic, infrastructure and ecological systems make Pakokku vulnerable, with varying degrees of risks between rural and urban areas, and areas next to the river or in-land. Although areas next to the river have privileged access to water and more fertile land, they are also exposed to floods, which destroy crops or halt economic and social activities causing socio-economic damages; areas in-land are not exempt from floods, as seasonal streams suddenly result in flash-floods during torrential short rains, while for the rest of the time they are at risk of heat-waves, droughts and water scarcity. Highly dependent on climate-sensitive agriculture, with poor vocational training and undiversified economy, Pakokku inhabitants suffer and migration in-country or abroad is common.

3.1. DEFINING VULNERABILITY & RESILIENCE IN THE CONTEXT OF PAKOKKU

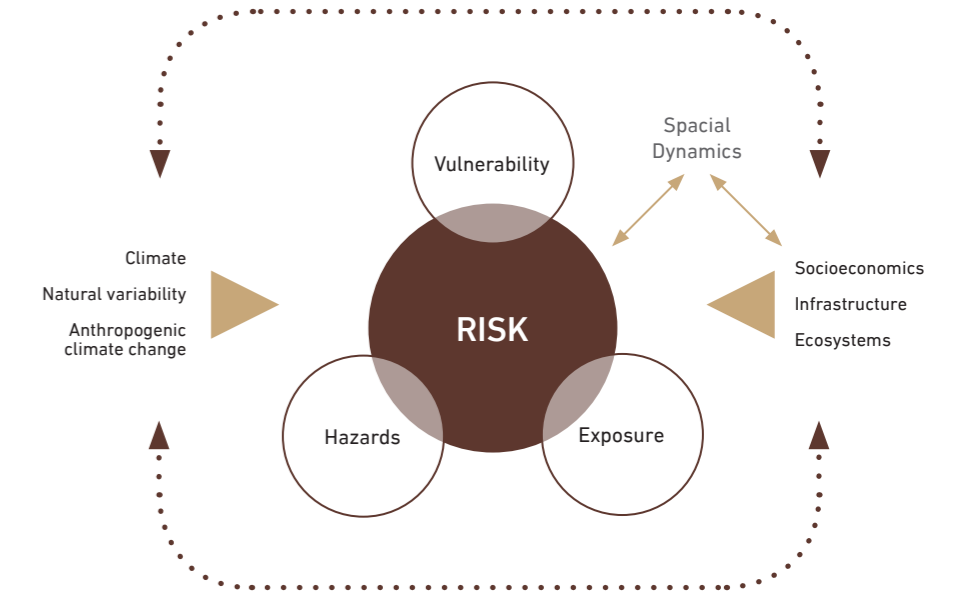
Vulnerability and resilience are multi-semantic notions. In this report, their use is based on the following definitions and sources

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 the Figure hereunder.

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 a review of urban resilience trends: UN-Habitat, 2017. Trends in Urban Resilience, 2017 (Retrieved at <https://unhabitat.org/books/trends-in-urban-resilience-2017/>) For more references, also see: Arup, 2014. Facing up to the future: the City Resilience Index. (Retrieved at http://www.arup.com/city_resilience_index)

Overall Vulnerability Framework



3.2 CLIMATIC FEATURES, NATURAL HAZARDS AND OBSERVED IMPACTS

- A shorter monsoon season results in water shortages for agriculture, drinking water, and livestock while heavier rains in a shorter amount of time destroy crops, disrupt economic activities and endanger people and assets.
- Higher temperatures result in faster evaporation of fertilizers impacting nutrient cycling in soil and lowering agricultural yields, faster evaporation of rainwater harvested during a shorter monsoon season, and they also facilitate the appearance of new pests and diseases and failure of certain crops.
- Erratic rainfall patterns challenge already the agricultural activities, which predominantly occupy people in the township
- Floods and inundation, runoff water and flash-floods affect agriculture, economic activities in urban areas, and social activities such as education and threaten people and assets.
- Severe heat affects livestock health and agricultural productivity

Pakokku faces a number of direct impacts resulting from climate hazards and long term change. While some of these are observed in several areas in Myanmar, others are specific to, or are more pronounced, in Pakokku. 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 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.

Temperature change and associated water shortages are arguably the most serious challenges facing Pakokku. The record high temperature recorded in Pakokku was 45.9°C in May 2010. Progressive temperature change and increasing extremes have a several primary impacts. Communities consulted during the assessment in Pakokku reported that extremely high temperatures, especially when sustained over several months, can affect human health. This impact is especially acute in the young, elderly, and vulnerable and in rural areas where there is little shelter available.

Communities in Pakokku also report that extremes of temperature also result in deaths among livestock, with resultant loss of incomes and indebtedness (livestock breeders often take loans to fund and expand their business). Communities also report that severe heat affects the productivity of daily wage labourers, because they are discouraged from seeking work on very hot days (i.e. days with a temperature of over 40°C) This, in turn, decreases productivity and reduces incomes.

As shown in Section 4.1, the historical trend in rainfall change in Pakokku is not clear. However, the data shows that, although there are fluctuations in the amount of rain that Pakokku receives, in many years the rainfall received is very



Figure 13. Township and village administrators participate in hazard mapping exercises during the study © Sukun/MCCA 2016

low, at around 400 millimetres per annum, which is substantially lower than the national average rainfall (about 2,500 millimetres per year) and the dry zone average, which is around 1,000 millimetres per year. In Pakokku, 61 per cent of households rely on tube wells and bore holes, while 14 per cent rely on either wells or springs or on rivers, streams, or canals. Extremely low levels of rainfall severely impact people, and the 14 per cent of people that rely on uncovered sources are especially exposed because a lack of rain and high temperatures happens because of a greater number of clear sky days, which increase evaporation. Consultations and documentaries conducted by MCCA during and after the assessment converge on that there has been

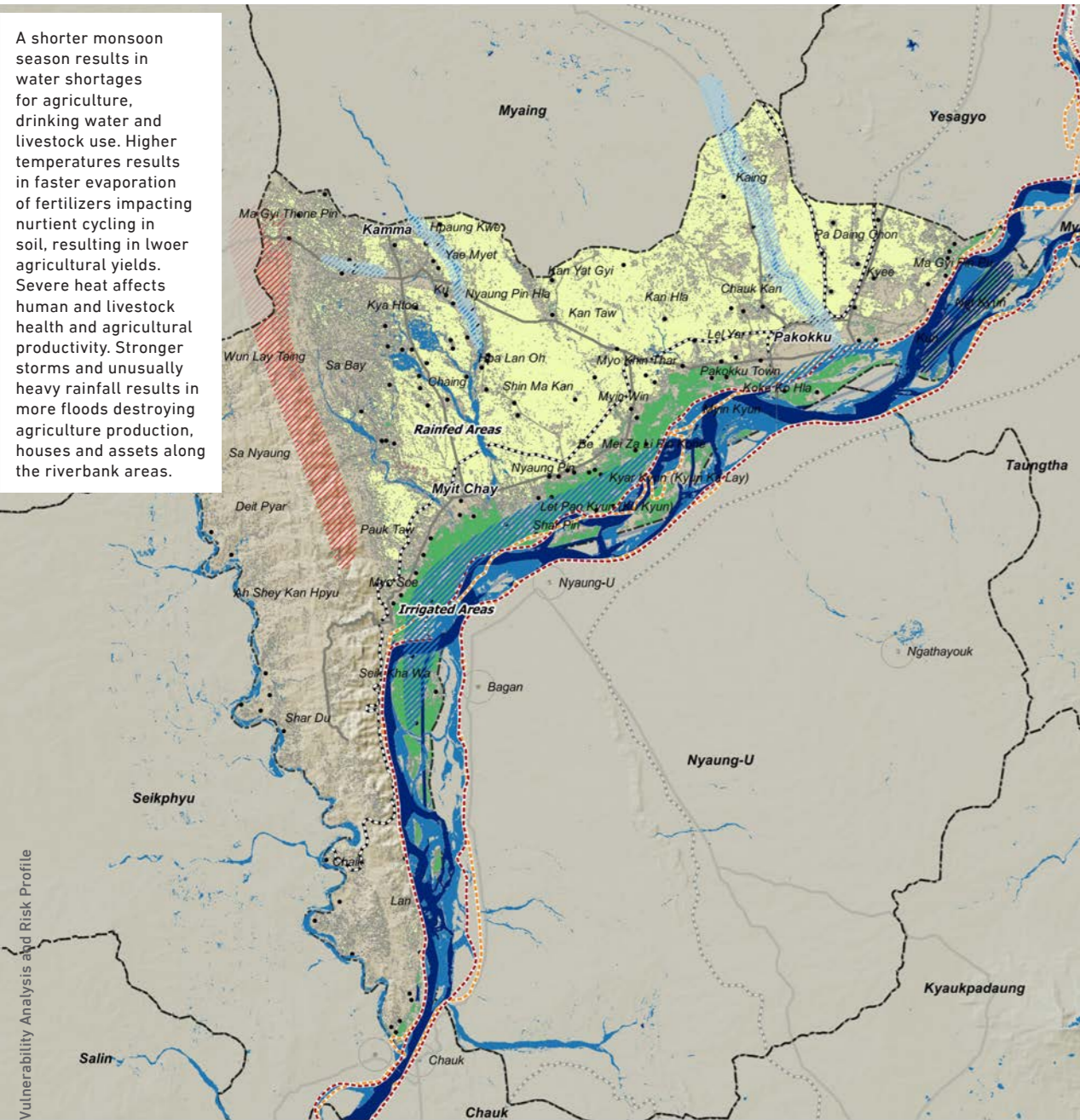
a loss of productivity. In the words of community members “[...] Before we were able to grow two crops a year but now we can only grow one crop because of limited rainfall during the pre-monsoon period. It’s been severe since 2011” (See box ‘Voices from Pakokku’ in the following pages).

Unseasonal or particularly heavy precipitations, on the other hand, are causing recurrent, more intense and frequent floods that affect the villages and urban wards along the river, as well as all villages bordering seasonal streams.

Low levels of rainfall mean that groundwater recharge is limited. This causes severe impacts on

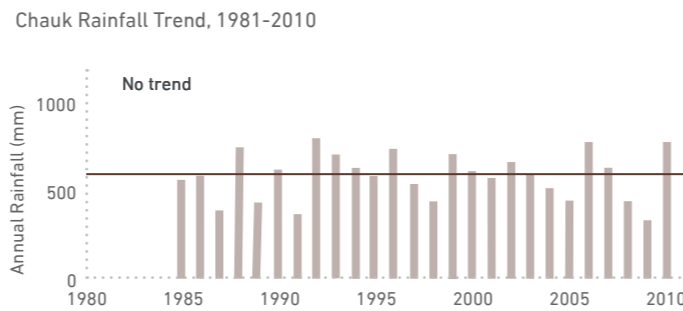
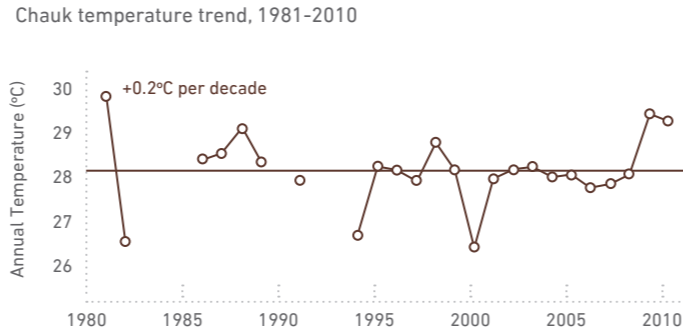
the 61 per cent of people who depend on tube wells and bore holes for their drinking water. This means that people have resorted to digging much deeper to access their water, which presents challenges to villagers, and in some cases has resulted in people relying on lower quality water, as some wells were reported to have gradually become more saline over time. In some villages, especially in the centre and north of the township, people reported that water from deeper sources has higher calcium deposits or other impurities that make it below World Health Organisation standards.

In addition to water quality issues, even where communities have access to tube wells or bore holes, the quantity is insufficient. This means that people don’t have enough water for drinking and household use, and rarely any for agricultural use. As we see in the socio-economic analysis section of this report, irrigation is almost non-existent away from riverbank areas. The lack of water in in-land areas therefore means that agricultural productivity continues to be severely impacted, resulting in very low incomes in the agriculture sector. During local consultations communities reported significant drops – 80 per cent in some cases – in the sale value of crops such as sesame and ground nuts because of a lack of water.



A shorter monsoon season results in water shortages for agriculture, drinking water and livestock use. Higher temperatures results in faster evaporation of fertilizers impacting nutrient cycling in soil, resulting in lower agricultural yields. Severe heat affects human and livestock health and agricultural productivity. Stronger storms and unusually heavy rainfall results in more floods destroying agriculture production, houses and assets along the riverbank areas.

Historical climate and trends near Pakokku
 The station shows no important trends in rainfall or temperature. At Chauk, the wettest day on record in November 1988 saw 157mm of rain in one day. The temperature on the hottest day on record reached 45.9°C in May 2010.



- | | |
|--|--|
| Agriculture | Main communication routes |
| ■ Irrigated agriculture | — Main road |
| ■ Rainfed agriculture | — Secondary road |
| ▨ Main deforestation areas | — Railroad |
| Floods | ■ River |
| ▨ Flash floods affected areas | ▨ Seasonal streams |
| ▨ Seasonal flooded areas | ▭ Riverbed in 2016 |
| ▨ Flooded areas | ▭ Riverbed in 2003 |

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. 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 2014)

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

ECOSYSTEM CONDITIONS

- A history of deforestation and land degradation have reduced the ability of the surrounding ecosystem to provide critical services, reducing crop productivity and yields.
- A naturally highly seasonal, dry climate, and poor water quality limit water security in the township, making it highly vulnerable to any reduction in water availability or quality driven by climate change.
- Combined, these conditions have resulted in highly variable, low crop yields that are likely to further decline with increasing temperatures and changes in rainfall patterns.

That people in the township and surrounding dry zone have been able to rely on agriculture for livelihoods for centuries in a naturally dry, variable climate and low productivity environment indicates some innate levels of resilience to changes in climate. Reliance in rain-fed areas of the township on crops that are well adapted to such an environment supports this¹⁹. However, trends in natural resource degradation in this already dry, low productivity system both in the larger dry zone and within the township have limited the provision of key ecosystem services important to local livelihoods and their ultimate resilience to changes in climate.

A history of deforestation has caused desertification and land degradation that significantly compromises the ability of the surrounding ecosystem, reducing already low crop yields

Decades of deforestation, driven by demand for fuelwood, construction materials, and conversion to agricultural land, has led to desertification in and around the township. This is clearly evidenced by the Normalized Difference Vegetation Index (NDVI) index in the land use maps (see PKK05, for example), which show very low levels of vegetation throughout the township. Households are forced to travel ever farther for fuel wood due to the near total loss of nearby forests. In an already dry, erosion-prone landscape with light, low quality soils, deforestation has also increased erosion and flood risk, including rapid, flash floods. Pakokku is already highly exposed to flooding from upstream due to its location on the banks of the Ayeyawady River; continuing deforestation in upstream mountainous areas further increases its exposure.²⁰ Combined, deforestation both within and upstream of the

¹⁹ Matsuda, M. 2013. Upland Farming Systems Coping with Uncertain Rainfall in the Central Dry Zone of Myanmar: How Stable is Indigenous Multiple Cropping Under Semi-Arid Conditions? Human Ecology, 41, p 927-936.
²⁰ WWF Myanmar, 2016. Natural Connections: How natural capital supports Myanmar's people and economy.



Figure 14. Logs in Pakokku waiting to be moved by river (c) Sukan MCCA/2016

township—including in floodplain areas that provide an important natural flood barrier—make it highly vulnerable to increasingly frequent flooding events as rainfall intensity and variability increases.

The current lack of vegetation cover also affects soil quality and productivity. It increases evaporation and aridity, reducing soil moisture and further contributing to already significant erosion that worsens desertification as temperatures rise and the dry season lengthens. Naturally high levels of soil salinity are likely to be further increased if farmers are forced to rely on saline groundwater sources as seasonal rains become more erratic and less productive.²¹ These factors, combined with naturally light, easily eroded soils, make soil productivity, and therefore

agricultural yields,²² highly likely to decline as temperatures increase and the dry season lengthens.

A naturally highly seasonal, dry climate, combined with poor water quality limit water security in the township, making it highly vulnerable to any reduction in water availability driven by climate change

With its enormous upstream drainage basin, the Ayeyawady River is the lifeblood of Pakokku, providing abundant water supplies to the township, well in excess of current demand. However, with limited water infrastructure (see below) to manage and store highly seasonal flows, and the large majority of rain-fed agricultural land (80 per cent), water availability is still a challenge for the township. Groundwater aquifers do provide a key supplemental source for more than 60 per cent of the population, but quality varies, with at least one major aquifer below Pakokku containing only brackish or saline water that is too low quality to use for agriculture or domestic purposes.²³ Very little is known about surface water-groundwater interactions, including recharge rates; more research is necessary to understand exactly how much water is available and at what quality. Local and upstream erosion affects water quality in the township, which contributes to high sedimentation in river flows that can impact irrigation and energy infrastructure and limit domestic use.²⁴ The Ayeyawady River has naturally high sediment

levels, but they are likely to increase because of on-going upstream deforestation, especially as rainfall becomes more erratic. All of these factors indicate increasing limitations on water availability in the township in the coming decades as rainfall and associated surface water flows become increasingly erratic.

Combined, these conditions have resulted in highly variable, low crop yields that are likely to further decline with increasing temperatures and changes in rainfall patterns

Combined, deforestation, variable water availability, and limited soil productivity all contribute to low, highly variable crop yields in Pakokku and the larger dry zone. As temperatures increase, resulting in increased evaporation, and rainfall becomes increasingly variable and intense, yields will be further challenged. For a region where livelihoods are heavily dependent on productive agriculture, households in Pakokku are thus extremely vulnerable to climate change. This is analysed further in Chapter 4.

21 International Water Management Institute (IWMI). 2015. Improving water management in Myanmar's dry zone for food security, livelihoods and health. Colombo, Sri Lanka: International Water Management Institute (IWMI). 52p.

22 Matsuda, M. 2013. Upland Farming Systems Coping with Uncertain Rainfall in the Central Dry Zone of Myanmar: How Stable is Indigenous Multiple Cropping Under Semi-Arid Conditions? *Human Ecology*, 41, p 927-936. 20

23 International Water Management Institute (IWMI). 2015. Improving water management in Myanmar's dry zone for food security, livelihoods and health. Colombo, Sri Lanka: International Water Management Institute (IWMI). 52p.

24 WWF Myanmar. 2016. Natural Connections: How natural capital supports Myanmar's people and economy.



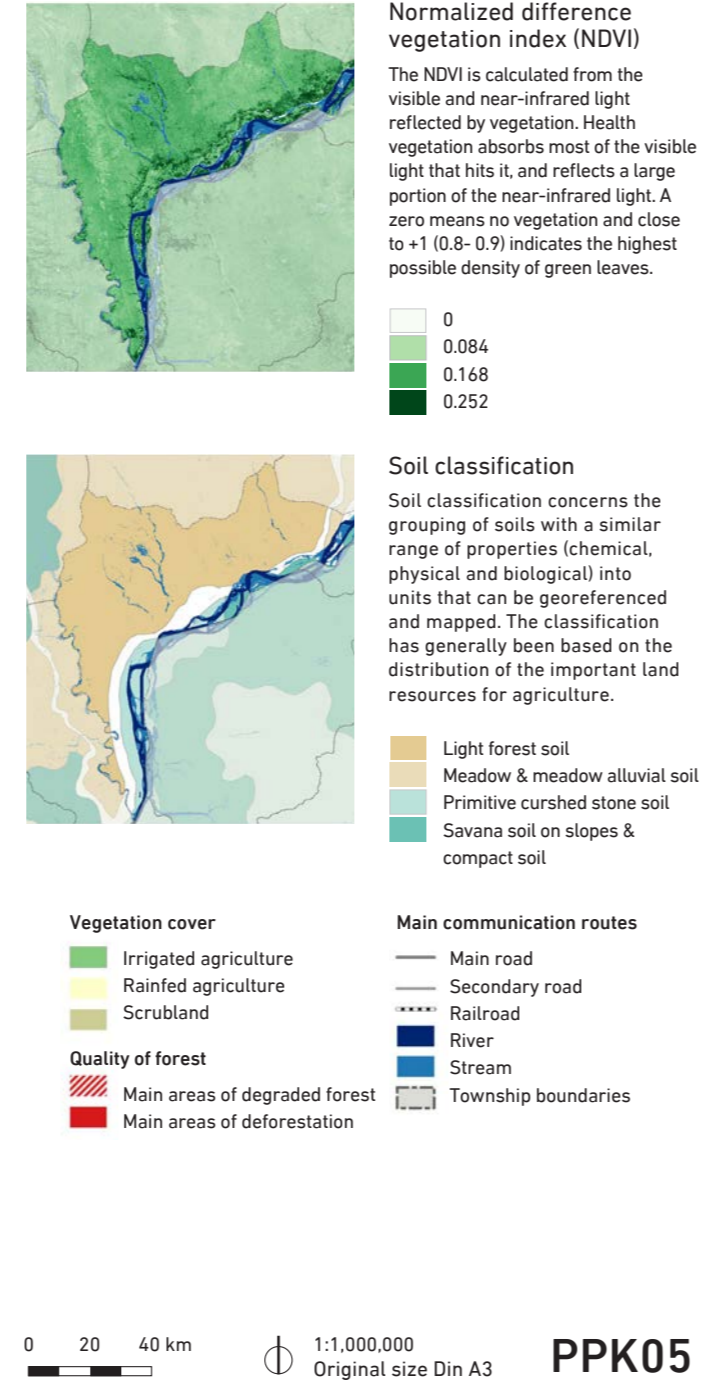
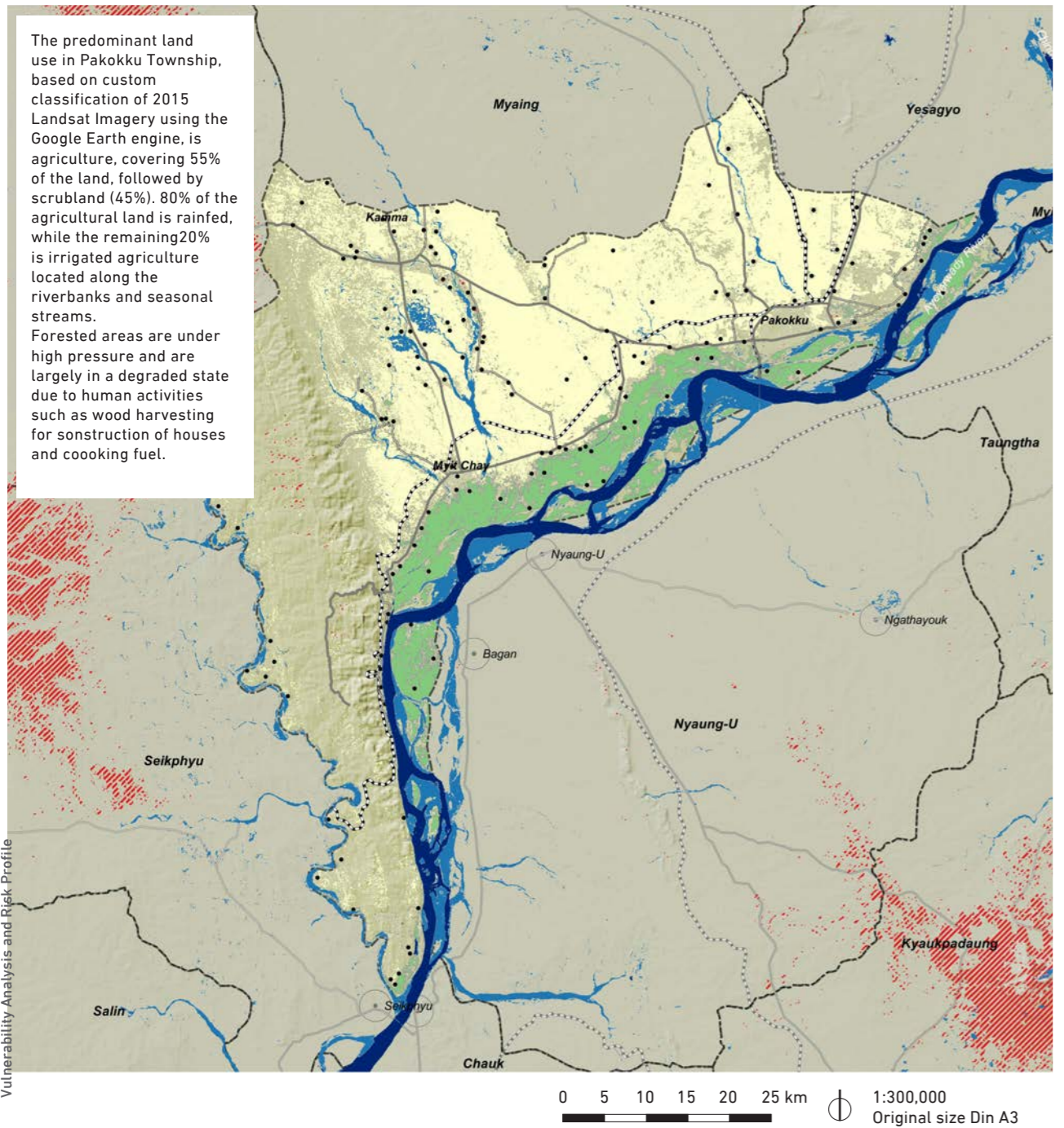
Figure 15. Group photo of community in Pakokku Township

Voices from Pakokku: U Ko Maung Win, Pakokku

“We started to see the effects of climate change around the year 2000. The temperatures are so high during summer now. Rainfall patterns are changing too. Before we were able to grow two crops a year but now we can only grow one crop because of limited rainfall during the pre-monsoon period. It's been severe since 2011. There was heavy rain a few years ago and 500 people died in another village. The forest was destroyed by the water. The monsoon used to come 45 days after Thingyan but now it comes much later and it ends sooner than it used to. The monsoon used to finish in October, but now it's the first week of September. This really affects us as farmers. Since July there's been a severe drought and this has lowered our farm yields. We just can't grow our crops like we used to and we worry a lot. We used to grow double the amount of sesame that we do now because we have to wait to grow it later in the monsoon season. This year we lost a third of our crops from the drought. We now grow it as a monocrop, along with pigeon pea and green gram. Some have switched to livestock or moved to other cities such as Pakokku, Muse and Yangon to find work. Mostly it's the young men that move – they get jobs as carpenters or construction workers. The women that leave find work as maids in cities or selling vegetables in the market. They usually never come back here, or only once a year during festivals. We're sad when they leave.

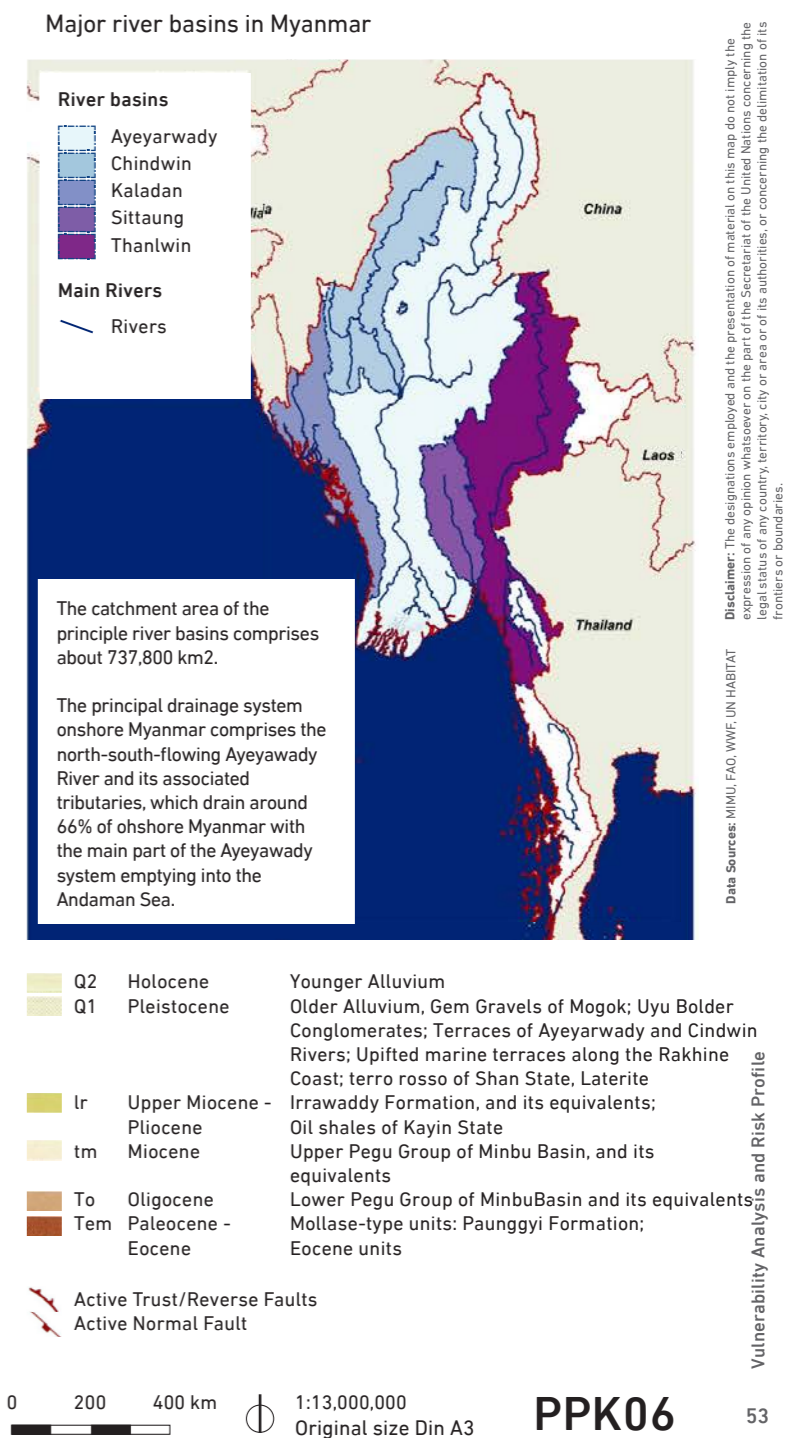
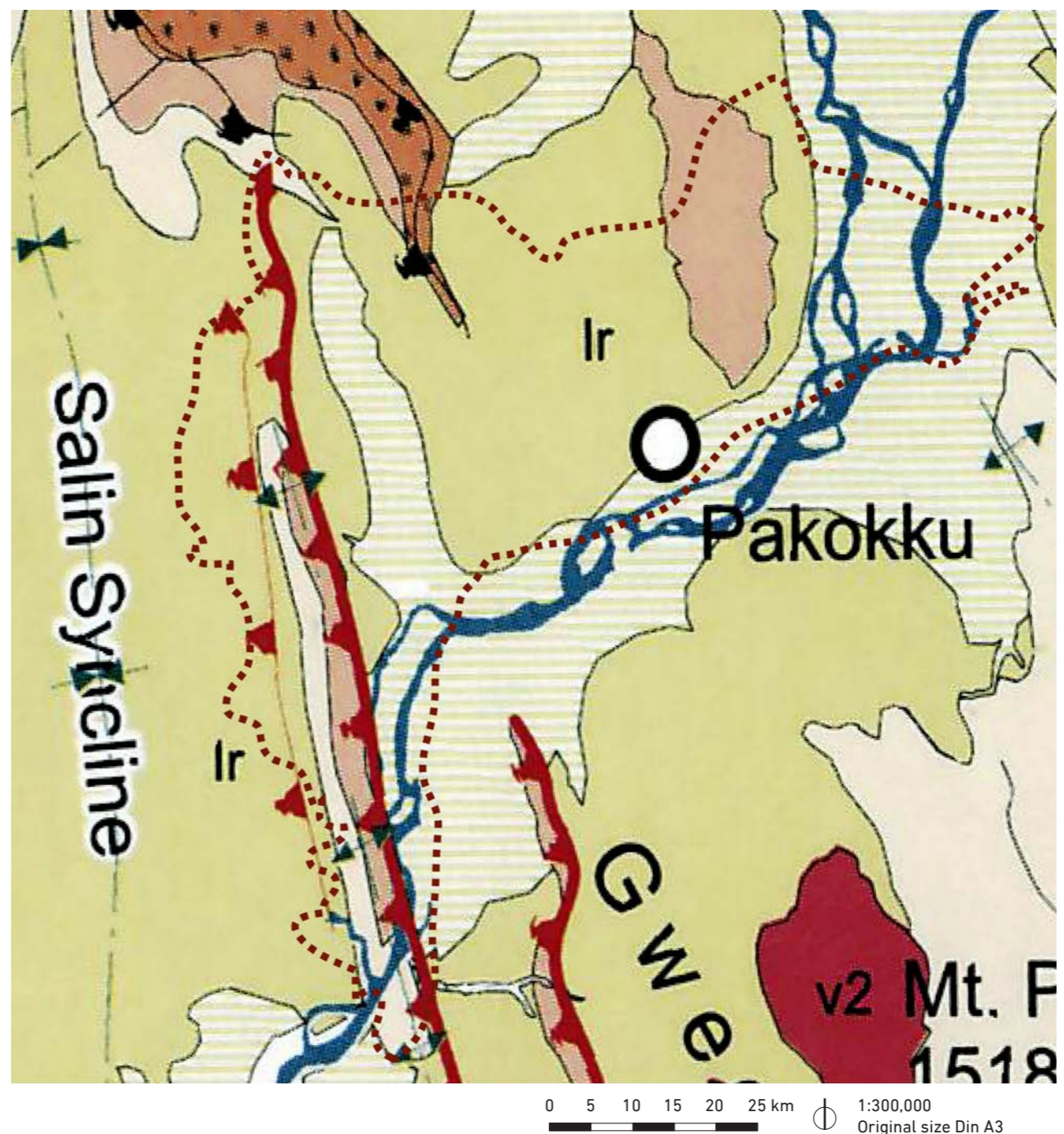
The old people in our village are farmers but the youth have little interest in farming. They want to live in cities. A lot take on work as brokers – they buy clothes and blankets in Mandalay and then sell them in various villages. Parents want their kids to work in the fields, but because of the drought they don't want to because it makes it such a difficult life. Parents worry about their children going somewhere else; what might happen to them. There is a training school run by the Indian government in a village three miles away. They teach skills in carpentry, masonry and welding. But a high school diploma is needed to attend, and only one person from this village graduated from high school. That's changing now though – our generation used to only finish primary school but the young people study more now”.

2016 | Vegetation cover and soil classification



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2016 | Geology and hydrology

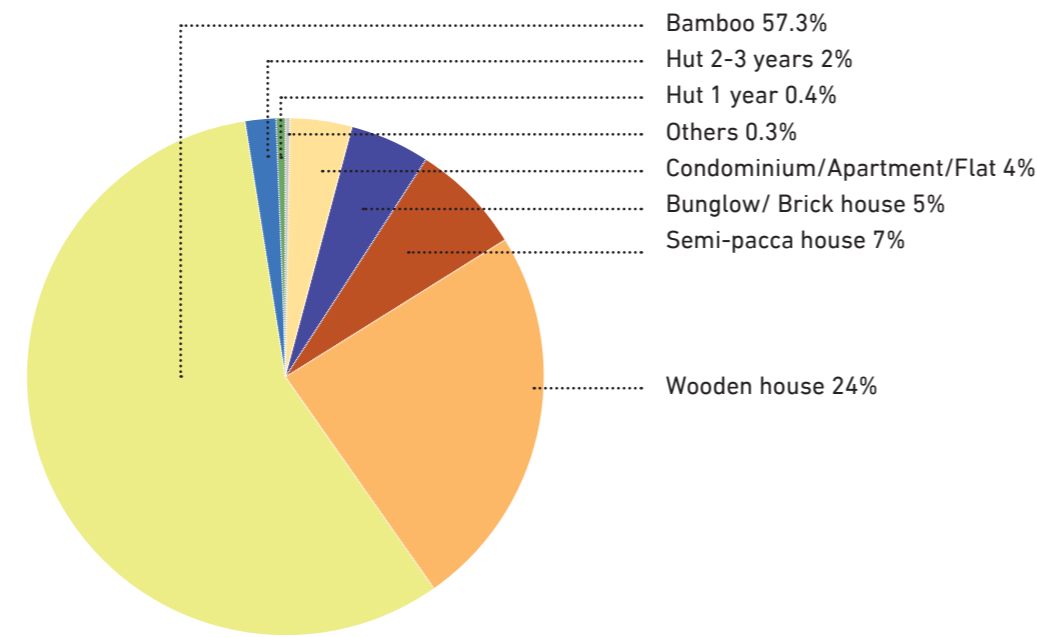


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INFRASTRUCTURE CONDITIONS

- Housing construction is vulnerable to strong winds and floods, mainly in communities along river bank areas
- Freshwater availability will worsen due to the lack of infrastructure for water storage and management at community level
- Disaster and climate resilient protection services coverage is very limited
- Poor transport communication infrastructure is highly vulnerable to hazards, reducing people's mobility in rural areas
- The lack of climate-sensitive land-use planning increases communities' vulnerability to future hazards

Figure 16. Types of housing units in Pakokku



Housing construction is vulnerable to strong winds and floods, mainly in communities along river bank areas

There is limited access to energy sources and high dependence on wood harvesting in rural communities. According to the 2014 census, 92 per cent of the housing units in Pakokku Township are built from local materials; wood or bamboo hut type houses with roofs made from local leaf. The remaining 8 per cent are apartments and

brick houses mainly located in urban areas; Pakokku Town, Kamma, Myit Chay and Southern area of Lan²⁵. In addition, firewood and charcoal are the main sources of cooking fuel (used by more than 71 per cent of households), followed by electricity used by 28 per cent of households, mainly in urban areas. Availability of local materials has declined, pushing people to go further to collect wood or to spend more money in buying it, making households increasingly vulnerable.

²⁵ Table I-1: Conventional households by type of housing unit. The 2014 Myanmar Population and Housing Census

This limited access to energy sources and wood harvesting practices are unsustainable and will inevitably lead to the complete deforestation, and loss of vegetation cover, which will increase flood risk and exposure to erosion destroying houses. Despite this, some retrofitted, flood resilient houses are present in communities near the riverbank, but current building techniques are still weak and the increase in the cost of materials has led people to use less materials, reducing houses' safety.

The electricity network in Pakokku consists of four electric power stations located in Pakokku Town, and in the village tracts of Kamma in the north west, Saik Kha Wa in the south and Kywe Te in the east. Distribution is through three low voltage power lines (66Kw) and several distribution power lines (11 Kw) providing electricity to towns and villages²⁶. 31 village tracts (out of 56)²⁷ have access to electricity network on grid, representing the main source of lighting energy for 57 per cent of the households, while solar energy is the least common, used by only 5 per cent of the households.²⁸

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

Water is clearly the most significant constraint communities are facing in Pakokku. Despite

availability of surface water from the Ayeyawady River and storage reservoirs; there are six government built dams in the township²⁹, the underdeveloped infrastructure available in communities and the high costs of pumping remain a major challenge for people's access to water.

Water harvesting at household level is often ineffective, management is insufficient and quality is becoming problematic. There is a widespread perception that, over the last years, the increase in temperatures coupled with the shorter rainy season has seriously impacted access to water for human and animal consumption, groundwater is available in deeper levels where the quality is worse, and ponds dry up for most of the dry season.

According to the census,³⁰ groundwater is the main freshwater source for drinking use; 68 per cent of the households rely on boreholes and wells, while only 4 per cent of the households have rain water harvest ponds. 15 per cent of the households have piped water, mainly in Pakokku and Kamma Town.

Despite the lack of water availability, few households have individual water harvesting, which appears to be a low-cost alternative to the high cost of digging deeper wells year after year.

²⁵ Table I-1: Conventional households by type of housing unit. The 2014 Myanmar Population and Housing Census
²⁶ Pakokku Planning Department
²⁷ Matrix of functions questionnaire
²⁸ Table J-1. The 2014 Myanmar Population and Housing Census
²⁹ Township Planning Department
³⁰ Table J-2: Conventional households by source of water for drinking use. The 2014 Myanmar Population and Housing Census



Figure 17. Irrigation canal in Pakokku



Figure 18. Example of rainwater harvesting in a school in Kamma



Figure 21. Means of transportation along the Ayeyawady River

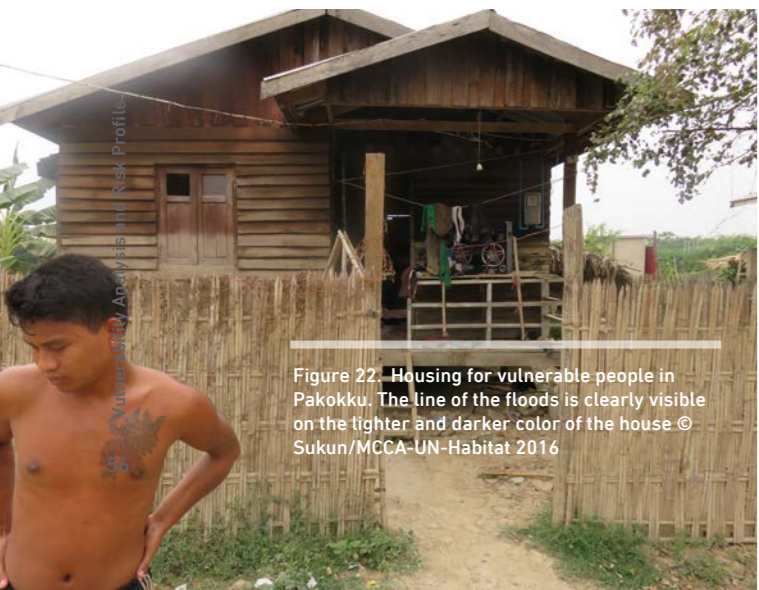
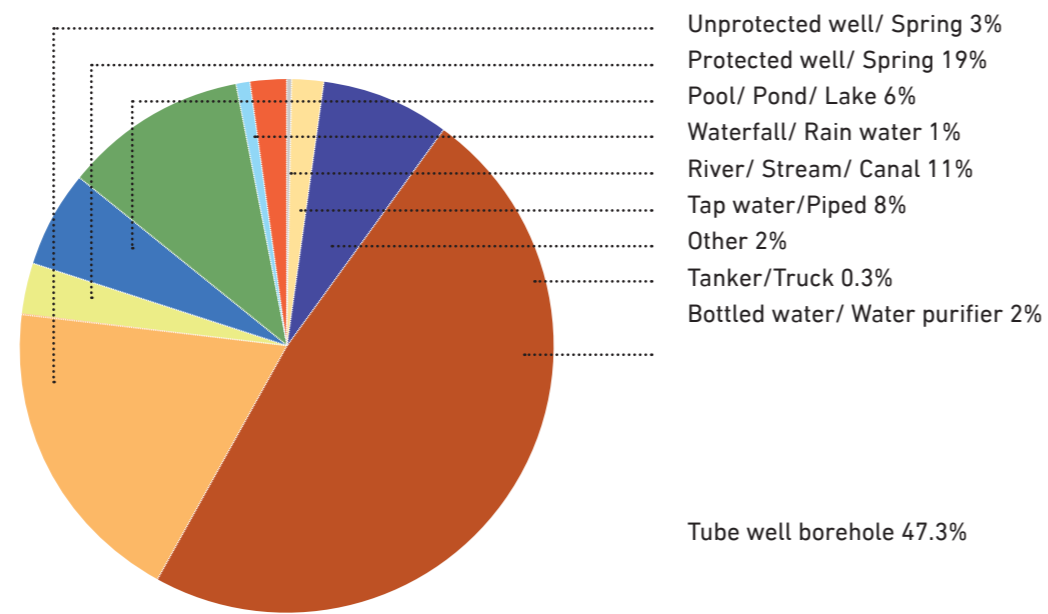


Figure 22. Housing for vulnerable people in Pakokku. The line of the floods is clearly visible on the tighter and darker color of the house © Sukun/MCCA-UN-Habitat 2016

Figure 19 Sources of drinking water in Pakokku



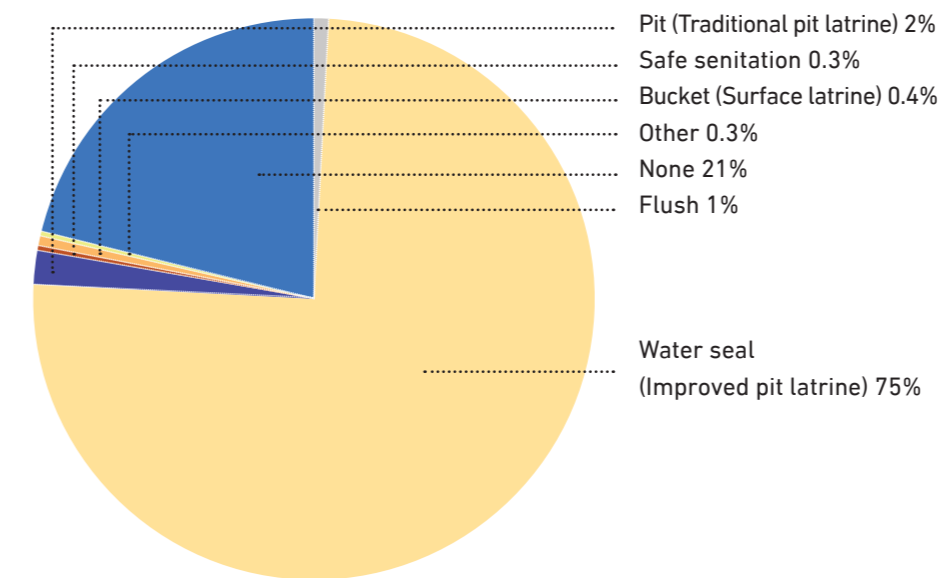
While the Ayeyawady River flows all year-round, many of the smaller streams are seasonal. In local consultations communities along the riverbanks reported having access to irrigation infrastructure, and using ditches or pumped water from the river, for drinking, agriculture and livestock uses during the rainy season.

In the dry season, when water levels fall below the level of the riverbed, flows continue in the sandy aquifers of the river channel, and communities

can access water through shallow wells. However, intense runoff and soil erosion caused by more intense rains and storms will result in more damage to water facilities.

Some schools, health posts and other public buildings have rain water harvesting facilities but these are often poorly managed; communities consistently highlighted water management as the main problem, as some users tend to deplete resources and not manage them wisely. At

Figure 20 Sources of drinking water in Pakokku



community level, there is a lack of infrastructure such as water tanks and reservoirs for water capture and storage.

The only exceptions are in monasteries and development organization buildings, but these are insufficient for most communities.

A system of irrigation canals and dykes is available in some communities along the riverbanks allowing different types of crops.

Safe sanitation (flush and water sealed latrine) is the main sanitation facility in Pakokku (78 per cent of households), while 19 per cent of the households do not have access to any type of sanitation facility³¹. The lack of disposal of untreated domestic wastewater and solid waste management, coupled with the overuse of fertilizers and pesticides in agriculture will further affect the water quality, which already has higher levels of calcium. Despite the lack of data available on water pollution, the

expected increase in urbanization and intensified farming practices will result in deterioration of water quality

Disaster and climate resilient protection services coverage is very limited

Health and education coverage is good across the township, however public buildings are often not disaster-resilient and therefore cannot be used as shelters in case of strong winds and flooding, which increases communities' vulnerability to more intense hazards. Similarly, monasteries remain key in providing informal social services, such as temporary shelter and water, but their limited capacity and resources don't cover all communities.

Basic health coverage is good across the township except in western areas where there is a lack of health facilities. There are 7 rural health centres (RHC) and 34 sub-rural health centres (SRHC) distributed across the township. The sub-rural health centres are all within 5km to 10km (1-2hours' walk) of the rural health centres, each of which provides basic health services to a population between 2,500 and 5,000 inhabitants. Four station hospitals (SH), two in the northern area of the township (located in Kamma and in Kya Htoe), a third one located in the central area (Myit Chay), and a fourth along the northern primary road to Mandalay (Kaing), which

31 Table I-3: Conventional households by type of toilet. The 2014 Myanmar Population and Housing Census

provide health services to the population of these areas. Finally, one township hospital (TH) located in Ward 2 in Pakokku Town, provides specialised health services to the total population of the township.

45 village tracts have access to basic education facilities, which suggests that at least primary education is available to almost all children in the township, if we allow for some travel time. A further 34 village tracts have secondary schools, which would suggest a fairly wide coverage of educational facilities. Tertiary education is available at the universities located in Pakokku Town and in Tin Gat. There is, however, a lack of technical and vocational training centres.

Monasteries provide the main shelter facilities from floods, strong winds, and heavy rains, however their limited accommodation pushes some people to stay in temporary houses located in safer areas until they can go back to their houses. The lack of storage facilities in these areas and the lack of capacity to carry most of their belongings affects their income severely during such events. Monasteries also provide shelter during periods of high temperatures and heat waves, especially to elderly women in rural areas where there is little shelter available.

There is a lack of awareness and robust mechanisms of early warning systems, evacuation routes and disaster management committees, especially in communities along the riverbanks. Pakokku has a well distributed network of mobile-phone masts from the main telecom companies in Myanmar (MPT, Ooredoo and Telenor)³² except in the western areas. Radio and television are the main means of communication at household level, followed by mobile telephones.³³ This means that there is potential for a good community radio network that can relay information on, preparedness and early warnings. However, no local radio stations are present in the township, meaning people primarily listen to national or region-level radio.

Poor transport and communication increases vulnerability to hazards, reducing people's mobility in rural areas

Pakokku Township has a good transportation infrastructure, consisting of water, road, railway, and air transport facilities.

Pakokku has an airport located approximately 1.6 kilometres east of Pakokku Town, though it currently does not offer any flights. Nyaung U airport,

³² Pakokku Planning Department

³³ Table J-5: Conventional households by availability of communication and related amenities, The 2014 Myanmar Population and Housing Census

Voices from Pakokku: Myat Myat Khine, 31, Shwe Khan Tar village.

"In 2012 there was a terrible flood. It happened at around 3am when we were sound asleep – we weren't at all prepared and there was no time to take any belongings. We just ran for our lives. My two children were aged seven and three at the time. The electricity was cut out by the flood so we were in the dark and it was really scary. Back then we didn't have mobile phones and there was no warning information system. Most people were swept away by the currents because they didn't know what to do. Fifty children died.

It was my first experience of a very serious flood – there had only been smaller floods before. The whole house was destroyed. We lost all our belongings and stayed in the monastery for two weeks. We had food but there were so many people living there – I think about six hundred. After two weeks, some were able to move to a new home, but we had to pay three lakh to repair ours so it took time. I worry about the possibility of another flood. We can't move somewhere further from the river's edge because we're too poor. I feel unsafe almost every day but I cannot move. All my relatives live here also. Even if the house is very tall and strong, the ground will move from underneath it. Whether it gets swept away depends on the force of the current. That flood in 2012 swept away 300 homes".

around 32 kilometres away, offers flights to Yangon and Mandalay. There are railway connections to neighbouring townships from Pakokku town: (i) Pakokku- Myaing; (ii) Pakokku- Yesagyo; (iii) Pakokku- Seik Phyu; and (iv) Pakokku- Bagan.

Pakokku's location on the Ayeyawady River, Myanmar's most important commercial waterway, means it plays an important role as a trading centre for the Chindwin and Yaw River valleys, mainly for agricultural products including peanuts, sesame, rice, and palm sugar, in addition to timber. Currently, port facilities are underdeveloped; no machinery and equipment is available and cargo handling is done manually. In 2012, the Department of Water Resources and Improvement of River Systems, under the Ministry of Transport, planned new ports to facilitate speedier transport of commodities and people along the Ayeyawady and Chindwin Rivers. Four ports were planned along the Ayeyawady River, at Sin Khan and Mandalay in Mandalay Region, and at Pakokku and Magway in Magway Region. Pakokku port was intended to accept goods from upper Myanmar and help to distribute them to the west of the Chindwin River ³⁴

³⁴ <http://www.mmimes.com/index.php/business/1766-government-plans-six-new-ports-on-chindwin-ayeyawady.html>

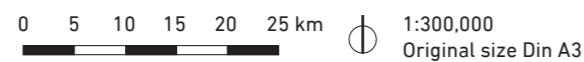
A national paved road connects Pakokku, through a bridge over the Ayeyawady river, with Bagan (32km) and further to Mandalay (168 km). To the west, this national road links Pakokku with Pauk (70km) and continues to Chin State. Transport infrastructure from Pakokku to northern areas (Sagaing State) consists of national paved roads, through the town of Myaing and through the town of Yesagyo. Transport infrastructure to southern areas is less developed however, consisting of one paved road to Myit Chay, which continues unpaved to Seikphyu and Chauk. Communities in this area face frequent flooding especially in the rainy season, complicating mobility and communication when crossing the seasonal streams.

A network of secondary and tertiary unpaved roads derived from the main national roads, provide transport communication to rural settlements. However, stronger storms and unusually heavy rainfall results in more floods, reducing people's mobility, especially in riverbank areas. Some communities reported using green infrastructure to protect from river and stream erosion in the form of bamboo embankments and temporary wooden bridges, but so far they have proved to be insufficient.

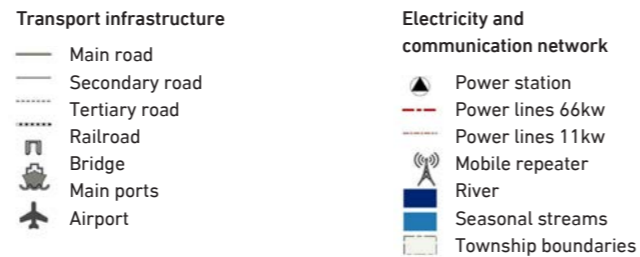
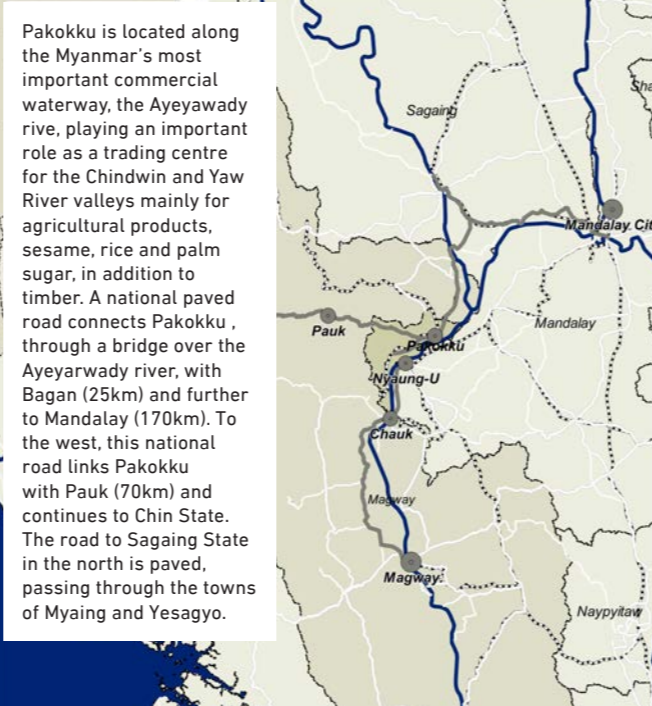
The lack of climate-sensitive land-use planning increases communities' vulnerability to future hazards

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 potential vulnerability of households, especially in coastal areas where the projected sea-level rise will reduce availability of land and ultimately will result in displacement of communities to northern areas.



Main transportation routes



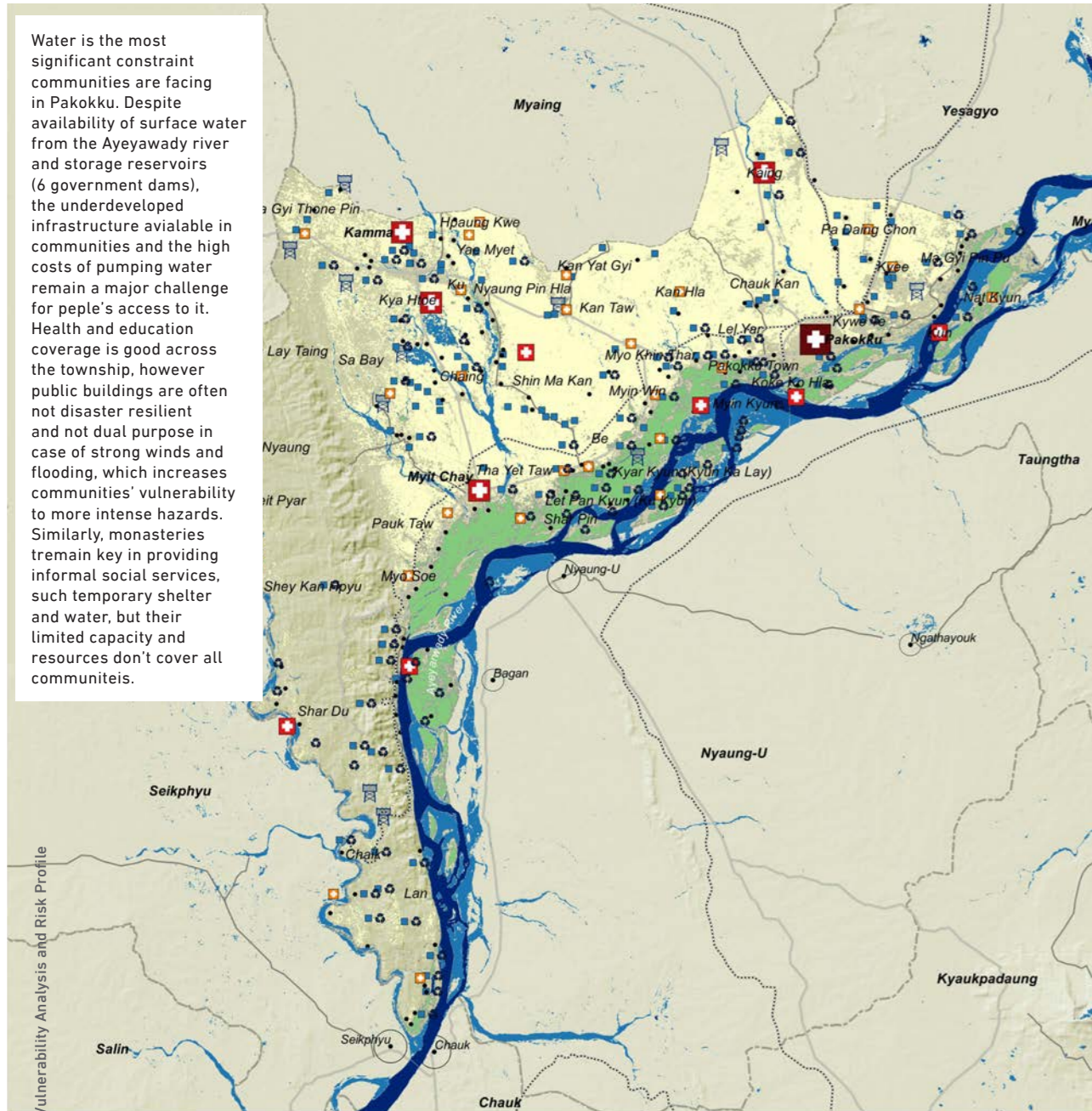
PPK07

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 its authorities, or concerning the delimitation of its frontiers or boundaries.

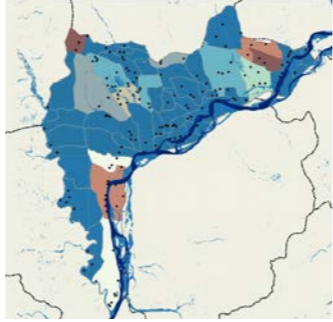


Figure 23. Flood in Pakokku downtown covered by the media (MCCA/July 2017)

Water is the most significant constraint communities are facing in Pakokku. Despite availability of surface water from the Ayeyawady river and storage reservoirs (6 government dams), the underdeveloped infrastructure available in communities and the high costs of pumping water remain a major challenge for people's access to it. Health and education coverage is good across the township, however public buildings are often not disaster resilient and not dual purpose in case of strong winds and flooding, 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.



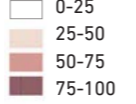
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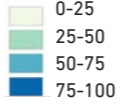
Main drinking water sources at household level

According to the census 2014, groundwater is the main freshwater source for drinking use..

Surface sources (%HHs)

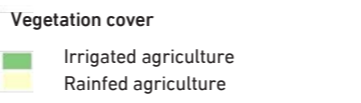
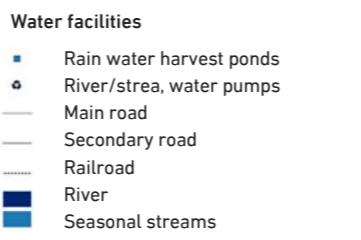
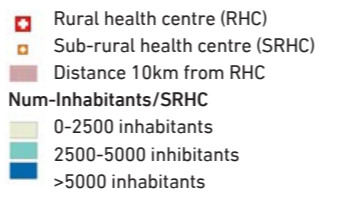


Groundwater sources (%HH)



Rural health cover

Basic health coverage is good across the township except in western and southern areas where there is a lack of sub-rural health centres (CRHC) and distances to rural health centres (SRHC) are greater than 5km to 10km (1-2h walking).



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PPK08

SOCIO-ECONOMIC CONDITIONS

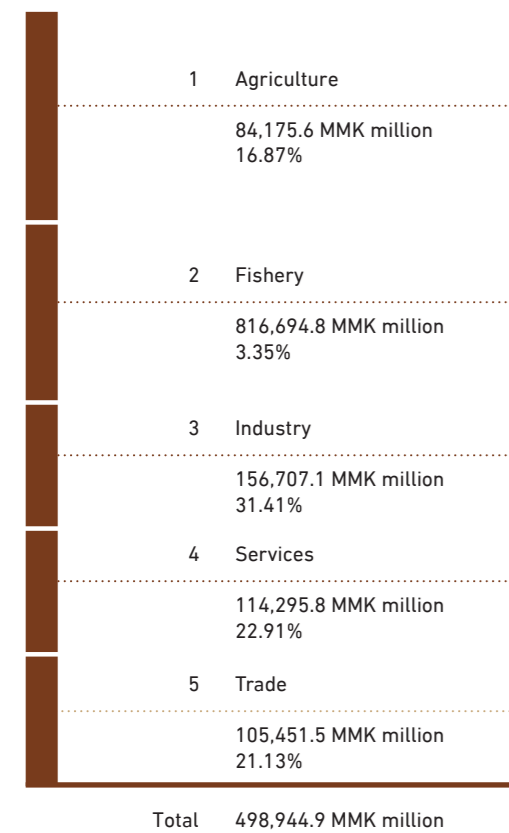
- There is very high youth migration, with a sex imbalance. This results in fewer young, skilled and capable workers, an unusual sex ratio and a high number of female-headed households.
- Relatively few people have completed education beyond grade-5 level, and virtually none have vocational training. This makes it hard to attract high value-added, labour intensive industry to the township.
- Household incomes, especially in agriculture, are very low. This limits flexibility to prepare for and respond to climate hazards and slow onset changes.
- Industry is the most valuable sector, and is less climate vulnerable than agriculture, but does not create jobs. Household level small businesses are particularly present in Pakokku town
- Low levels of education, low incomes and high migration are mutually reinforcing.

Agriculture defines the economy of Pakokku Township, especially in the rural areas. Pakokku Town itself acts as a trading centre, and transportation hub for road and river transport, primarily, and is home to some small scale, cottage industries.

Pakokku's economy reflects the environmental profile of different parts of the township. Broadly, there are five different zones; Pakokku Town, riverbank areas, seasonal flash flood (wet-dry) areas, inland dry and mountain dry areas. These zones have slightly different livelihood practices, and are influenced by natural hazards in a slightly different way. In all areas outside Pakokku Town, agriculture is the main source of livelihood. In the inland dry area, farmers mainly grow cash crops such as ground nuts, sesame, and pigeon peas. A similar profile exists in the mountain dry area, though this area is very sparsely populated. With greater access to water; especially by the river but also in the wet-dry areas, farmers grow these crops as well as vegetables, chilli and tobacco. In Pakokku Town there is a greater mix of livelihood activity. Trade in agricultural products and other goods is important in the town, as the main urban centre in the township. There is some industry around onward transportation because of the port on the Ayeyawady River. There are also some cottage industries, with small scale production of building materials and garments, particularly slippers.

As in many areas of Myanmar, landlessness is an ongoing challenge, and is a serious issue in Pakokku. 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. In Pakokku, daily wage labour tends to be in agriculture in rural areas, but more varied in urban areas, but particularly in cottage industries and construction.

Figure 24 Economic Output by Sector in Pakokku³⁵



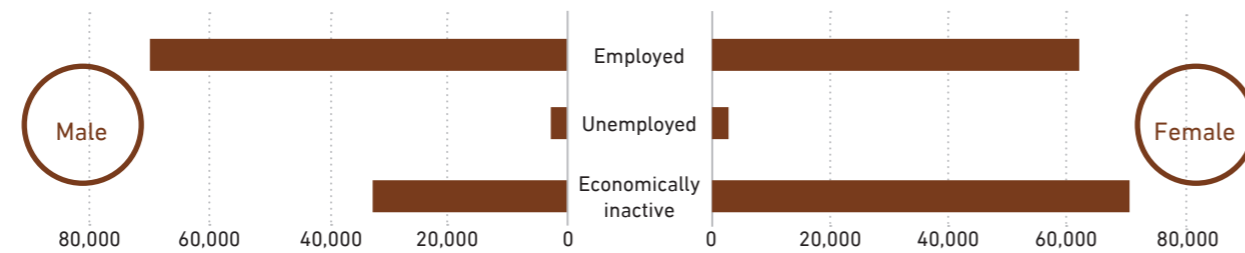
Based on the above data, the annual output per capita in Pakokku is US\$1,433 (1,719,600 Kyat). This is slightly higher than the national GDP per capita figure, which is US\$1,203.5 (1,444,200 Kyat)³⁶. According to the same data set the projected output per capita for fiscal year 2016-2017 is US\$1471 (1,765,200 Kyat). This represents projected annual growth of about 2.65 per cent, much slower than annual growth figures of approximately 7 per cent.

The total size of the labour force, defined as everyone over 10 years old, is 240,494. On the surface, the unemployment rate is low, at 4.1 per cent. However, this is made less reliable by the unusually large proportion of the population that is economically inactive; a situation that is made less clear by comparatively low school enrolment. The prevalence of daily wage labour

partially explains this, as defined above. Daily wage labourers are in-between formal and informal, moving between work in salt production, in industry, in the formal sector and agricultural labour or trading goods, in the informal sector, making the classification of economic activity (i.e. active or inactive) very challenging.

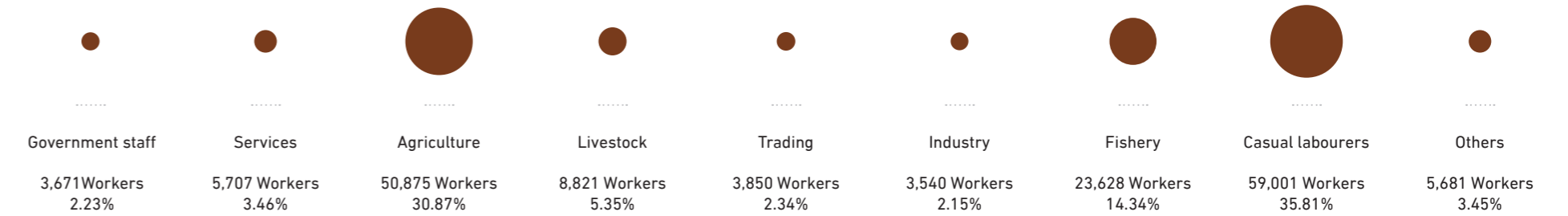
Based on data from the Township Planning Office, we can see that the sector breakdown of employment in Pakokku shown in Figure 16 gives the number of people economically active and in-work as being 206,778, which is substantially higher than the equivalent figure from the census of 131,885. However, if we subtract people classified by the Department of Planning as working in trade and 'others', the number of people economically active people who are employed

Figure 25. Labour Force Participation in Pakokku³⁷



³⁵ ibid
³⁶ World Bank
³⁷ Ministry of Immigration and Population (2015) The 2014 Myanmar Population and Housing Census, Magway Region, Census Report Volume 3-N, Table D1a

Figure 26. Job Categories in Pakokku³⁸



becomes 130,353; within 1,500 of the census figure. This difference in classification is the most likely explanation for this discrepancy.

Agriculture as a share of the Pakokku's economic output represents only 16.87 per cent, but it employs 46.6 per cent of economically active people in the township. This means that annual output per capita in the agriculture sector is US\$727.92 (873,504 Kyat), considerably lower than overall output in the sector nationally and if equated to income, representative of income at a shade under US\$2 (2,400 Kyat) per day. However, using the Planning Department statistics, there are 83,351 people who are either economically inactive or currently seeking work. If we assume that the same proportion of economically inactive people depend for their livelihood on agricultural incomes as those working in agriculture (46.6 per cent), the income figures become much lower. Under this assumption, an additional 38,842 people depend on agriculture for their livelihood. As a result, the

output per capita in agriculture is US\$519 (622,800 Kyat) per year. If we assume that farmers keep 100 per cent of their output – which is unlikely – this translates to a gross daily income of US\$1.42 (1,704 Kyat) per day, before production costs.

One reason this report factors economically inactive people into estimations of output per capita 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 communities that depend on agriculture, men and women undertake different tasks that contribute towards one household income. However, as Figure 15 shows, 68 per cent of people classified as economically inactive are women. This indicates that women are often working, in agriculture and trade, but are 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.

Incomes appear similarly low in the fishery sector; fishery is worth only 3.35 per cent of total output but employs 5.27 per cent of the economically active population. This gives an annual output per capita of approximately US\$1,276 (1,531,200 Kyat). However, if we apply the same assumptions as in agriculture, that fishery also supports the same proportion of economically inactive people as its share of employment, the average annual output per capita becomes US\$909 (1,090,800 Kyat).

If we assume that the 28,267 people classified as working in other employment sectors are split equally between industry and trade, we see that the output per capita in these sectors is still higher than in fishery and agriculture. In trade, the output per capita, assuming that half of the people classified as working in other sectors are working in trade, is US\$1,410 (1,692,000 Kyat) per year, roughly in

³⁸ Pakokku Township Department of Planning



Figure 27. In Pakokku town small household-based crafts, such as weaving or production of slippers are very diffused. During floods, these economic activities may stop for several days and even weeks, affecting the livelihoods of people Photo: © Sukun / MCCA 2016

line with the average for the township. The annual output per capita in industry (assuming the number working in industry is equal to half of the 'other' category workers plus the casual workers) is US\$9,142 (10,970,400 Kyat), much higher than the average for the township.

Output per capita offers us an approximation of income. In agriculture and fisheries, we can assume that people retain close to 100 per cent of their output because the vast majority of farmers are smallholders (meaning they don't employ many workers, other than seasonal, casual labour), access to markets is not generally problematic and there is little room for wages to go any lower. Unlike in some other areas, producers are less reliant on 'grey market' middlemen to trade their produce. However, in trade and especially industry such an assumption is much harder because value generation is not retained through wages. Without a wage or household income survey – such work has not been carried out locally – it is not possible to accurately estimate incomes in trade and industry, but in trade especially we can realistically assume they are also low, based on output per capita.

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



Figure 28. U Bo Bo from Pakokku Township

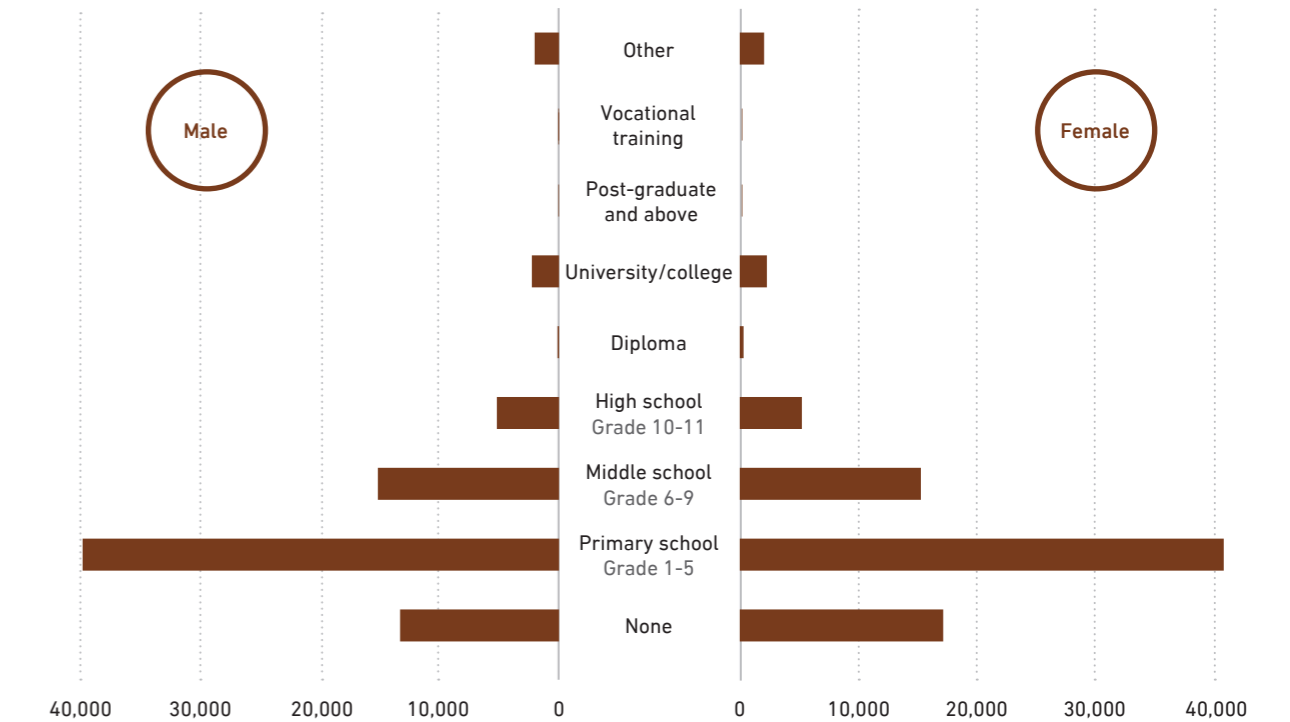
Voices from Pakokku: U Bo Bo, 62

I started growing groundnut when I was 19 I also grew sesame and green gram. I stopped farming when I was 55 and switched to agriculture because it was too hard to make ends meet.

I have four sons and shared the land with other farmers – it's basically subsistence farming. I take care of 20 goats for their owner. If the weather is okay, the farming is okay. Goats don't need good weather to survive. But for three months during the year, when there's the drought, it's difficult to have enough feed for the goats because the earth gets so dry. I managed to earn enough money for a year as a farmer but then the drought got more severe.

For a couple of years after 2003 it was really hard to put food on the table. So I moved to Mandalay with my family. That was when I was 48. I spent eight years in Mandalay driving a trishaw. My expenses were much higher in Mandalay than here in the village. I discovered that earning money as a trishaw driver was more difficult than farming because I had to pay rent on the trishaw, which was K10,000 a day. My profits were only K10,000 to 12,000 a month and I became depressed. My wife is not in good health so she couldn't work. So we came back here in the end, but life is still hard. I'll change professions again if I need to.

Figure 29. Education levels in Pakokku³⁹



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 Pakokku (agriculture, trade and industry) we must assume that daily wages in agriculture and trade are less than the 3,600 Kyat wage floor, as average output

per capita in the agriculture sector is lower than this at 2,393 kyat per day and only marginally higher – 4,366 kyat per day – in trade. Typically, economists would assume that daily wages cannot be higher than daily output.

³⁹ Ministry of Immigration and Population (2015) The 2014 Myanmar Population and Housing Census, Magway Region, Census Report Volume 3-N, Table D6a



3.4. SPATIAL STRUCTURE OF PAKOKKU

- Pauk and Magway provide main socio-economic functions to western areas and southern areas respectively, while Mandalay represents the closest city for labour migrants and market supplies.
- Western areas of the township show the lowest levels of socio-economic and infrastructure development, covering only basic health and education services and some basic needs. These areas concentrate 30 per cent of the total population and appear to be rather isolated.
- Pakokku Town and Myit Chay are the two main clusters of settlements of the township covering the highest levels of socio-economic functions and connectivity and provide the greatest number of social and basic services.
- Kamma and Lan are considered nodal towns or important

centres of socio-economic activity to rural areas located strategically at township's border crossings.

- Three primary corridors along the main routes of road transport networks are crucial to support the economy of the township, enabling connectivity among the two main clusters and nodal towns.

The analysis of the human settlements using the matrix of functions (see Annex A3 Methodology of the Matrix of Functions) 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 ecosystems services play in this structure.

The assumptions, in this assessment, are that human settlements that have fewer functions available are more vulnerable, and that providing the services that are largely missing would reduce their vulnerability. 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, so that

some basic needs. Intermediate village tracts (IVT) are located along the primary roads, have better access to transportation and communication, coupled with higher levels of health and education facilities, allow the presence of more economic activities and more cultural and security services (levels 3, 4 and 5). Main village tracts (MVT) are located at the junction of primary and

secondary roads and along the riverbanks, and are considered the first trade centre and provisioning market to surrounding rural areas (levels 6, 7 and 8). Finally, Kamma is the second urban areas of the township (level 10) providing services to the population in western areas and Pakokku Town is the main urban centre (MUC), covering the highest

number of functions and the most unique ones across the township (level 15).

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

- Two main clusters of settlements, centred in Pakokku Town and Myit Chay, which have the highest levels of socio-economic functions, are suitable for investment and provide the greatest number of social and basic services:
- Finally, three primary corridors along the main routes of road transport networks towns: North-South:

Yesagyio – Pakokku – Be - Myit Chay –Lan – Salin, North: Pakokku – Chauk Kan – Myaing Town and East-West: Pakokku – Kan Taw – Kamma – Pauk. These corridors remain crucial to support the economy of the township, enabling connectivity among the main clusters and nodal towns.

Figure 32. Typologies of Village Tracts

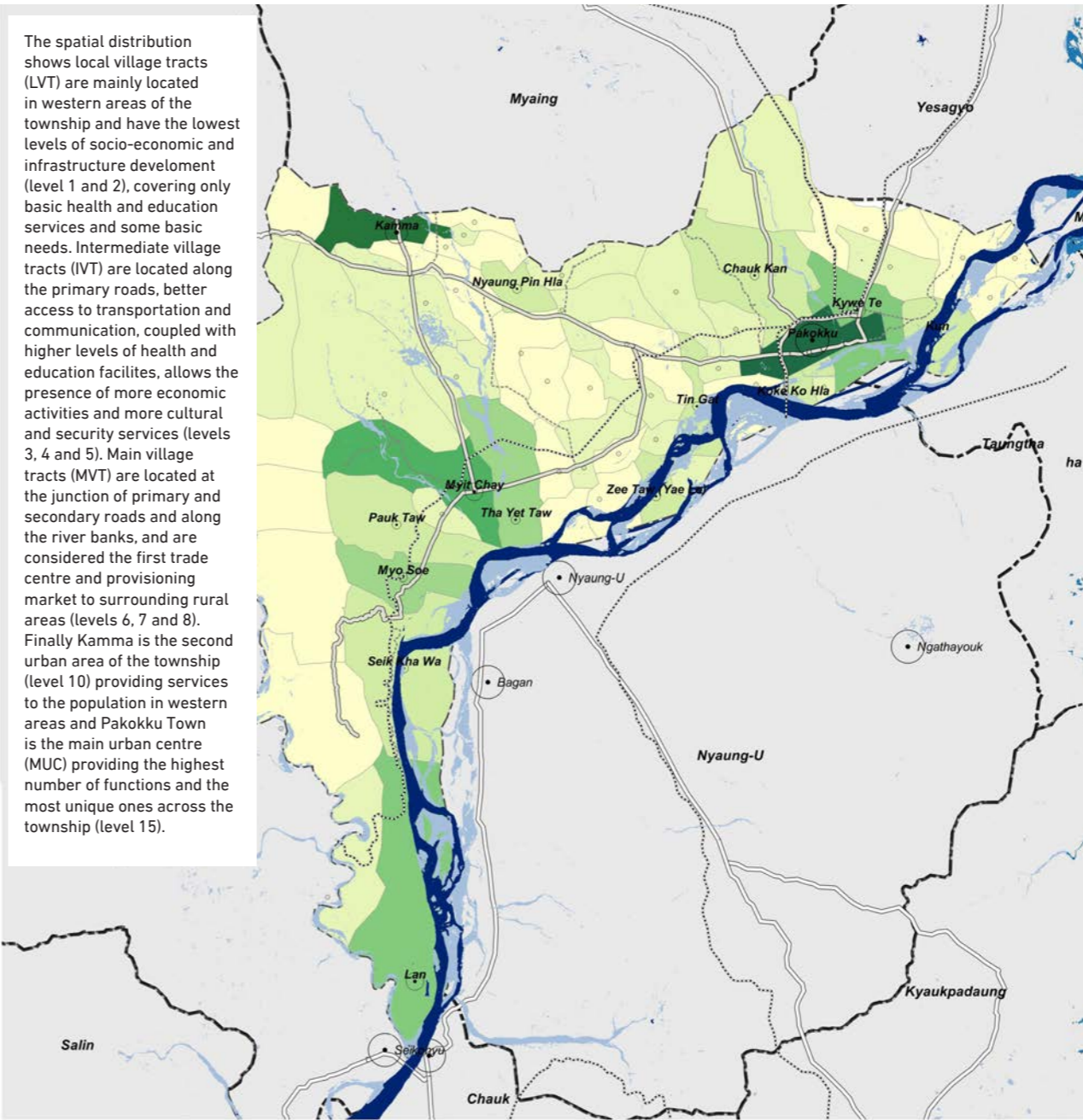
TYPE	LOCAL VILLAGE TRACT (LVT)	INTERMEDIATE VILLAGE TRACTS (IVT)	MAIN VILLAGE TRACTS (MVT)	LOCAL URBAN CENTRES (LUC)	MAIN URBAN CENTRES (MUC)
CENTRALITY SCORE	37,80– 129,70	138,80 - 242,80	277,00- 417,10	670,60	967,80
LEVEL OF HIERARCHY	1 2	3 4 5	6 7 8	9 10 11	15
FUNCTIONAL COMPLEXITY	This type of settlement provides 28 functions and represents the lowest level of socio-economic and infrastructure development in the township. Transportation infrastructure is limited to unpaved roads. Electricity on grid and wells are the main public utilities and facilities available. Only basic health and education services are provided, while basic needs are met through small groceries and street sellers. Agriculture (mainly beans, groundnuts, maize and vegetables) and livestock are the main economic activities, together with some small weaving, sewing and carpentry businesses.	This type of settlement is considered the second level of socio-economic and infrastructure development, covering 49 functions (the 28 provided in the LVT category plus a further 21). Access to better transportation and communication facilities (paved roads, bus transportation, mobile repeater) coupled with higher levels of health and education facilities, allows the presence of more economic activities (factories) and more cultural and security services than the previous typology.	Water and land transportation infrastructure (harbour and bus station) allows the presence of markets (general and livestock), while the strategic location close to the river bank allows the use of an irrigation system.	Presence of more types of markets (fish and livestock) and specialised own account workers (lawyers and electricians)	Highest level of physical and socio-economic development, providing the highest number of functions and the most unique ones across the township.
POPULATION CHARACTERISTICS	According to the 2014 Census, around 30% of the total population of the township lives in the village tracts belonging to this category	According to the 2014 Census, 20% of the total population of the township lives in the village tracts belonging to this category	According to the 2014 Census, 15% of the total population of the township lives in the village tracts belonging to this category	According to the 2014 Census the total population of Kamma is 10,617 inhabitants, representing less than 5% of the total population of the township.	Pakokku concentrates 30% of the total population of the township (90,842 inhabitants)
NAME OF VILLAGE TRACTS / VILLAGE SETTLEMENTS	41 village tracts	10 village tracts	Kywe Te, Lan and Myit Chay	Kamma	
SPATIAL DISTRIBUTION	The western areas of the township are the least developed and are more isolated	The majority of these villages are located along the main transportation routes	Village tracts located at the junction of primary and secondary roads and along the river banks	Kamma is the second urban area of the township, providing services to the population in the western area	Main town

LOCATION	Eastern area	Central area	North western area	Southern area
TERRITORIAL INFLUENCE	The territorial influence of Pakokku Town, considered the main urban and trade centre of the township, is observed towards the north and east, along the primary roads to Mandalay	The territorial influence of Myit Chay, strategically located at the cross junction of primary and secondary roads, spreads along the primary paved road to Pakokku and along the secondary unpaved road to Kamma.	Located along the main road linking Pakokku Town with Pauk, Kamma appears to be more isolated with weak territorial influence over the neighbouring village tracts	Strategically located at the southernmost part of the township, at the border with Seikphyu and Chauk Townships, Lan appears to be rather isolated with weak territorial influence over the neighbouring village tracts
VILLAGE TRACTS	Pakokku Town, Chauk Kan, Koke Ko Hla, Kun, Kywe Te and Pakokku Kyun Ku	Myit Chay, Nyaung Hla, Pauk Taw and Tha Yet Taw	Kamma	Lan
TOTAL POPULATION	127,239 inhabitants (around 45% of the total population of the township)	32,331 inhabitants (10% of the total population of the township)	10,617 inhabitants (around 4% of the total population of the township)	9,910 inhabitants (around 3% of the total population of the township)
FUNCTIONAL COMPLEXITY	This cluster has the highest levels of physical development which allows the presence of more types of economic activities.	It appears as a well-balanced cluster of settlements providing adequate infrastructure and socio-economic services to the population in the central and southern areas.	Kamma is considered the second urban centre, providing main socio-economic services to the surrounding rural settlements in the north-western part of the township	Lan is considered the main urban centre, providing main socio-economic services to the surrounding rural settlements in the north-western part of the township





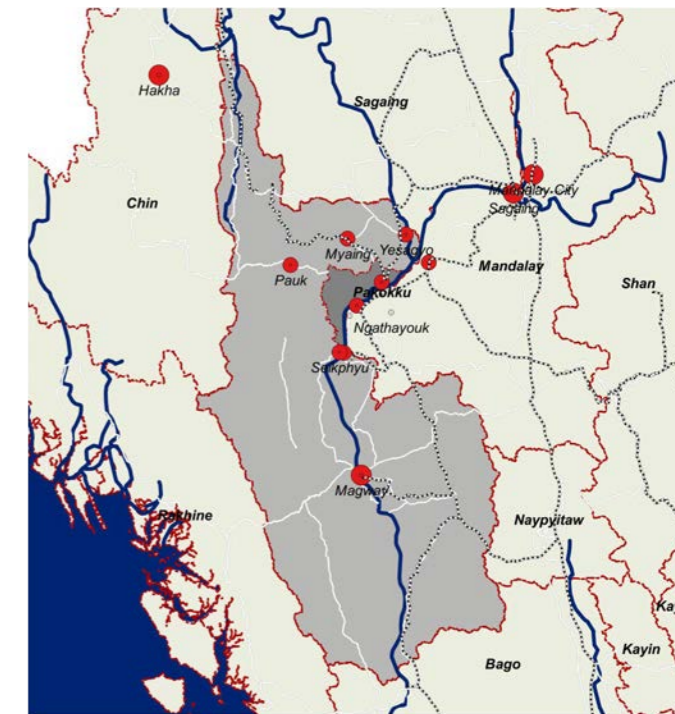
2016 | Spatial distribution of the type of settlements (MOF)



The spatial distribution shows local village tracts (LVT) are mainly located in western areas of the township and have the lowest levels of socio-economic and infrastructure development (level 1 and 2), covering only basic health and education services and some basic needs. Intermediate village tracts (IVT) are located along the primary roads, better access to transportation and communication, coupled with higher levels of health and education facilities, allows the presence of more economic activities and more cultural and security services (levels 3, 4 and 5). Main village tracts (MVT) are located at the junction of primary and secondary roads and along the river banks, and are considered the first trade centre and provisioning market to surrounding rural areas (levels 6, 7 and 8). Finally Kamma is the second urban area of the township (level 10) providing services to the population in western areas and Pakokku Town is the main urban centre (MUC) providing the highest number of functions and the most unique ones across the township (level 15).

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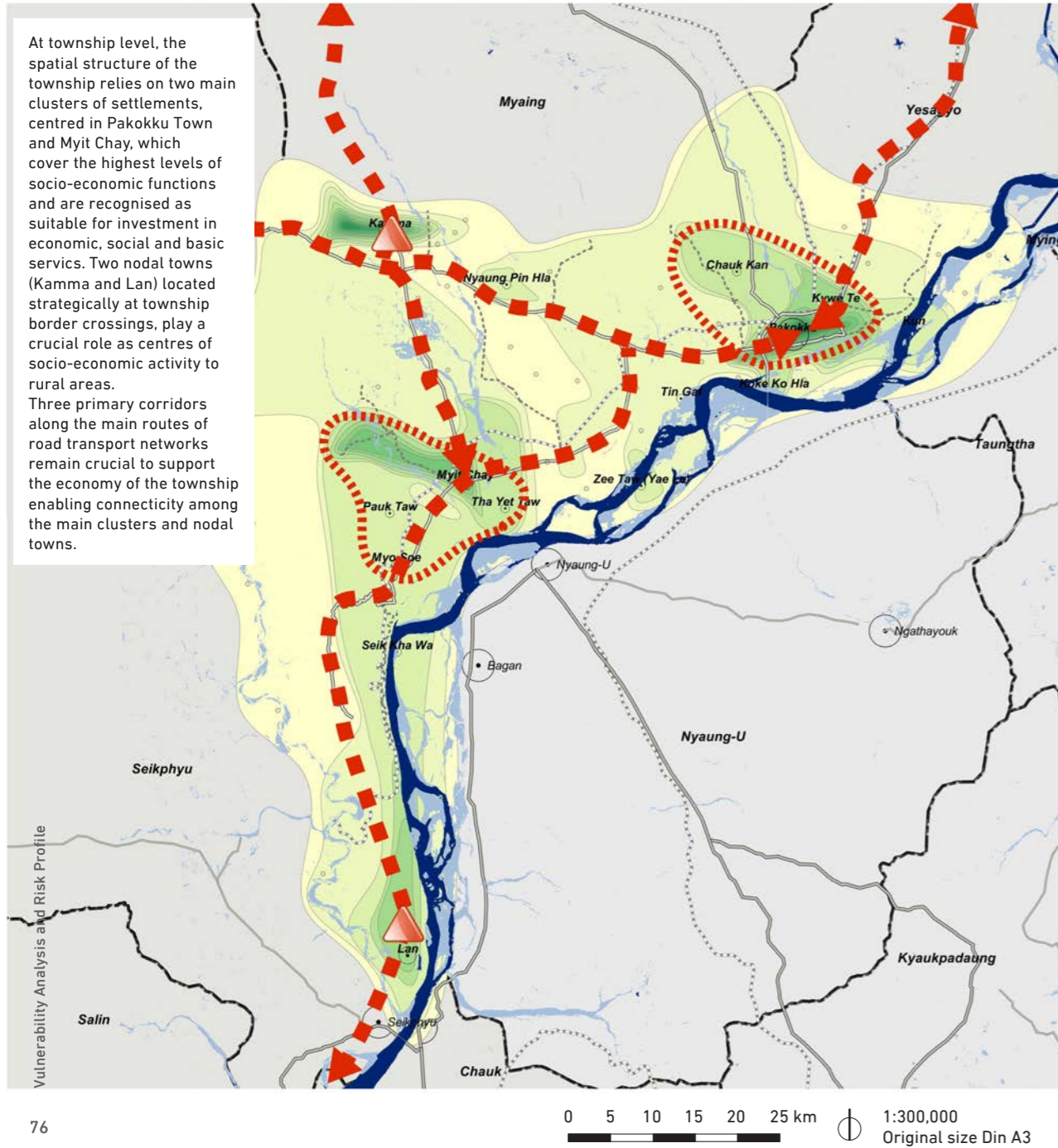
Main cities and towns in Magway and neighbouring regions



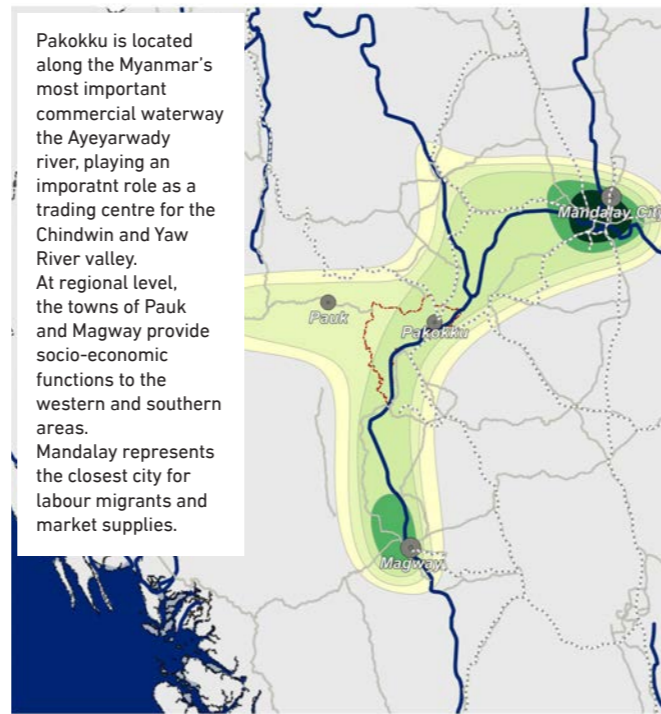
<p>Levels of Hierarchy</p> <ul style="list-style-type: none"> Level 1 Level 2 Level 3 Level 4 Level 5 Level 6 Level 8 Level 12 Level 15 	<p>Levels of Hierarchy</p> <ul style="list-style-type: none"> Local Village Tract (LVT) Intermediate Village Tract (IVT) Main Village Tract (MVT) Local Urban Centre (LUC) Main Urban Centre (MUC) <p>Main communication routes</p> <ul style="list-style-type: none"> Main road Secondary road River Stream Township boundaries
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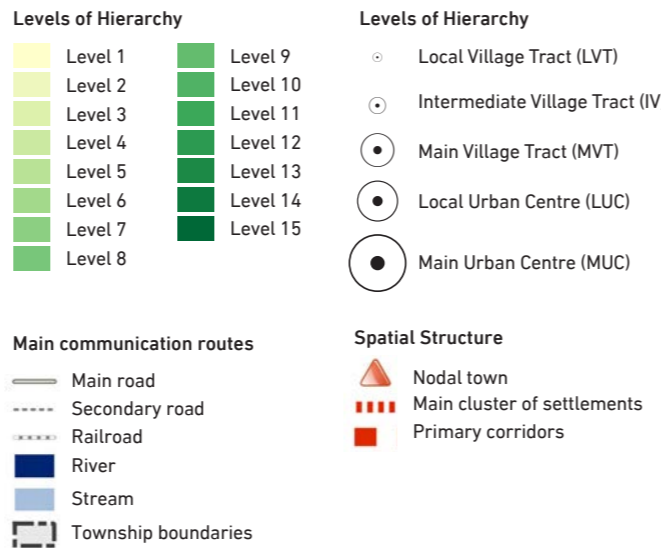


Territorial linkages at regional level



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Data Source: MIMU, UN HABITAT



3.5 CURRENT VULNERABILITY INDEX

As discussed in the methodology section of this report, the vulnerability index, which is calculated by village tract, allows the assessment team to understand which locations have greater vulnerability levels. The index considers access to drinking water, quality of forest 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 protective services under the infrastructure component. Together, these make up the sensitivity of the village tracts. Under hazards, the index considers strong winds and flooding under the intense rainfall component and drought and heat waves under the increase in temperature component. The total score for sensitivity is multiplied by the total score for hazards.

The results of the index are shown in map PPK11 on the next page. The index clearly shows that village tracts along the western border of the township and those located by the river have the greatest levels of vulnerability. However, there are also inland, drought prone townships that also have a high level of vulnerability, such as Kaing and Ma Gyi Thone. In the case of the western areas, they face multiple challenges, including drought, a lack of access to infrastructure and low levels of income. Areas by the river have higher incomes and greater average incomes, but have the

greatest exposure to hazards because of their location. Meanwhile, inland areas face very challenging access to water for both drinking and irrigation.

In some areas, indicators are constant, and thus the assessment determines that vulnerability is constant throughout the township. For example, heat waves are an equally constant threat throughout Pakokku and therefore all village tracts receive the same score for heat waves. Similarly, forests are an ecosystem service that benefits the whole township, so the score for quality of forest is equal for all village tracts.

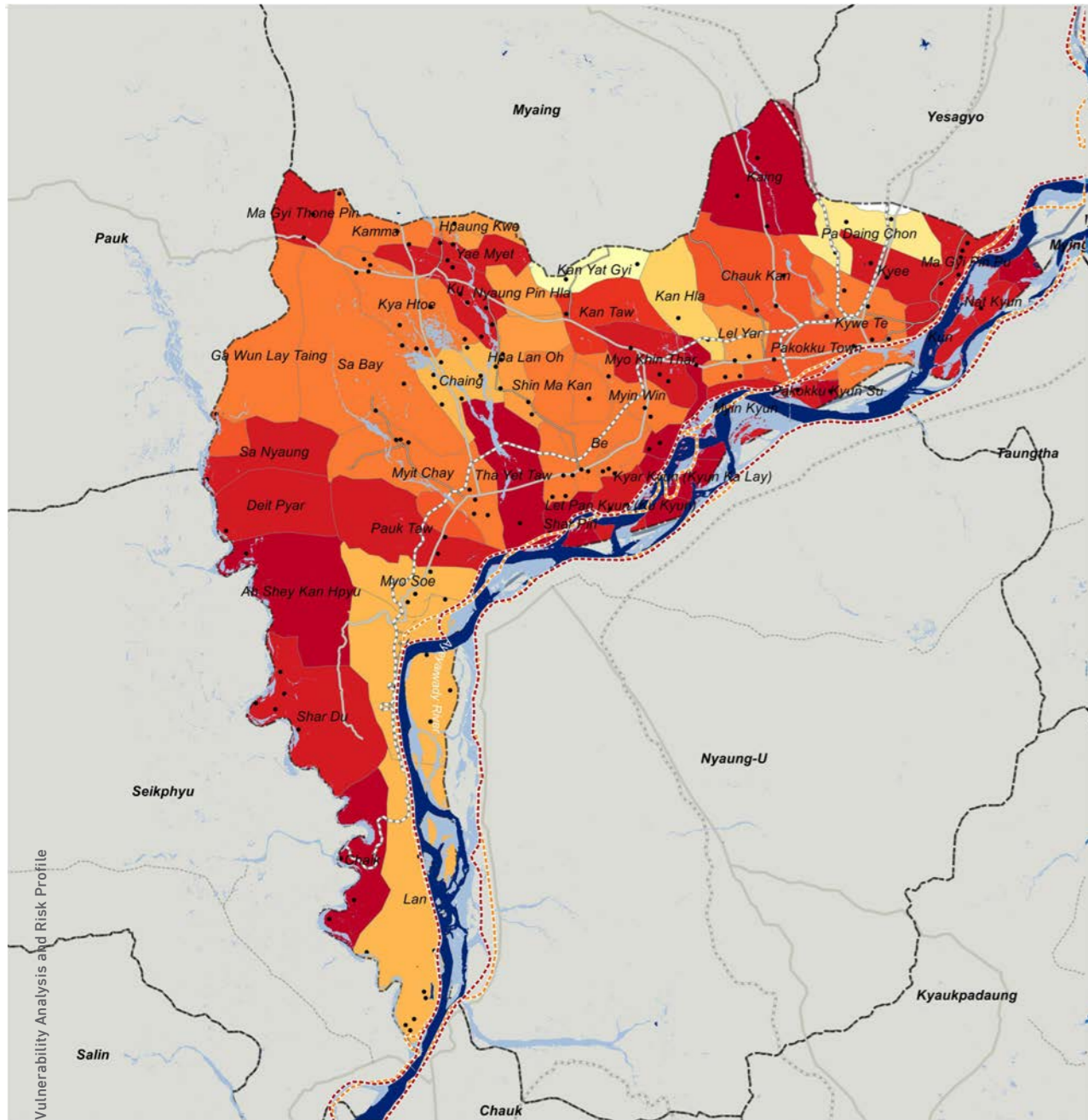
This means that, according to the vulnerability index, the coastal areas of the township are currently facing greater threats from climate change related hazards. This indicates that activities to build resilience can be targeted more effectively if they benefit these areas.



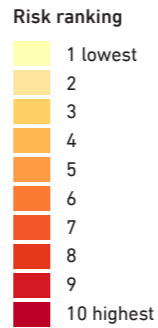
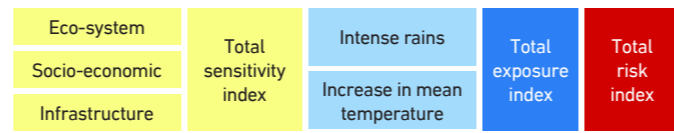
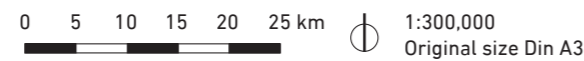
Figure 33. 350 Feet Ground Water Tube Well Construction in Pakokku

Figure 34. Vulnerability Ranking

Village Tract	SENSITIVITY INDEX									Total Sensitivity Index	HAZARD INTENSITY (frequency/magnitude)				Total Exposure Index	Total Risk Index	Ranking
	ECO-SYSTEMS			SOCIO-ECONOMIC			INFRASTRUCTURE				SEA-LEVEL RISE		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	Flooding	Heat Wave	Heat Waves			
Kan Yat Gyi	1	4	1	4	4	1	4	1	4	24	2	1	3	3	9	216	1
Pa Daing Gyi	1	4	2	4	4	1	4	1	4	25	2	1	3	3	9	255	2
Kan Hla	2	4	2	4	4	1	4	1	4	26	2	1	3	3	9	234	3
Chaing	1	4	2	4	3	1	4	1	4	24	2	2	3	3	10	240	4
Saik Ka Wa	1	4	1	3	3	1	4	3	4	24	2	3	2	3	10	240	4
Lan	1	4	2	3	3	1	4	3	4	24	2	3	2	3	10	240	4
Myo Soe	1	4	2	3	4	1	2	3	4	24	2	3	2	3	10	240	4
Nyaung Pin Hla	2	4	3	4	4	1	4	1	4	27	2	1	3	3	9	243	5
Hpa Lan Oh	2	4	3	4	4	1	4	1	4	27	2	1	3	3	9	243	5
Hpaung Kwe	2	4	3	4	4	1	4	1	4	27	2	1	3	3	9	243	5
Yae Lar	2	4	3	4	4	1	4	1	4	27	2	1	3	3	9	243	5
Lel Yar	3	4	3	4	4	1	4	1	4	27	2	2	3	3	9	243	5
Kamma	2	4	3	3	3	1	3	1	4	25	2	2	3	3	10	250	6
Kya Hote	2	4	2	4	3	1	4	1	4	25	2	2	3	3	10	250	6
Sa Bay	1	4	3	4	3	1	4	1	4	25	2	2	3	3	10	250	6
Myit Chay	2	4	3	3	3	1	4	1	4	25	2	3	2	3	10	250	6
Kywe Te	1	4	3	3	2	1	4	1	4	25	2	1	3	3	10	250	6
Kyun Nyo Gyi	3	4	3	4	4	1	4	3	4	28	2	1	3	3	9	252	6
Ga Wun Lay Taing	3	4	3	4	4	1	4	1	4	28	2	1	3	3	9	252	6
Nyaung Pin	3	4	3	4	4	1	4	1	4	28	2	1	3	3	9	252	6
Shin Ma Kan	3	4	3	4	4	1	4	1	4	28	2	1	3	3	9	252	6
Be	3	4	3	4	4	1	4	1	4	28	2	1	3	3	9	252	6
h Nauk Ma Gyi Kan	3	4	3	4	4	1	4	1	4	28	2	1	3	3	9	252	6
Myin Win	3	4	3	4	4	1	4	1	4	28	2	1	3	3	9	252	6
Shar Pin Kaing	3	4	3	4	4	1	4	1	4	28	2	2	3	3	9	252	6
Chauk Kan	2	4	3	4	3	1	4	1	4	26	2	2	3	3	10	260	7
Nyaung Hla	2	4	3	4	3	1	4	1	4	26	2	2	3	3	10	260	7
Myit Hpyar	2	4	3	4	3	1	4	1	4	26	2	3	2	3	10	260	7
Pakokku Town	2	4	3	3	1	1	4	1	4	26	2	1	3	3	10	260	7
Kan Taw	3	4	3	4	4	1	4	3	4	29	2	1	3	3	9	261	8
Ma Gyi Thone Pin	4	4	4	4	4	1	4	2	4	30	2	3	2	3	9	270	9
Koke Ko Hla	3	4	3	3	2	1	4	1	4	27	2	2	3	3	10	270	9
Ku	3	4	3	4	3	1	4	3	4	27	2	3	2	3	10	270	9
Kun	2	4	3	4	2	1	4	1	4	27	2	1	3	3	10	270	9
Kyee	4	4	4	4	4	1	4	3	4	30	2	2	3	3	9	270	9
Sa Nyaung	2	4	3	4	3	1	4	1	4	29	2	2	3	3	10	270	9
Deit Pyar	2	4	3	4	3	1	4	2	4	27	2	2	3	3	10	270	9
Myo Khin Thar	3	4	3	4	3	1	4	2	4	27	2	2	3	3	10	270	9
Shar Du	2	4	3	4	3	1	4	1	4	27	2	2	3	3	10	270	9
Yae Myet	3	4	3	4	3	1	4	2	4	27	2	3	2	3	10	270	9
Nay Kyun	2	4	3	4	2	1	4	1	4	27	2	3	2	3	10	270	9
Pauk Taw	2	4	3	4	2	1	4	3	4	27	2	3	2	3	10	270	9
Ma Gyi Pin Pu	2	4	3	4	2	1	4	3	4	27	2	3	2	3	10	270	9
Myin Kyun	2	4	3	4	2	1	4	3	4	27	2	3	2	3	10	270	9
Pan Kyun (Ku Kyun)	2	4	3	4	2	1	4	3	4	27	2	2	3	3	10	280	10
Kaing	3	4	3	4	4	1	4	3	4	27	2	2	3	3	10	280	10
Ah Shey Kan Hpyu	3	4	3	4	3	1	4	1	4	28	2	2	3	3	10	280	10
Chaik	2	4	3	4	3	1	4	2	4	28	2	1	3	3	10	280	10
Kyun (Kyun Ka Lay)	3	4	3	4	2	1	4	3	4	28	2	3	2	3	10	280	10
Zee Taw (Yae le)	1	4	3	4	2	1	4	3	4	28	2	3	2	3	10	280	10
Tin Gat	3	4	3	4	2	1	4	3	4	28	2	3	2	3	10	280	10
Pakokku Kyun Su	3	4	3	4	2	1	4	3	4	28	2	3	2	3	10	280	10
Mei Za Li Pin Kone	3	4	3	4	2	1	4	3	4	28	2	3	2	3	10	280	10
Shar Pin	3	4	3	4	2	1	4	3	4	28	2	3	2	3	10	280	10
Shwe Dar	3	4	3	4	2	1	4	3	4	28	2	3	2	3	10	280	10
Tha Yet Taw	3	4	3	4	2	1	4	3	4	28	2	3	2	3	10	280	10



Vulnerability Analysis and Risk Profile



PPK11

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

3.6 SUMMARY OF VULNERABILITIES



Vulnerability Analysis and Risk Profile

ECO-SYSTEMS

Decades of deforestation within the township and surrounding mountains have almost eliminated sources of fuel wood and building materials.

People in Pakokku must now travel further for fuel wood, taking considerable time and effort to meet these basic needs, or paying increasing prices, as they have to be harvested and transported from further upstream.



Figure 35 - Timber being transported through Pakokku

Decades of deforestation in and surrounding the dry zone, including in upstream mountain areas, has increased flood risk and reduced sediment retention, increasing flood risk and impacts in Pakokku and other townships on the Ayeyawady River, affecting livelihoods and infrastructure.

With the third highest deforestation rate in the world, Myanmar is facing deforestation challenges

INFRASTRUCTURE

Houses are vulnerable to strong winds and floods, because construction primarily relies on local materials and is often poorly executed, or not adapted to increased frequency and intensity of hazards.

Roofs and walls are both constructed mostly in natural materials (such as leaves, wood, bamboo is also available in some areas). Availability of materials has declined for the main structures and will continue to because of ongoing deforestation. 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



Figure 36 - A flood-vulnerable house near a seasonal stream

to heightened intensity of cyclones and floods There are however examples of adaptive housing. In the picture, communities have built their own house above the expected line of floods, in Pakokku township. This could be replicated.

Limited access to energy sources and high dependency on wood harvesting in rural areas.

The electricity network across the township is good. Electricity is the main source of lighting energy (57 per cent of the households) and the main source of

SOCIO-ECONOMIC

Education levels are low and vocational skills are limited

Relatively few people, especially women, have completed education beyond grade 5 level, and virtually none have received vocational training. This means that it is difficult to attract high-value added industry that requires skilled and semi-skilled workers to the township. It also makes it more difficult for people in the township to innovate or provide services that are not generally available (such as machinery repair or other engineering services)

Damage to assets and total loss of crops is common.

While areas by the river and inland water bodies are more productive they are also more vulnerable to floods. When flooding occurs, there is little or no protective infrastructure, meaning that partial or total losses of crops are common. Moreover, when crop losses occur, farmers have no way to compensate for losses through social safety nets



Figure 37 - Dry former agricultural fields in central Pakokku

ECO-SYSTEMS

nationwide, affecting a variety of ecosystem services. The most important of these for Pakokku and the larger dry zone are regulation of downstream flooding and sedimentation. As upstream areas are increasingly cleared, flooding and sedimentation increase in downstream dry zone villages. Combined with increasingly erratic and intense rainfall patterns, these services will further degrade in the future, directly impacting crops, livelihoods, and infrastructure in the township.



Decades of deforestation and land degradation within Pakokku and the surrounding dry zone have significantly compromised the provision of

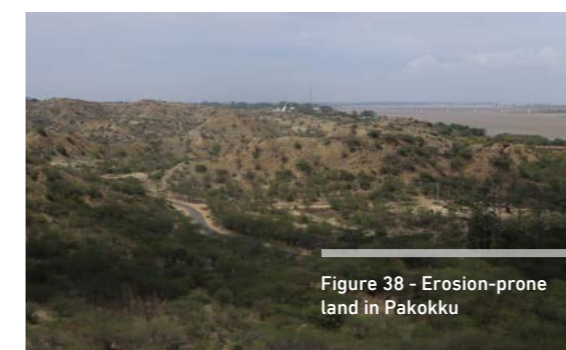


Figure 38 - Erosion-prone land in Pakokku

INFRASTRUCTURE

cooking fuel (28 per cent of the households) especially in communities in urban areas. However, firewood and charcoal remain the main source of cooking fuel in rural areas (used by more than 71 per cent of households).

The supply of wood is declining. This practice is unsustainable as depletion of the natural capital of forestry makes household increasingly vulnerable, the



lack of material available in closer areas pushes people to go far to collect wood or to spend more money in buying it.

Transportation infrastructure has been made vulnerable because of floods

A network of secondary and tertiary unpaved roads connected to the main national roads, provide transport communication to rural settlements, however, stronger storms and unusually heavy rainfall results in more floods reducing population's mobility, especially in riverbank areas.

SOCIO-ECONOMIC

or alternative livelihoods, resulting in temporary migration and increased poverty. Farmers also lack access to formal forms of credit, making it much more difficult to recover from flooding and resultant damage to land and productive assets.

Similar issues occur for livestock herders. The lack of adequate shelter for animals exposes them to flooding and periods of extreme heat. This causes death and disease among livestock. This reduces income but it is also a driver indebtedness; livestock herders borrow at interest rates of up to 20 per cent on the black market to replace their herds.

Household incomes, especially in agriculture, are very low. This limits flexibility to prepare for and respond to climate hazards and slow onset changes.



Figure 39 - A woman working in small-scale trade in Pakokku Town

ECO-SYSTEMS

essential ecosystem services like water retention, groundwater recharge, and productive soils, and is increasing desertification.

Pakokku's dry zone ecosystem is not as productive as other systems in Myanmar, like tropical forests or the Ayeyawady Delta. It nevertheless has provided critical ecosystem services like soils and flood retention for households for centuries. However, deforestation and land degradation in recent decades is resulting in ever-increasing erosion, augmented in recent years by increasingly erratic rainfall and higher temperatures that are reducing soil moisture. Combined, these climate changes and history of deforestation will further increase desertification in the coming decades, making agriculture-based livelihoods increasingly untenable.



Figure 40 - Groundwater extraction in Pakokku

INFRASTRUCTURE



Figure 41 - Poorly constructed shelter/storage in Pakokku

Some communities reported using green infrastructure such as bamboo embankments to protect from river and stream erosion and temporary wooden bridges, but they proved to be insufficient.

At community level, the coverage of disaster and climate resilient basic and protection services is very limited

Basic health and education coverage is good across the township. However, public buildings are often not disaster-resilient and therefore cannot be used for



SOCIO-ECONOMIC

The nature of agriculture in the township, and especially in the dry area, where it is characterised by non-irrigated fields used to grow low-value cash crops means that incomes remain low. Meanwhile, in the riverside area, partial and total loss of crops is common, so better infrastructure and higher incomes are offset by losses, which are occurring increasingly frequently.

Agriculture is the greatest single livelihood source in Pakokku; 46.6 per cent of people depend on it for their primary source of income, so a lack of stable water access for agriculture inevitably results in low and unstable incomes



Figure 42. Small household trade in Pakokku downtown is often times disrupted by recurrent floods for up to 3 weeks, because of lack of drainage

ECO-SYSTEMS

In the hot, dry climate of the dry zone, Pakokku already faces significant seasonal limitations to water availability, forcing much of the population to rely on poor quality groundwater sources.

Strong seasonal fluctuation in water availability in Pakokku, combined with the dry climate, make the township highly vulnerable to increasingly erratic, intense rainfall that is falling over fewer days in the rainy season, lengthening the dry season. Though more research is necessary to determine the exact relationship between surface and groundwater flows, this is likely to further limit already poor quality groundwater sources that are highly saline, as recharge is further limited by deforestation and high intensity rains that do not seep into subsurface aquifers. This makes livelihoods in Pakokku directly dependent on water availability and extremely vulnerable to future reductions driven by climate change, especially due to inadequate and degraded water storage and management infrastructure (see next section).



Figure 43 - A degraded riverbank on the Ayeyawady near Pakokku Town

INFRASTRUCTURE

double purpose in case of strong winds and floods, which increases communities' vulnerability to more intense hazards especially in riverbank areas.

Communities reported monasteries are the main shelter facilities to floods, strong winds and heavy rains, however their limited accommodation pushes some people to stay in temporary houses located in safer areas until they can go back to their houses. The lack of storage facilities in these areas and the lack of capacity to carry most of their belongings affects severely their income during such events. Monasteries also provide shelter during periods of high temperatures and heat waves, especially to elder women in rural areas where there is little shelter available. There is a lack of adequate shelter also for livestock, which increases loss of animals during periods of floods and heat waves.

Lack of capacity to mitigate erosion from river and seasonal streams through formal infrastructure, and some attempts to manage it through autonomous community small infrastructure

Communities along the riverbank and seasonal streams reported seasonal flooding and flash floods during the rainy season are more frequent.



SOCIO-ECONOMIC

A lack of skills hampers infrastructure development

Low educational outcomes and a lack of technical and vocational training and skills exacerbates problems of water scarcity. Firstly, it means that there are few people with the necessary skills in-township to design and install improved water infrastructure.

Budgets for infrastructure repair are limited

Government budgets for infrastructure maintenance, repair and improvement are limited, and the ability of local government to dedicate budget for infrastructure improvement is also very limited. When combined with the lack of available technical skills locally, this creates significant challenges; even if funding were available to improve infrastructure skills would need to be brought in from elsewhere.

There is a very high level of youth migration, with a gender imbalance. This results in fewer young, skilled, and capable workers

The causes of migration are complex, but the fact that outward migration almost always takes places among the youth demographic, suggests that a lack of education and employment opportunities are the overwhelming drivers. Added to this is a gender disparity – three times more men migrate. This is the main driver of female-headed households, the number of which is likely to continue to increase. Female-headed households are usually worse-off than male-headed households. As the migrants are

ECO-SYSTEMS

Increased erosion due to land degradation and deforestation, both within the township and upstream, will continue to degrade as increasingly intense storms increase erosion.

Light soils in the dry zone and Pakokku in general contribute to high sediment loads in surface water flows, but these are increasing due to local and upstream deforestation, affecting drinking water quality and degrading irrigation pumps and other water infrastructure. Increasingly erratic and intense storms will further degrade water quality as more top soil is eroded.

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.

Deforestation and land degradation trends that are increasing desertification, combined with changes in rainfall patterns, will further decrease soil productivity

Farmers in Pakokku struggle to produce consistent crop yields due to a variety of factors, but low soil quality and consistent water availability are perhaps the most important. Without significant intervention to improve farming techniques and develop water

INFRASTRUCTURE

Systems of local embankments have been constructed, but their effectiveness is limited and every year requires improvement and strengthening.

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, 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 potential vulnerability of all households.

In addition, there is a lack of awareness and robust mechanisms of early warning systems, evacuation routes and disaster management committees, especially in communities along the riverbanks.

The population relies mainly on wells and rain for drinking water, irrigation, and other domestic uses in rain-fed areas. Households mostly rely on drinking water from groundwater sources (wells/boreholes) highly vulnerable to drought.

Water supply is drawn on a mixture of surface and groundwater sources. Groundwater is available in deeper levels where the quality is worse, and ponds dry up for most of the dry season.

Availability of surface water (from rivers and seasonal streams) is less limiting than access, due to costs

SOCIO-ECONOMIC

young and generally unskilled, migration with dignity becomes a serious challenge. As incomes decrease because of climate change, greater levels of migration are inevitable. While some



Figure 44. Although markets are vibrant but poor transport affects commerce @MCCA

families will benefit from remittance, and income, once remittance is factored in, may even increase, this is a high-risk approach as remittances are often unstable, especially from young, unskilled migrants.

Low levels of education, low incomes and high migration are mutually reinforcing.

People who earn less are less likely to secure high-paying jobs, and because of a shortage of

ECO-SYSTEMS

infrastructure, yields will continue to decline as climate change impacts worsen.

Low yield crops in Pakokku are highly vulnerable to increasing temperatures, which, in conjunction with decreased water availability, will also decrease productivity.

While intercropping systems in the rain-fed areas of the township are somewhat well adapted to dry conditions, increasing temperatures will push the limits of their suitability, further decreasing yields, and regardless of water availability. Rice paddy productivity will also decline, even with stable water supplies, solely due to higher temperatures, especially at night, which have been shown to particularly affect rice productivity.



Figure 45 - Dryland crops in Pakokku

INFRASTRUCTURE

of pumping and sparse infrastructure especially in remote rain-fed areas far from major rivers. This makes rain-fed areas more vulnerable to more scarce and variability of rainfall.

Infrastructure for water harvesting is inefficient and management of storage is poor. This is will worsen with a shorter monsoon season that will reduce the amount of days for collection of rain and more intense rains that will damage water infrastructure.

Only some wards in Pakokku and Kamma town have access to piped water.

Low levels of rainfall and increasing temperatures are

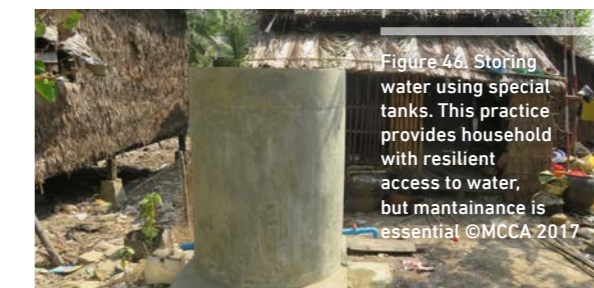


Figure 46. Storing water using special tanks. This practice provides household with resilient access to water, but maintenance is essential @MCCA 2017

seriously impacting communities in rain-fed areas as water from groundwater sources is found in deeper lower quality aquifers, while community ponds dry up for most of the dry season. Communities along the riverbanks, can access water through shallow wells when water levels fall below the level of the riverbed, however stronger rains and river flooding damages facilities.

Access to drinking water at household level is often ineffective, management of the water consumption

SOCIO-ECONOMIC

labour-intensive jobs in the township, and low-incomes, especially in agriculture, these people are more likely to migrate. This will continue until a virtuous cycle is created, with greater levels of and access to education that will help to create a pool of skilled workers, attract higher value added industry and move people away from agriculture.

Industry is the most valuable sector, and is less climate vulnerable than agriculture, but does not create jobs

Despite the above, industry is the largest sector in Pakokku in terms of output. However, industry only provides work for less than 7 per cent of the population. This may be because of the non-labour intensive nature of industry in the township – transportation and logistics. The economic growth potential of industry is clear, but for it to be of transformational benefit more labour intensive industry is required.

is insufficient, and hygiene problematic. This leaves households vulnerable to lower quality water, increased evaporation, stronger rains in shorter amount of times that render water harvesting and destroys facilities and management of water storage challenging (keeping the water for the duration of the dry season).

There is a lack of infrastructure for water storage at community level (such as water tanks and reservoirs)

In schools, health posts and other public buildings and insufficient presence of dedicated water reservoirs managed by communities.

Exceptions are found in monasteries, and in development organization buildings, but they provide water for relatively few people. Management of water storage is an ongoing problem, where some people overly deplete available water and there is no effective means to control water use.

The existing large-scale irrigation systems are only available in some communities along the river banks, management is inadequate with little capacity to provide water to all farmers equitably, sustainably, and efficiently

A large-scale system of irrigation canals and dykes is available in some communities

along the riverbanks allowing different types of crops (primarily rice).

Communities prioritise expansion of these irrigation canals in rain-fed areas as the significant reduction of rainfall is decreasing production yields, and quality.

There is a lack of knowledge of small-scale supplemental irrigation techniques and technologies such as drip irrigation systems.

River basin management should be considered when expanding the irrigation canals as will ultimately affect the Deltaic ecosystem downstream.



Figure 47 : Floods in Pakokku (MCCA, July 2017)



4

CLIMATE CHANGE AND FUTURE RISK

- The temperature in Pakokku is expected to rise over the coming decades; annual average temperatures could rise by 1.2-2.7°C.
- Warming in the hot season (March-May) and cool season (November-February) is projected to slightly exceed warming in the wet season (June to October).
- The number of extreme heat days in Myanmar is projected to increase. By mid-century, extreme heat days during March to 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 Pakokku, with more rain during the wet season.
- In the cool season, climate models suggest that Pakokku may be more likely to see a decline in rainfall, than an increase.
- Decision-makers will need to plan for warmer temperatures, more frequent extreme heat days, greater amounts of wet season rain, decreased cool-season rainfall, and uncertain rainfall during the hot season.

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 Pakokku 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.

CLIMATE MODELLING METHODOLOGY

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 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



Figure 48. Annotated climatology for Chauk weather station (nearest to Pakokku)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Minimum temperature (°C)	13.7	15.7	20.0	24.7	25.9	25.1	25.1	25.0	24.5	23.5	20.4	15.6
Maximum temperature (°C)	30.0	33.5	36.7	39.4	37.5	34.7	34.5	33.8	33.4	33.2	31.6	29.5
Mean temperature (°C)	21.9	24.6	28.4	32.0	31.7	29.9	29.8	29.4	28.9	28.4	26.0	22.5
Rainfall (mm)	0	2	3	18	93	138	56	128	168	158	54	5

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

analysis uses weather station data from 1981-2010 based on data provided by the Myanmar Department of Meteorology and Hydrology (DMH).

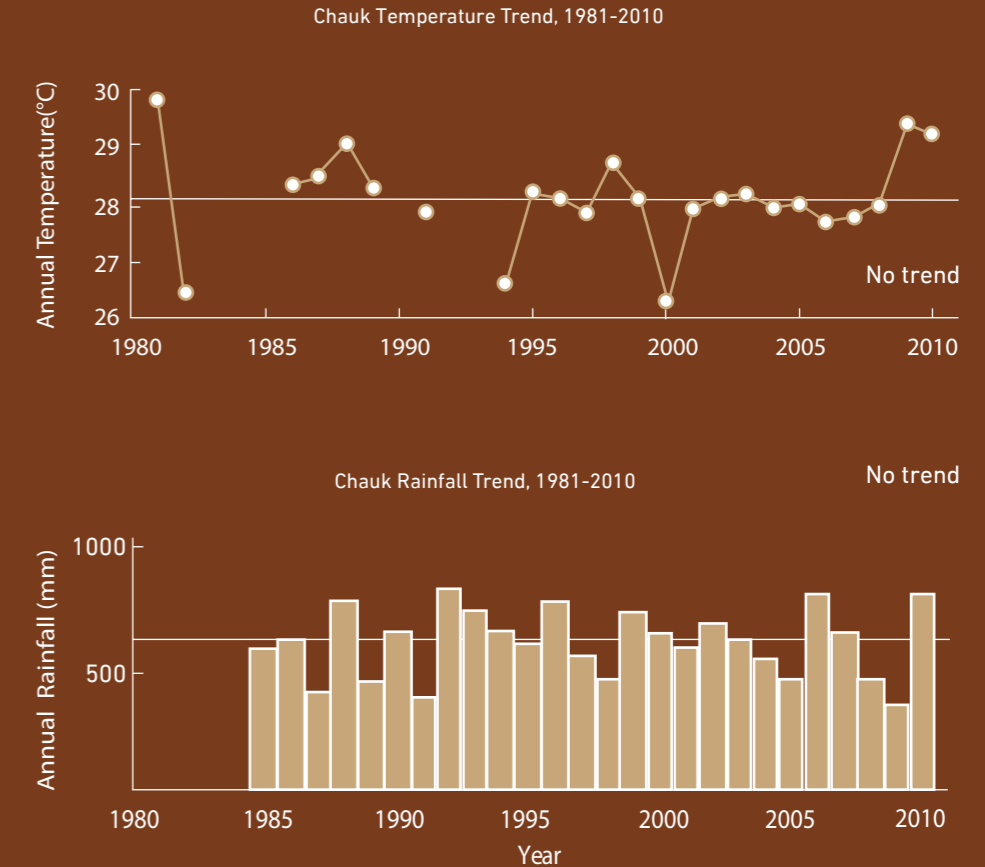
Observed Climate

Figure 48 shows the average historical weather conditions (climatology) during 1981-2010 for the nearest weather station to Pakokku – Chauk station, located 50 kilometres to the south. No station data was available for Pakokku at the time of the assessment. The proximity of Chauk to Pakokku and its location within the central dry zone, suggests that the two sites likely experience comparable climate conditions. The results in Figure 36 suggests that the driest month is January and the wettest is September. The warmest parts of the year are April and May, and the coolest months are December and January.

The trend in annual mean temperature and total annual rainfall from 1981-2010 for Chauk is also shown in Figure 37. The station shows no important trends in rainfall or temperature.

At Chauk, the wettest day on record in November 1988 saw 157mm of rain in one day. The temperature on the hottest day on record reached 45.9°C in May 2010.

Figure 49. Annual mean temperature and total rainfall over 1981-2010 at the Chauk weather station. Rainfall data is incomplete until 1985, and scattered patches of data are missing from the temperature record until 1994. There are no important trends in these climate variables over the time period.



4.1 CLIMATE CHANGE PROJECTIONS

- Figure 49 shows that temperature in Pakokku is expected to rise over the coming decades due to increasing greenhouse gas concentrations, though the magnitude of warming varies by season. By mid-century (2041-2070), annual average temperatures are projected to rise by 1.2-2.7°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 central dry zone and nationally for Myanmar show changes similar to those at the local Pakokku level.
- The analysis also examined how extreme hot days in Myanmar are projected to change. During 1981-2010, about 1 extreme heat day⁴¹ per month 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 to 4-17 days per month.

- Overall, annual rainfall is projected to increase locally in Pakokku, and throughout the central dry zone and Myanmar as a whole. The model results suggest that total rainfall during the monsoon season may increase in Pakokku, as well as at the regional and national levels. In the cool season, however, models indicate that Pakokku and the dry zone are more likely to see a decline in rainfall than an increase. This is a contrast to the changes projected for the country as a whole, where cool season projections range from increase to decrease. Wide ranges in the trajectory of future rainfall at both seasonal and annual timescales compared to the baseline suggest that it will be necessary for decision makers to plan for such uncertainty.

Over the coming century, the citizens of Myanmar, including Pakokku, will feel the effects of climate change. This report highlights key climate projections, which indicate increased temperatures and changing rainfall patterns. The climate projections in this report can help decision makers to incorporate these emerging risks into long-term planning. By doing so, the community in Pakokku will have additional information for the crucial step towards building a resilient society.

Figure 50 Projected change in mean temperature (+°C) and mean total rainfall (%) in 2041-2070 compared to the 1980-2005 baseline average for Pakokku, the central dry zone and for Myanmar. 1 Low estimate refers to the 25th percentile of model outcomes in greenhouse gas emissions scenario RCP 4.5; 2 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 differs, therefore the actual change in rainfall (in mm), will depend on the various baselines of each region.

	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
PAKOKKU								
TEMPERATURE	+1.2°C	+2.7°C	+1.5°C	+3.1°C	+1.0°C	+2.3°C	+1.3°C	+2.9°C
RAINFALL	+6%	+23%	-15%	+17%	+9%	+28%	-27%	+9%
REGIONAL - MAGWAY								
TEMPERATURE	+1.2°C	+2.7°C	+1.5°C	+2.9°C	+1.1°C	+2.3°C	+1.3°C	+2.9°C
RAINFALL	+8%	+22%	-12%	+14%	+9%	+26%	-19%	+6%
MYANMAR								
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%

* 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.

⁴¹ 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).

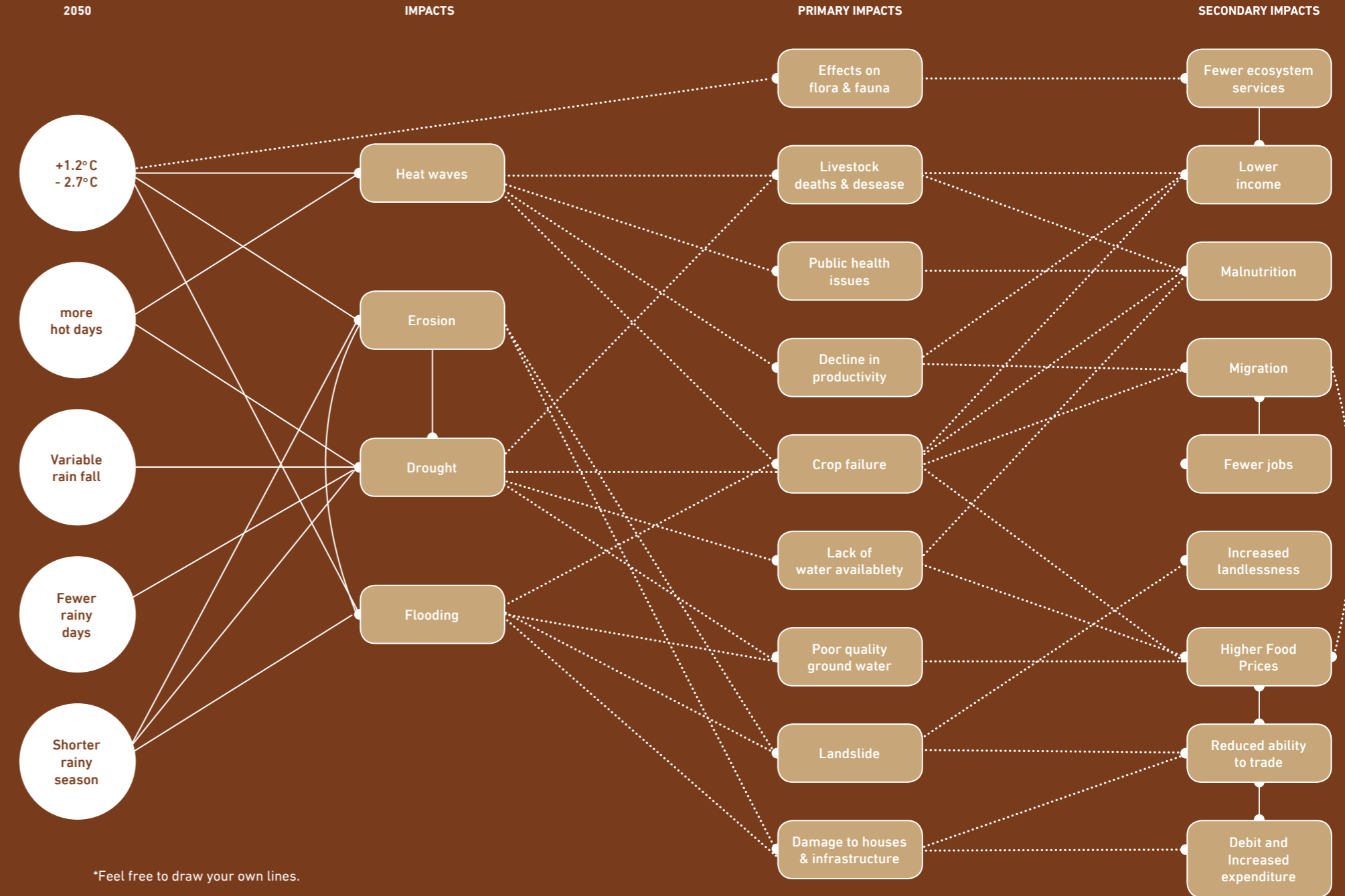
4.2 POTENTIAL IMPACT PATHWAYS

Through consultations with the communities and based on the analysis of secondary data conducted by the assessment team, a 'pathway to impact' graphic was created. This figure shows the primary and secondary impacts that may occur because of changes in the climate and resultant hazards by 2050. The pathway to impact graphic also shows the complex interrelationship between hazards and impacts, including how a given primary impact can cause multiple secondary impacts. This is not a forecast but an effective visual representation of the potential climate change impacts on Pakokku.

The left-hand column shows the full range of projected changes in the climate as discussed in Section 3 of this report. The second column shows what the team and communities have identified to be the four major hazards that are already affecting Pakokku, and are likely to become more severe in the future as a result of projected climate change. These are: heat waves, drought, erosion, and flooding. The primary impacts occurring because of these hazards are listed in the next column. Here we see that multiple hazards can cause some impacts. For example, crop failure can result from three of the hazards identified; heat waves, drought, and flooding.

Secondary impacts consider the broader, knock-on effects in the township. Continuing the example of crop failure, we see from the graphic 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 to seek work, either in Mandalay, Yangon or abroad. They can also have an impact on the capacity to grow crops in the future due to 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 therefore public health related impacts can increase.

Figure 51. Pathway to impact graphic



4.3. FUTURE RISK PROFILE AND VULNERABILITIES

The projected changes in the climate appear in two main ways:

- i. Firstly, they will increase the intensity and possibly frequency (although there is less confidence in this) of rapid on-set disasters. This means greater impacts from destructive weather systems such as storms, intense rains, periods of extreme heat and floods
- ii. Secondly, they 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 natural flood defences

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.

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. Pakokku's hazard and risk profile will worsen, with a combination of longer, hotter periods, including extreme heat, periods of heavy rain in the monsoon season, flooding and possibly stronger storms. Under the current conditions and trends, there is no indication that vulnerabilities will reduce 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 the hazards described above.

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 ecosystems, infrastructure and socio-economic conditions could be in the township under a 'business-as-usual' (BAU) scenario.

While analysing all systems in the township is not possible, it focuses on the main, interlinked systems that people in Pakokku 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**

If these ecosystem trends continue unabated in the coming decades, a significant portion of the population in Pakokku will be forced to either migrate or adapt through alternative livelihoods, as the township will only be able to support a much lower percentage of agriculture-based livelihoods. Some irrigated areas along the river will still sustain agriculture production, though with significantly lower productivity due to increasing temperatures,



+ 2° C Warmer

Increase in mean temperature of 2.7°C - with peaks in the hot season of up to 39.4° C⁴²

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 -15% to +17% in the hot season; and -27% to +9% in the cold season⁴³

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
Longer/Hotter dried season	Heat waves and urban heat island effect; Reduced water availability; Human health impact; Livestock health impact

^{42, 43} According to Columbia University downscale climate projections for the Magway Region 2011-2040, as compared to 1980-2005 average

highly variable water flows, and increased frequency and intensity of extreme events like strong storms and winds, droughts, and floods. The lengthening dry season will also reduce productivity due to the shorter growing season. Agriculture in rain-fed areas, where productivity is already highly variable, will be even lower, as soil productivity declines due to increasing desiccation and soil moisture loss, highly variable and shortening rainy season, and extreme events that damage crops. Some rain-fed farmers will be able to adapt, especially with access to groundwater, but with unsustainably high pumping costs, many will be forced to migrate to urban areas.

Agriculture production relies mainly on the interaction of three main eco-system services (soil, freshwater source, and type of crops) that are already highly impacted by climate change:

The number of people depending on rain-fed agriculture will decrease by 2050, especially in western and central areas of the township where freshwater sources for irrigation will reduce crop production

Communities along the riverbank will face more floods, landslides and intense runoff due to the projected increase in intense rains which will result in more frequent damaged crops and water infrastructure for irrigation.



Up to 2.7°C
Warmer



- Days of
Rain



+ Sea Level

44 FAO, 2014; IWMI, 2013
45 IWMI, 2103; FAO, 2014

HAZARD	ECO-SYSTEM SERVICE	MAIN PROJECTED IMPACTS
Higher average temperatures cause big changes in extreme heat	Soil	Increasing temperatures will result in more frequent, intense, and in some cases longer dry spells, reducing soil moisture and increasing erosion for already degraded, loose, sandy soils, reducing agriculture productivity ⁴⁴
	Freshwater	Higher temperatures will increase evaporation for surface waters, leading to reduced water availability, especially during the dry season and for rain-fed areas. Even where groundwater is available, already high salinity levels in many aquifers will further reduce water availability ⁴⁵
	Crop	Increased temperatures alone will limit crop productivity, reducing already low yields, especially in rain-fed areas, and regardless of water availability and soil impacts that will further decrease productivity.

HAZARD	ECO-SYSTEM SERVICE	MAIN PROJECTED IMPACTS
Shorter rainy season	Soil	Increased soil alkalinity primarily caused by using saline groundwater for irrigation, and reduced soil moisture due to longer dry spells will reduce soil quality and increase erosion, increasing desertification.
	Freshwater	Water shortages that affect crop production will increase in frequency as the number of rainy days decreases and evaporation increases. Groundwater recharge rates will likely decline with fewer rainy days in the dry season, which could potentially increase salinity concentrations in some aquifers and further limit water availability.
	Crop	A shorter rainy season will further limit already low crop productivity, especially in rain-fed areas, in combination with impacts on soils, evaporation, and reduced water availability.

HAZARD	ECO-SYSTEM SERVICE	MAIN PROJECTED IMPACTS
More heavy rain, less useful and more damaging	Soil	Intense rains following lengthier dry periods increase runoff rate and soil erosion, increasing desertification.
	Freshwater	Severe inundation will further damage water infrastructure such as pumps, shallow dug wells and tube wells, irrigation systems, and storage ponds
	Crop	Increasingly frequent and intense storms and resulting floods will significantly reduce already highly variable yields, increasing the risks of production and reducing reliance on agriculture for livelihoods.

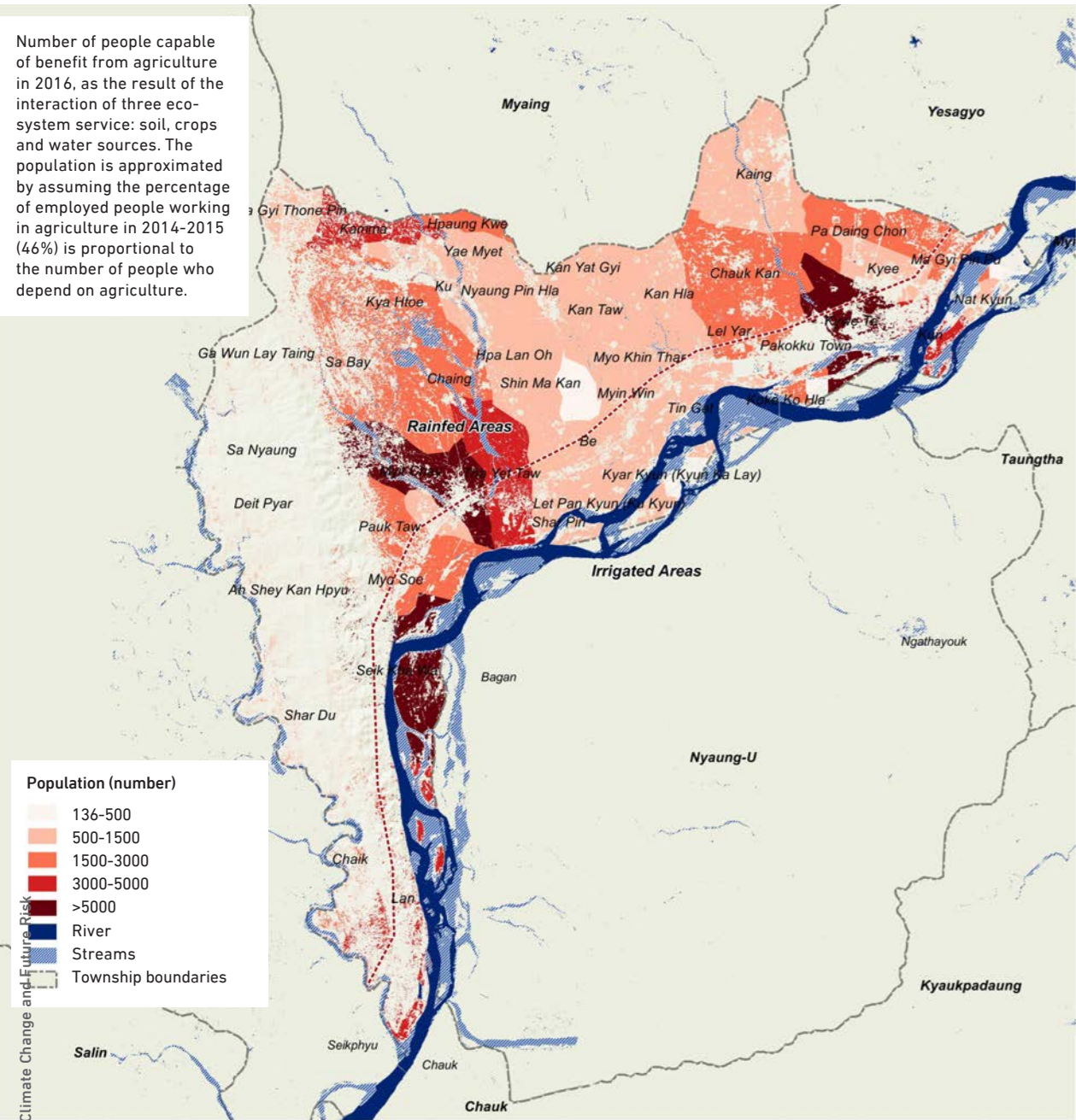
If we assume that lost production is equivalent to lost incomes and that people do not make up for lost incomes with other forms of livelihood, we are likely to see gross incomes (before production expenses) of less than US\$1 (1,200 Kyat) per day, inflation adjusted, by 2050. This figure is before the additional stresses caused by extremes or disasters, such as pests, which are harder to estimate in the future.

This severely reduced income is likely to further drive up migration, all else being equal. Low incomes in the agriculture sector are already driving up the number of people who leave the township to seek work. If present migration patterns continue, this will lead to a severe shortage of people in the 15-30 age category and an increasing gender gap, as, to date, male migrants have outnumbered females by around three to one.

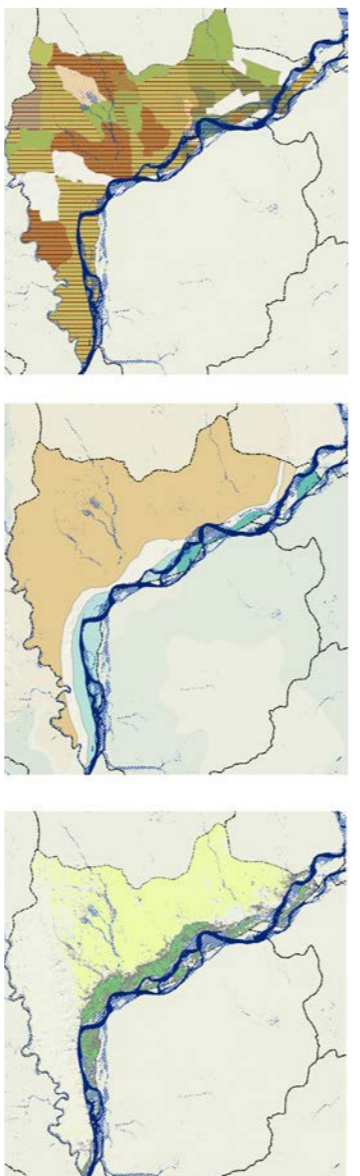
The following maps PKK12a and PKK12b show the current situation and the future scenario in 2050, estimated by applying a coefficient of reduction on 2016 baseline (refer to annex A3 for detailed calculations).



2016 | Capacity of the population to benefit from agriculture in 2016



Type of crops

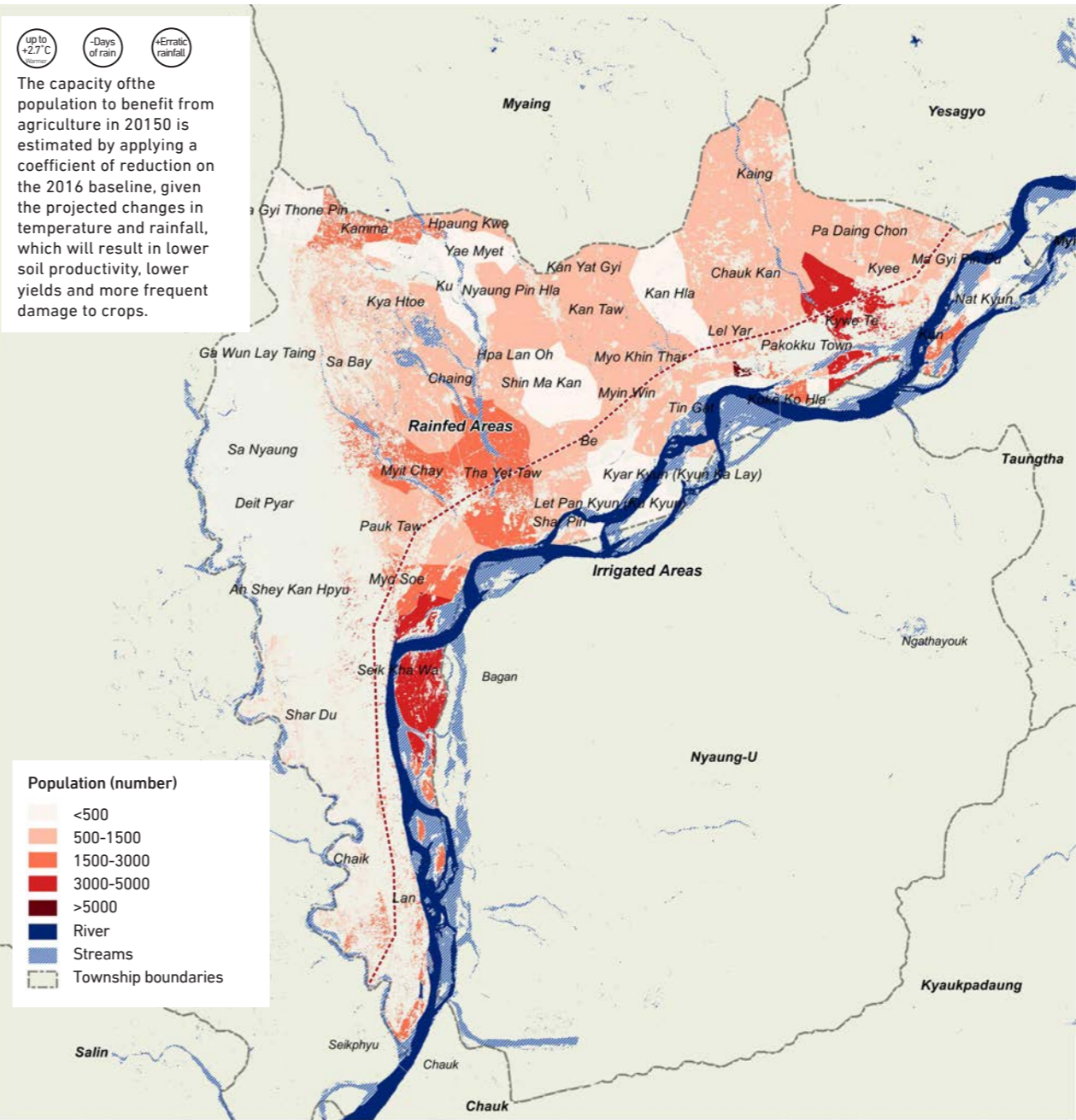


- Crop types**
- Type of crops cultivated in each village tract in 2016.
- Vegetables
 - Groundnut
 - Rice
 - Flowers
 - Tabacco
 - Maize
 - Beans

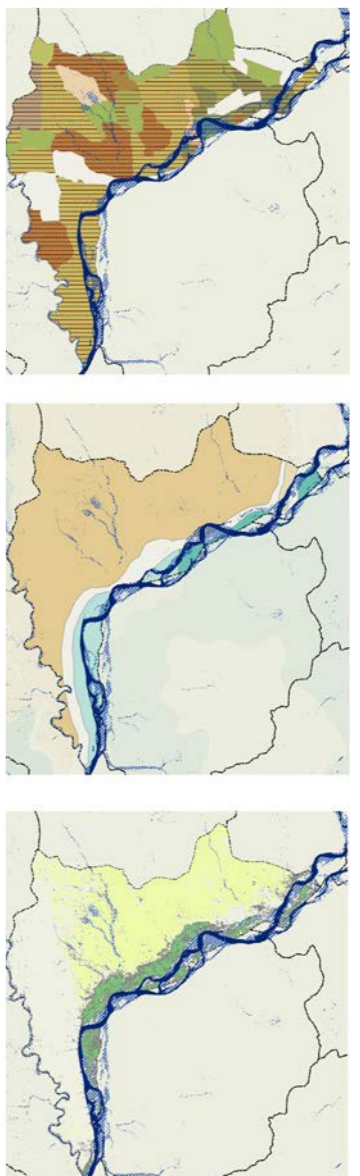
- Soil classification**
- Soil classification concerns the grouping of soils with a similar range of properties (chemical, physical and biological) into units that can be geo-referenced and mapped. The classification has generally been based on the distribution of the important land resources for agriculture.
- Light forest soil
 - Meadow & meadow alluvial soil
 - Primitive crushed stone soil
 - Savana soil on slopes

- Water sources**
- 80% of the agriculture land in Pakokku is rainfed while the remaining 20% is irrigated located along the riverbanks and seasonal streams
- Scrubland
 - Irrigated agriculture
 - Rainfed agriculture

2016 | Capacity of the population to benefit from agriculture in 2050



Type of crops



- Crop types**
- Type of crops cultivated in each village tract in 2016.
- Vegetables
 - Groundnut
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- Water sources for agriculture**
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- Scrubland
 - Irrigated agriculture
 - Rainfed agriculture

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 Census 2015, Pakokku Township Planning Department, Pakokku General Administration Department, UN HABITAT

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Data Source: MIMU Census 2015, Pakokku Township Planning Department, Pakokku General Administration Department, UN HABITAT

2. Fewer people are likely to have access to freshwater for drinking water use by 2050

In recent years, increased temperatures, coupled with a shorter rainy season, have seriously reduced access to drinking water for human and animal consumption.

There is a widespread perception that in recent years the increase in temperatures coupled with a shorter rainy season has seriously reduced access to drinking water for human and animal consumption, especially during the dry season. Uncovered sources, such as ponds, dry up for most of the dry season, limiting access to drinking water to groundwater sources. In addition, groundwater recharge is limited, which causes people to dig much deeper to access freshwater, which can have higher calcium content and a salty taste.

Village ponds often dry out in the early stages of the dry season and villagers will then revert to subsurface supplies that are more perennial in nature but may be situated in remote areas, meaning water is transported 3-4 kilometres by foot for household use.

Change in precipitation patterns results in more frequent heavy rains and winds that increase exposure to flooding in communities located along the riverbank and seasonal streams. Meanwhile, intense runoff and soil erosion caused by more intense rains results in more water facilities damaged.



+ 2.7° C
Warmer



- Day of
Rain



+ Intense
Rainfall

HAZARD	ECO-SYSTEM SERVICE	MAIN PROJECTED IMPACTS
Higher average temperatures correlate with heat waves and extreme high temperatures	Surface water	Higher temperatures will lead to even greater evaporation and aridity, as water availability and soil moisture decline, limiting vegetation growth, which will limit groundwater recharge and flood retention services.
	Vegetation cover	Though considerable apparent groundwater supplies exist within the zone, problems of salinity, calcium and even arsenic contamination, as well as poor knowledge of where subterranean resources are located, will continue to limit the scale of water supply. Unsustainable extraction could result as surface water becomes less available.
	Surface water	Availability will decline as evaporation increases.

HAZARD	ECO-SYSTEM SERVICE	MAIN PROJECTED IMPACTS
Shorter rainy season	Type of vegetation	Increase desertification as soil moisture declines and less water is available for vegetation growth, limiting groundwater recharge and flood retention.
	Groundwater sources	Fewer rainy days will result in reduced recharge during the wet season, reducing availability during the dry season. FAO,2014
	Surface water	Less time for rainwater harvesting and storage, reducing availability, especially toward the end of the dry season.

HAZARD	ECO-SYSTEM SERVICE	MAIN PROJECTED IMPACTS
More heavy rain, less useful and more damaging	Type of vegetation	Loss of vegetation cover, increased runoff rate, and soil erosion, damaging water storage facilities.
	Groundwater sources	Decreased sub-surface flow and recharge as most flows run-off downstream rather than recharging local aquifers.
	Surface water	Reduced availability, as flows from intense rainfall events are difficult to capture and can even damage storage infrastructure. Uncontrolled livestock watering, the absence of periodic desilting, or a failure easily damage small ponds to maintain the spillways so that over-topping occurs during periods of heavy rains (FAO,2014).

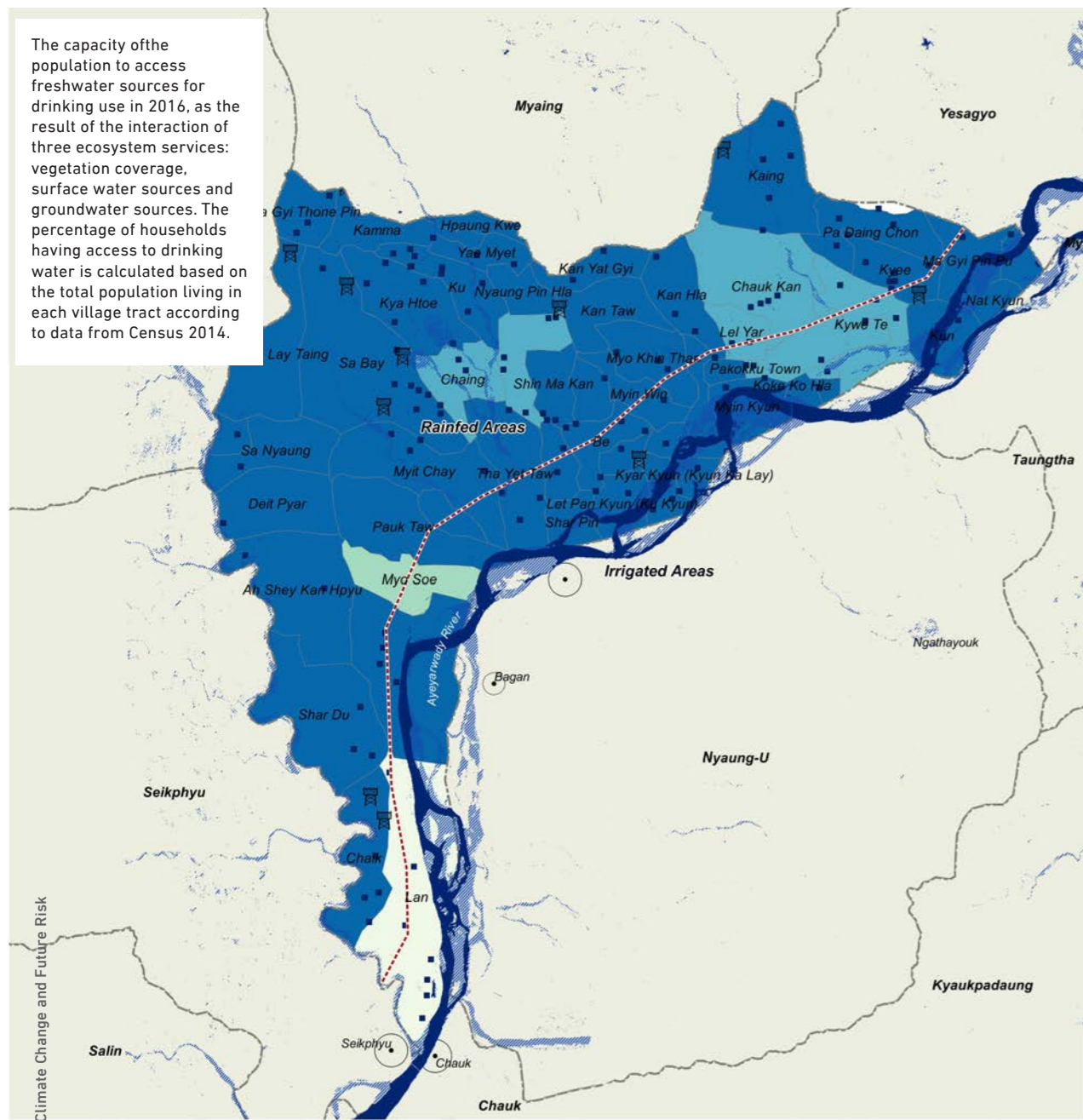


Access to freshwater for drinking use is dependent on surface and sub-surface sources: rainwater harvested in storage ponds, flows from the Ayeyawady River, and groundwater aquifers.

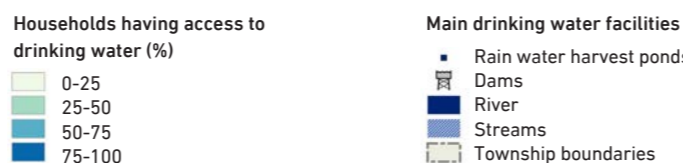
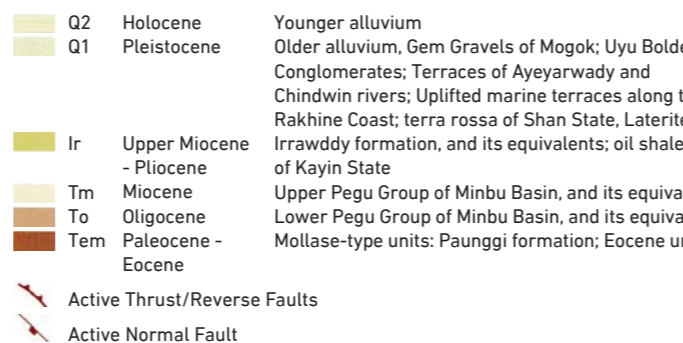
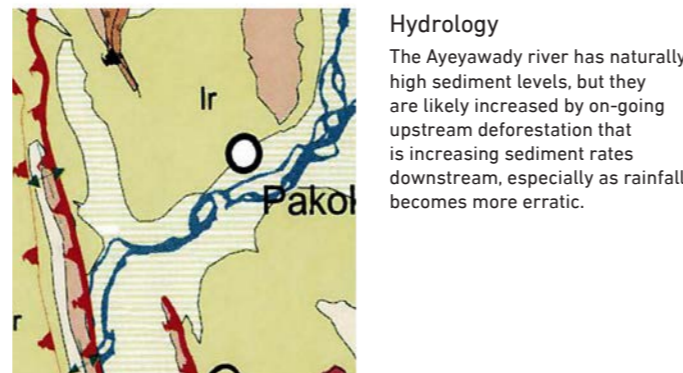
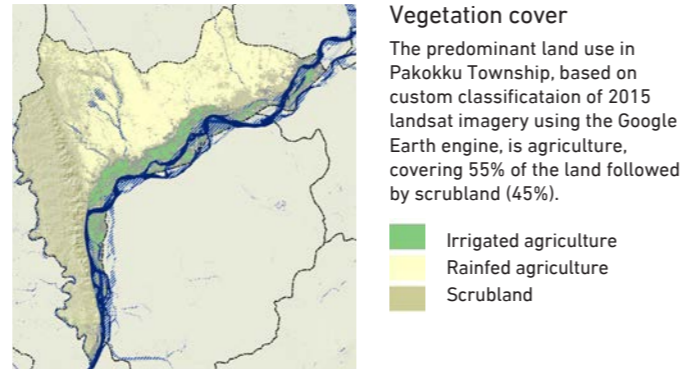
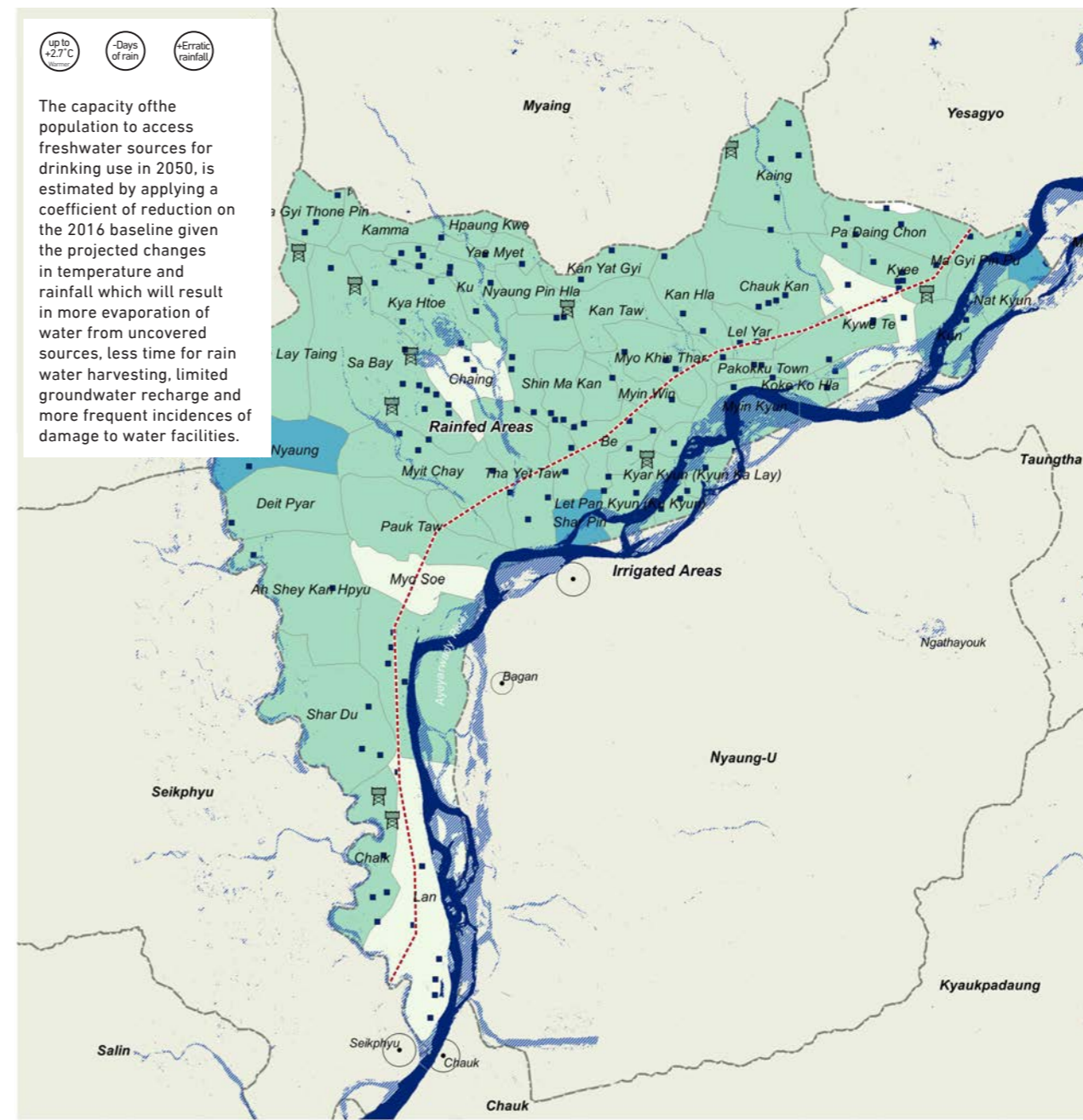
Water quality and availability will depend on both natural sources and direct human impacts on the larger surrounding dry zone landscape, including deforestation upstream that can increase sedimentation rates in the Ayeyawady River.

A lack of water access for drinking is also likely to further worsen health indicators, including maternal health, as well as migration. Pakokku already has child mortality 40 per cent higher than the national average. With a worsening situation in terms of water access we can expect to see child mortality worsen, even as the national level figure improves, widening the gap between Pakokku and the rest of Myanmar. Similarly, as access to water decreases, and this interacts with reduced incomes from agriculture, described above, migration is highly likely to increase, with a greater number of men migrating, causing more female-headed households. As the township moves away from agrarian livelihoods towards creating employment through industry and services, greater concentrations of people are likely in the urban area. This means that supplies will need to be ensured in urban and peri-urban areas, where large concentrations of workers are likely to live.

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



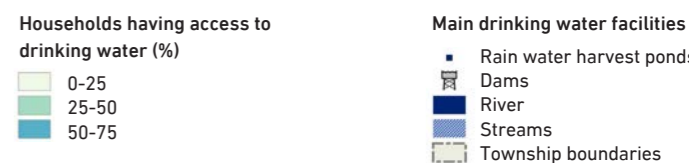
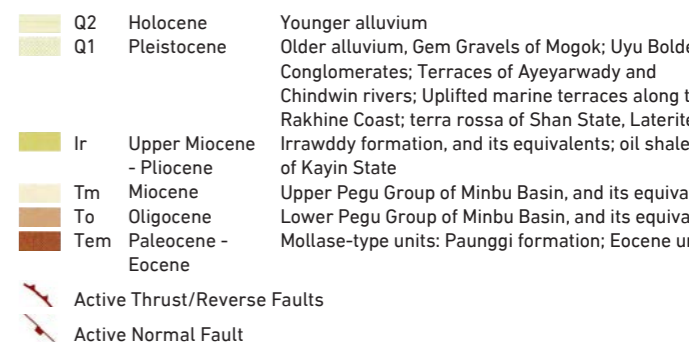
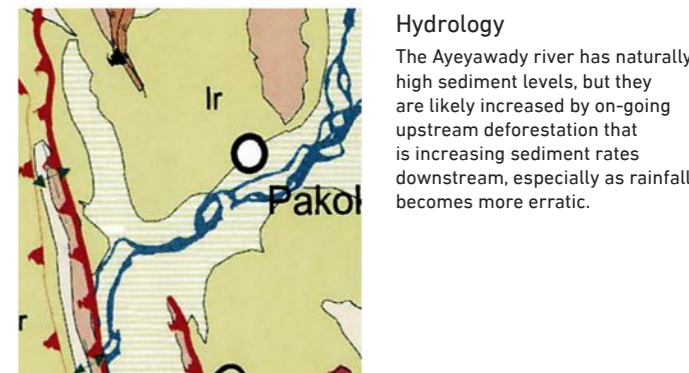
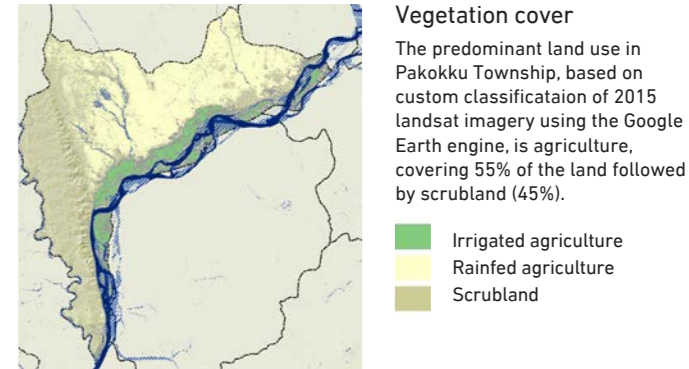
2016 | Capacity of the population to access freshwater for drinking use in 2050



Scale: 0 20 40 km | 1:1,000,000 | Original size Din A3 | **PPK13a**

Disclaimer: The designations employed and the presentation of material on this map do not imply the endorsement by the United Nations of any particular view or 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, Census 2014, Pakokku Township Planning Department, Pakokku General Administration Department, UN HABITAT



Scale: 0 20 40 km | 1:1,000,000 | Original size Din A3 | **PPK13b**

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Data Source: MIMU, FAO, WFP, UN HABITAT

Climate Change and Future Risk

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:

3. People's mobility and communication is expected to be reduced especially in riverbank and south-western areas of the township by 2050

Pakokku town has a good transportation infrastructure, consisting of water, road, railway, and air transport facilities.

Pakokku Town is located along the Myanmar's most important commercial waterway, the Ayeyawady River, playing an important role as a trading centre for the Chindwin and Yaw River valleys, mainly for agricultural products including peanuts, sesame, rice and palm sugar, in addition to timber. However, port facilities are underdeveloped, no machinery and equipment is available and cargo handling, which is done manually.

National paved roads and a railway connects Pakokku town to neighbouring townships. A network of secondary and tertiary unpaved roads provides transport communication to rural settlements, however stronger storms and unusually heavy



+ Intense
Rainfall

HAZARD	ECO-SYSTEM SERVICE	MAIN PROJECTED IMPACTS
More heavy rain, less useful and more damaging	Type of vegetation	Landslides in riverbank areas damages vegetation cover and destroys roads and harbours/port facilities
	Type of soils	Large quantities of rain falling over short periods will result in more flooding and erosion

rainfall results in more floods reducing population's mobility especially in riverbank communities.

Changes in the Ayeyawady River bed during the period from 2003 to 2016⁴⁶ show that floods have affected more than thirty per cent of the population living in riverbank areas.

Access to transportation and other types of infrastructure is essential for continued socio-economic development. Widespread, continuously functioning infrastructure – especially transportation – is a good proxy for the likelihood of industrial development. Without well-functioning transport, power and water infrastructure, it is highly unlikely that services and industry, which are higher value added sectors and thus have the potential to pay higher salaries, lifting people out of poverty, are unlikely to locate in Pakokku.

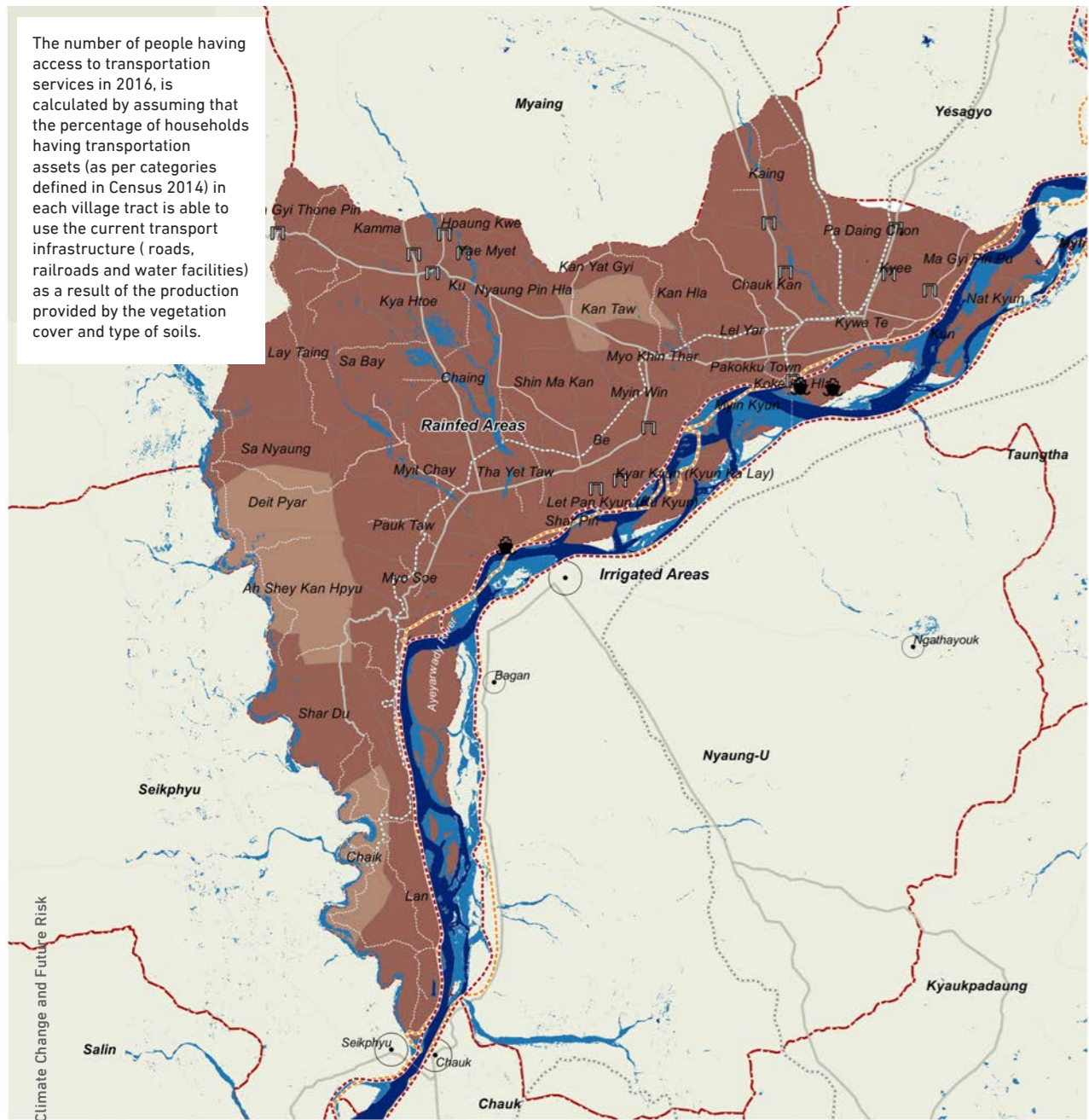
Access to transportation services mainly on the interaction of two main eco-system services (type of vegetation and soil) that are already highly impacted by climate change:

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 (refer to annex A3 for detailed calculations).

⁴⁶ Delineation of river bed has been digitized directly from processed satellite images SRTM 90m DTM from 2003 and Landsat images from different years, using GIS software ArcGIS and QGIS



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



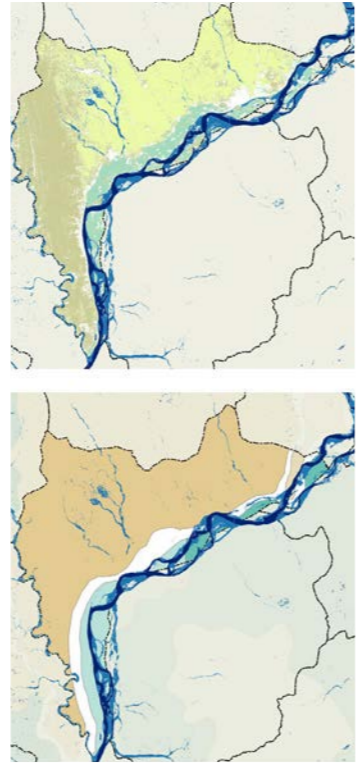
0 5 10 15 20 25 km 1:300,000 Original size Din A3

Climate Change and Future Risk

up to +2.7°C

-Days of rain

+Erratic rainfall



Vegetation cover
The predominant land use in Pakokku Township, based on custom classification of 2015 landsat imagery using the Google Earth engine, is agriculture, covering 55% of the land followed by scrubland (45%).

- Scrubland
- Irrigated agriculture
- Rainfed agriculture

Soil classification
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.

- Light forest soil
- Meadow & meadow alluvial soil
- Primitive crushed stone soil
- Savana soil on slopes

Transportation infrastructure

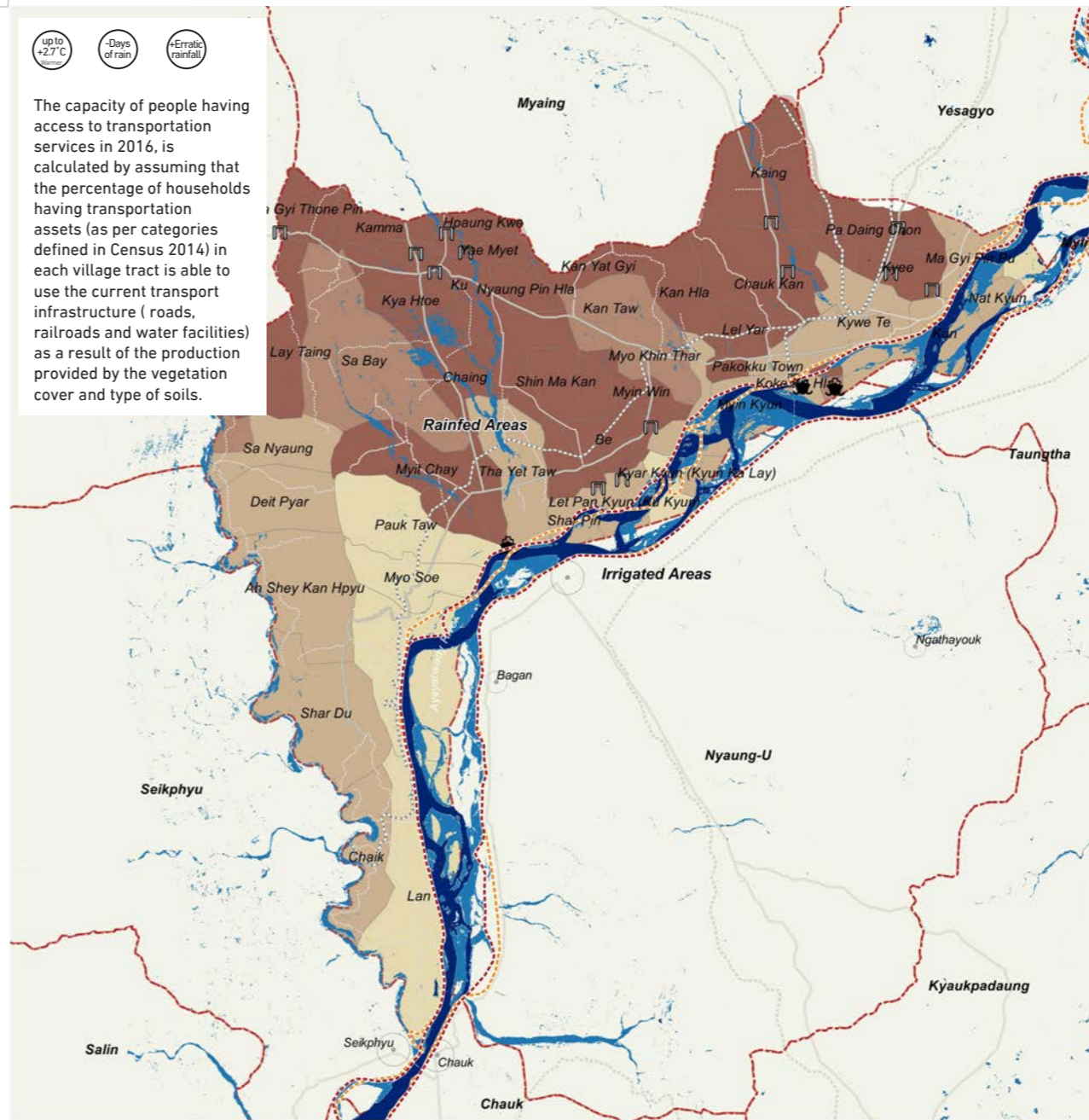
- Main road
- Secondary road
- Tertiary road
- Rail road
- Bridge
- Main ports
- River
- Streams
- Riverbed in 2016
- River bed in 2003
- Township boundaries

Households having access to drinking water (%)

- 50-75
- 75-100

0 20 40 km 1:1,000,000 Original size Din A3 **PPK14a**

2016 | Capacity of the population to have access to transport services in 2050



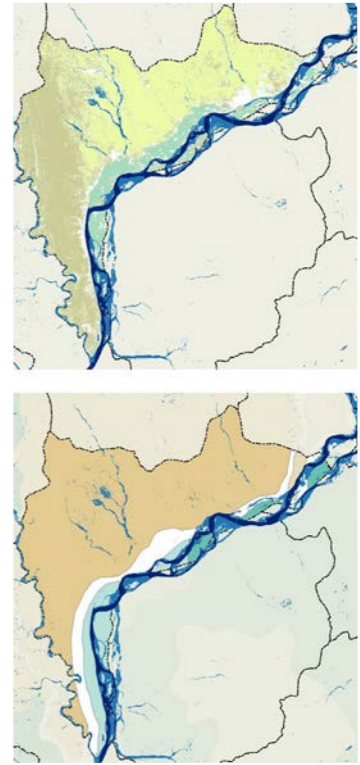
0 5 10 15 20 25 km 1:300,000 Original size Din A3

Climate Change and Future Risk

up to +2.7°C

-Days of rain

+Erratic rainfall



Vegetation cover
The predominant land use in Pakokku Township, based on custom classification of 2015 landsat imagery using the Google Earth engine, is agriculture, covering 55% of the land followed by scrubland (45%).

- Scrubland
- Irrigated agriculture
- Rainfed agriculture

Soil classification
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.

- Light forest soil
- Meadow & meadow alluvial soil
- Primitive crushed stone soil
- Savana soil on slopes

Transportation infrastructure

- Main road
- Secondary road
- Tertiary road
- Rail road
- Bridge
- Main ports
- River
- Streams
- Riverbed in 2016
- River bed in 2003
- Township boundaries

Households having access to drinking water (%)

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

0 20 40 km 1:1,000,000 Original size Din A3 **PPK14b**

Climate Change and Future Risk

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 its authorities, or concerning the delimitation of its frontiers or boundaries.

5

OVERALL FINDINGS



5.1 DEFINING SCENARIOS

A. This assessment presents three broad scenarios of the future; A) business as usual, B) resilience is built to maintain current living standards, and C) resilient, sustainable economic development for Pakokku. These scenarios can help local and national government to plan for actions that will increase Pakokku's resilience to the impacts of climate change. Planning actions based on scenarios is in-line with the IPCC pathways approach, which is defined in the IPCC 5th Assessment Report, and is a common way that governments and industries use to plan for the future .⁴⁷

- It is important to note the difference between a strategy 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.

⁴⁷ Economist Intelligence Unit (2016) – New Directions: Myanmar to 2030



Figure 52. Graphic representations of forecast



Figure 50. Forecasts

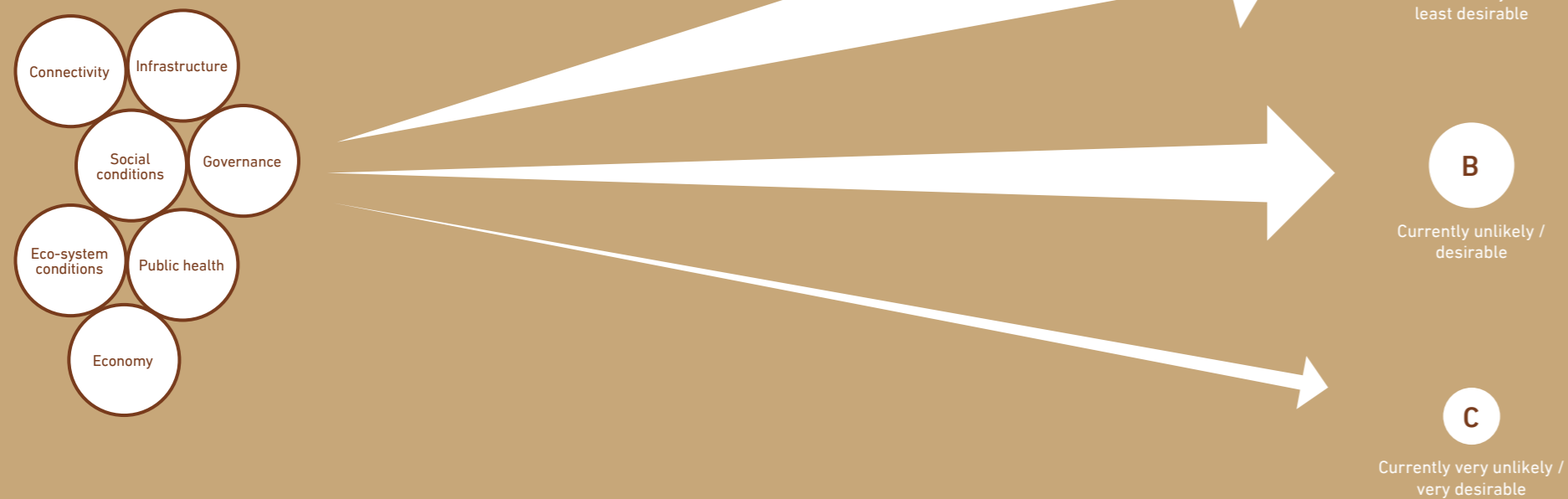


Figure 53. Scenarios ⁴⁸

SCENARIO A

Business as usual: no specific adaptation effort.

In this scenario authorities and communities do not recognise 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 and ecological.

SCENARIO B

Resilience is built to maintain current living standards

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 Pakokku's people.

SCENARIO C

Resilient, sustainable economic development for Pakokku

Under this scenario, resilience is built that enables economic and social development, despite changes in climate in which effective, strategic planning, resources, coordination, and time is assigned not only to maintain basic safety conditions, but to achieve development goals.



5.2. SCENARIOS FOR PAKOKKU 2050

Scenario

A

BUSINESS AS USUAL SCENARIO (BAU)

- In this scenario authorities and communities do not recognise 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 and ecological.
- Ultimately, this increasingly affects people's life, livelihoods, health and safety until 2050 and beyond.
- Under this scenario, the spatial structure of Pakokku, affected by seasonal flooding, heat and drought, and heightened risks of rapid on-set disasters, causing a loss of productivity, will undergo radical change.
- 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 constructing houses or locating industry in flood prone areas, or permitting over-extraction of ground water, carry severe long-term 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 resource – primarily water – use continues, incomes remain low and migration rates are high, Pakokku will not be able to support current and expected population growth at the same living standard as in 2016.

Under a business as usual scenario people in Pakokku will experience lower incomes because of a lack of irrigation, less predictable rainfall, and resultant lower access to water in the dry zone. This is because agriculture and livestock

are highly dependent on access to water. In the riverbank areas, while potential will remain for higher incomes due to greater water availability, partial and total losses of crops is likely to increase due to flooding, and as such people in these areas incomes will be at risk.

Migration will continue at least at present levels and will likely increase as incomes decline (in dry areas) and are more at risk (in riverbank areas). Migration is especially likely to increase if this is combined with present levels of and access to education. Based on present trends, this will lead to an even more imbalanced sex ratio, a greater number of female headed households. This will deprive the township of young and potentially skilled people, make incomes more unstable and could make women more vulnerable.

Water availability will decline. Projections show that there will be higher temperatures, declining rainfall and fewer rainy days because of climate change that will cause ground water levels to decrease. Without any measures to improve water storage infrastructure and distribution management, the amount of water available to communities will decrease from an already low baseline. Lack of water will both cause and exacerbate the impacts in agriculture, described above. This is because irrigation – which is already insufficient – will become even less available, as

existing canals dry up while demand for water becomes greater.

Unsustainable use of ecosystems will continue under a business as usual scenario because management systems to preserve ecosystems are not in place. Ecosystems in Pakokku provide construction and roofing material for houses, protection from the river and fertility for soils. If present, unsustainable ecosystem management practices continue, these ecosystem services will discontinue, resulting in more challenging conditions for house construction, greater flood risks and lower quality soils, inter alia.

Limited access to energy means that people rely heavily on fuel wood or charcoal for their energy. Under a BAU scenario, demand for energy would be at least constant, and would likely increase with natural population growth. This would result in more cutting for fuel wood and would accelerate the loss of ecosystems. Under the BAU, there would be no alternative, sustainable source of energy for the majority of the people.

If current trends continue, floods along the riverbank area could become more frequent, more severe, and last for longer. At present, there is little or no shelter network, except for some provision



from temples, meaning people depend on informal networks of relatives in times of flooding. As floods become more frequent, more severe and take longer to recede, the internal displacement within the township will cause addition burden on the monastery system, and on families living in the upstream area.

Under these circumstances, the 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 available⁴⁹. This remains crucial to support planning and direct interventions for adaptation but also,

	ECO-SYSTEMS SERVICES	SOCIO-ECONOMIC FUNCTIONS	INFRASTRUCTURE FACILITIES
Rain-fed Areas	Wood for charcoal; Roof/ wall material; Livestock; Vegetables; Flowers	Livestock market;	Rain water harvest pond; Well with hand pump
Irrigated Areas	Wood for charcoal; Roof/ wall material;	Aquaculture (crabs/ shrimps); Fishermen; Fish market	Rain water harvest pond; Unpaved roads; Bus transport on daily basis

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.

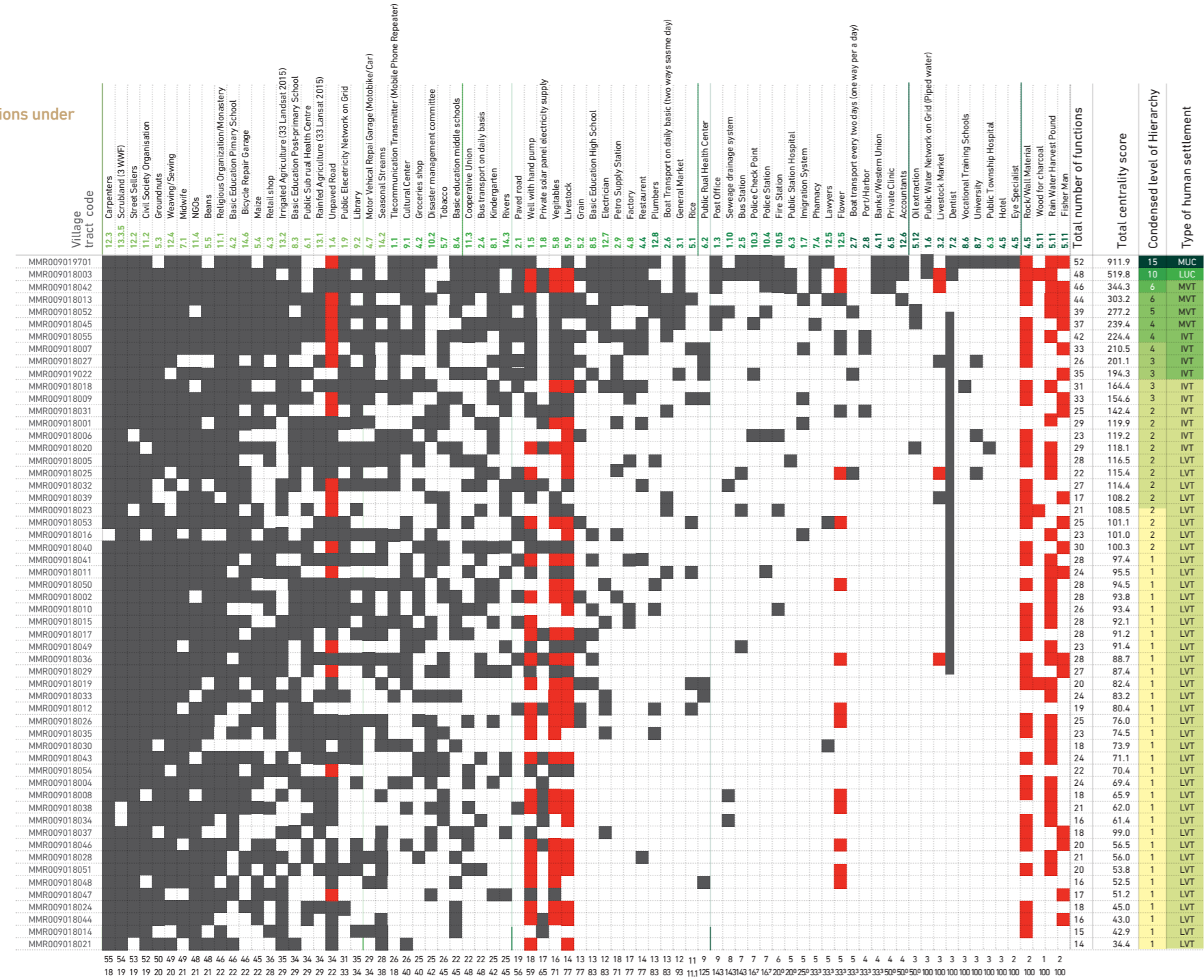
The new spatial analysis assumes that the following functions won't be available in each area:

The analysis of the matrix of functions in 2050 (see Figure 42 where red squares show functions not available in 2050 in each village tract and map PKK16) under a business as usual scenario, shows:

⁴⁹ This exercise should be understood as a tentative approximation of what could happen in the future rather than a forecast.



Figure54.
Matrix of Functions under
BAU scenario



* (Mobile Phone repeater) **** (68 Landsat 2015 + 54 WWF)
 ** (motorbike / car) ***** (20 Landsat 2015 + 2 WWF)
 *** (one way / day)

- Pakokku's level of socio-economic and infrastructure development would decrease across the township. Around 80 per cent of the population, mainly from western and central areas, would be living in village tracts classified as local village tracts (LVT), which would have only basic functions, assuming current population distribution.
- Pakokku Town and Myit Chay, would still be considered the two main clusters of settlements, however the "territorial influence" of Myit Chay would be reduced, providing fewer socio-economic services to the population in the central and southern areas.
- Kamma would still be considered the second urban centre of the township, but would provide fewer socio-economic services to the surrounding rural settlements in the north-western part of the township, which in turn would increase the dependency from Pakokku Town.
- Lan, located at the southernmost part of the township, would be more isolated as floods along the riverbank area could become more frequent, more severe, and last for longer, reducing mobility along the north-south corridor, linking Myit Chay and Lan.





Such measures would be necessary to curb rates of outward migration. In a rapidly developing country like Myanmar, high levels of youth migration are, to some degree, inevitable. However, by taking adaptation actions that will improve water access, and reverse the decline of rural livelihoods, rates of migration may ease. This will help to retain young, productive workers in the township and is one of the (several) pre-conditions

to attracting higher value-added sectors to the township. Linked to this, improving the access to education beyond the grade 5 level, including technical and vocational training, will further enhance the skill levels of the township and make it easier to attract higher value-added industry. Even if people with education migrate, there will be broader benefits because migration with dignity will be more likely.

If present flooding trends continue, livelihoods and assets in the riverbank area will continue to be threatened. To prevent this, and to maintain current conditions, some flood prevention measures will be required. This could take several forms, from ecosystem based adaptation options such as bamboo embankments to protect houses and fields to a more formal network of storage facilities and shelters, to reduce loss and damage and to improve shelter access.

Scenario

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,

- Under this scenario, resilience is built that enables economic and social development, despite changes in climate in which effective, strategic planning, resources, coordination, and time is assigned not only to maintain basic safety conditions, but to achieve development goals.
- Planning work that guides budget request to the regional and national authorities would be informed by this kind of assessment.
- This scenario implies investment from national authorities and international partners, to achieve three main results: 1) A greener, healthy environment that supports the living standards of Pakokku in a sustainable manner despite changes in climate, 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 over a long period of time, and by a number of actors, but particularly local and national government.

Pakokku in 2050 sustains and continues people's socio-economic development through a diversified economy, improved access to water and healthy, functioning ecosystems

To continue and improve its development trajectory in a way that is resilient to changes in the climate, Pakokku will require improved access to better quality water, both for drinking and irrigation purposes. As development proceeds, dependence on agriculture usually decreases, with a shift from small-scale, smallholder agriculture to a more commercial model. However, agriculture will continue to play an important role in Pakokku and in order to do so consistent, sustainable access to water is essential. In addition, for sustainable development to take place, a much greater proportion of homes will require piped or other reliable sources of drinking quality water.

Enhancing access to water will require significant investment in infrastructure and management. Firstly, more effective use of water from the river for irrigation would enable a greater number of farmers, further in-land, to irrigate their land. To do this, investment in canals and water-efficient irrigation systems would be required. Water efficiency is important – hence drip irrigation systems should be considered – because even with improved access to river water there is still greater demand for water than water available in the river. This means other water access and storage options are also essential. Improving rainwater harvesting and storage at the household and community level will enable improved access. Better management practices, such as creating local utilities that set nominal charges for water through willingness to pay surveys will ensure that water is distributed more effectively and reduce 'free-rider' problems. These options would also need to be supported by increased awareness and education on water use.

To ensure economic development that is resilient to climate change, Pakokku's economy will need to move towards a situation where there is greater value-addition in township, with a greater share of industry and services, and more people employed in these sectors. This will be complex; more skilled people are required and infrastructure will need to at the very least maintain functionality year-round, and industry especially will need to be more labour intensive. To do this, agricultural processing can be brought in-township, meaning a greater share of the agricultural value-chain takes place in Pakokku. The township could also look to locate manufacturing industry in the township, which would create large-scale employment opportunities that are less climate dependent. Small-scale actions can also transform the economy. As mentioned above, micro-credit can enable farmers to experiment with new crops, but it can also be used as means for people to move from smallholder agriculture to other forms of enterprise. In this regard, micro-credit can be a means to encourage innovation while moving people away from climate sensitive livelihoods.

Protecting flood prone areas, including parts of Pakokku town, from flooding is vitally important to resilient, sustainable development in Pakokku. This will require, as an initial step, a cost-benefit analysis type study of ecosystem and infrastructure options to protect the riverbank and defend people and assets from floods. Ecosystem based adaptation options have the potential to be cheaper and equally as effective as traditional infrastructure options. This initial decision-making would enable the most cost effective riverbank protection.



CONCLUSIONS AND RECOMMENDATIONS: PLANNING FOR ADAPTATION IN PAKOKKU

BUILDING RESILIENCE TO CLIMATE CHANGE IN PAKOKKU TOWNSHIP IS A GREAT AND URGENT CHALLENGE, ON WHICH LIFE, WELFARE AND PROSPERITY OF HUNDREDS OF THOUSANDS OF PEOPLE DEPENDS.

THE FREQUENT FLOODS AND ONGOING DROUGHTS IN PAKOKKU PROVIDE A REMINDER OF THE SENSITIVITY OF PAKOKKU TO SEVERE HAZARDS AND SLOW-ONSET CHANGES. 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 PAKOKKU 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 unveils three main broad findings:

1. Decision makers will need to plan for both rapid on-set disasters, particularly floods, as well as slow-onset changes, especially in heat, droughts, and water availability

Despite plentiful efforts to meet basic needs and improve infrastructure in recent years, Pakokku 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. Repeated flooding has caused severe damage to crops, have forced communities to relocate, both temporarily and permanently, and have resulted in lost livelihoods and indebtedness as people have to invest in repairing their homes. Meanwhile, heat and a lack of rain mean that, away from riverside areas, water availability is a constant challenging, causing low crops yields, loss of income and driving migration. Even with more rain, the likely concentration of this in a short rainy season is likely to cause further challenges in access to water, without adaptation measures. Meanwhile, upstream factors mean that flood risk is likely to continue for communities by the river. Heavier rain in the rainy season will increase the vulnerability of communities living by seasonal streams.

- Severe and wide-ranging vulnerabilities exacerbate these climate related threats, and are deeply interrelated with them

Despite its dry climate, and loose, sandy soil, the central dry zone had historically been a productive agricultural centre. The Ayeyarwady Dry Forests are critical to retaining this productivity, but current deforestation, agricultural practices and cutting for fuel and building materials represents a serious threat to their continued survival.

The socio-economic structure of Pakokku is also a key underlying vulnerability. Agriculture is by far the largest economic sector, but it generates minimal output, which translates to very low incomes, below the minimum wage. Agriculture is also highly climate sensitive, with communities reporting that yields have declined along with water availability in the dry area, while total losses of crops are common near the river. There is also a relatively high number of daily wage labourers, whose incomes are low and unstable. Women working as daily wage labourers report that their incomes are often as little as half of men's incomes. Migration rates are very high, with a high sex disparity; male migrants outnumber their female counterparts by three to one. This has resulted in 30 per cent of households in Pakokku being female headed. Agricultural value chains also largely take place outside the township, meaning

that there is little capacity to create value chains in-township that will help to create wealth, raise incomes and reduce poverty, an issue that is caused and exacerbated by a lack of skills resulting from minimal vocational training.

Western areas of the township that rely on unpaved roads and have limited services and communication infrastructure, this may lead to increasing isolation, making it harder for people there to access education and health facilities, and economic opportunities.

- These vulnerabilities must be tackled holistically, to generate co-benefits and enable adaptation. However, this requires effective strategic planning, resources, coordination, and time.

The response to this necessitates effective strategic planning, resources, coordination, and time. This assessment, the first of its kind in Pakokku, 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, but particularly local and national government. This is how Pakokku can develop along the third scenario identified in this report; in which resilience is built that enables economic and social development, despite changes in climate. If no actions are taken,

we are likely to see Scenario A, business as usual unfold, which will make life and livelihoods very challenging in the township.

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:

- It is crucial that healthy ecosystems are maintained and enhanced in Pakokku. Ecosystem services, as they represent a source of livelihood, cultural, spiritual, physical health and safety for a large number of people in Pakokku. They provide a variety of services to communities, without which household vulnerability will increase greatly from both rapid and slow on-set disasters from changes in climate. Actions must focus, among others, on:
 - Preservation and expansion of forest cover. Without this protection, communities will lose the multiple benefits of forests, including soil fertility, flood and erosion protection and food and other non-timber forest products.
 - Protecting and improving sources of water for both human and agricultural use.
 - Improving land management by, for example, taking steps to improve soil management, reducing use of harmful chemicals, increasing the use of organic fertilizers and improving knowledge of farmers and communities more generally on land management.
 - Reducing natural resource exploitation through improved knowledge.
- It is essential to protect the productive capacity of agriculture, on which so many livelihoods depend, from increasing heat and declining water availability, while generating more employment in less climate sensitive sectors
 - Enhance and diversify skills of people, both men and women, and especially younger people, to increase employability in different sectors in Pakokku and elsewhere, as some migration can't be avoided. Vocational training is also important as levels of technical qualifications are extremely low at present;
 - Strengthen the productive system, especially in agriculture, through improved techniques, seeds, and water-efficient irrigation techniques. Meanwhile, enhanced access to credit will enable farmers and livestock herders to make investments and diversify their incomes.
 - 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 Pakokku. It involves a large involvement of national, regional and district authorities, as well as development partners, and requires careful planning to be feasible.
 - 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 must continue to function and protect people during extreme heat, droughts and floods

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, extreme heat, drought and water shortages.

b. Housing and other public buildings should be designed, and, where possible, retrofitted to offer greater protection from extreme heat and floods.

c. Housing safety also includes improved sanitation, and, crucially, the capacity to harvest water safely with improved techniques.

d. 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, and increased evaporation.

e. Transport and connectivity infrastructure should be planned and maintained in such a way that all people have access to markets, schools and hospitals during floods, droughts and heat.

In addition, the study also concludes that planning for adaptation may benefit from improved local governance, meaning that priorities are captured and communicated at the township, district, and regional levels.

Finally, and as a cross-cutting issue, 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 Pakokku.

ADAPTATION ACTION PLANNING

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 Pakokku's development trajectory towards Scenarios B and, ideally, C.

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

1. A greener, healthy environment that supports the living standards of Pakokku in a sustainable manner despite changes in climate,
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

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 Pakokku 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.



ANNEX A1. CLIMATE CHANGE ADAPTATION PLANNING OUTPUTS (PAKOKKU TOWNSHIP)



Figure 55. Township administration after discussing the potential impacts of climate change (background) identify with MCCA and the village administrators potential adaptation measures © MCCA

Between April and August 2016, the MCCA team extensively studied the vulnerabilities to climate change in Pakokku 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 forests and water, 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. 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. In the following pages, the activities are reported as the communities have prioritized them, under three main outcomes. This forms the basis for an Adaptation Plan, to be adopted by Pakokku Township, which the MCCA supports as part of its programme.

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 drainage, water collection and distribution, flood-shelters. Based on the long-list of adaptive measures discussed with authorities, urban ward 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 Pakokku Township, which the MCCA supports as part of its program.



Figure 55. Landscape in Pakokku during the dry season. Dry river-bed may come back to life through flash floods following intense rains (c) Sukun/MCCA-UN-Habitat 2016

OUTCOME 1: ECO-SYSTEM

STRATEGIC OUTCOME	EXPECTED RESULT	ACTIVITIES	TYPE	COST	FEASABILITY	ACCEPTANCE	ADAPTATION/EFFECTIVENESS	BENEFIT ANYWAY/NO REGRET	SPEED	RANK/PERSCPTION	STRATEGIC VALUE	
To achieve a greener healthy environment that supports the living standard of Pakokku in a sustainable manner despite changes in climate	ER1 Pakokku has access to good forest to be manage sustainable, that protect, regulate erosion, soils, provides materials and generate income.	Protecting existing forestry areas by preventing and reducing upland/local logging through law and rules enforcement	●	4	3	3	5	5	2	22	100	
		Protecting existing forestry areas by creating community awareness on the need to maintain forestry coverage	●	5	4	4	4	4	4	25	100	
		Protecting existing forestry by providing alternatives sources of fuel (Cookstoves, Solar Panel, Biomass) that also improve incomes	●	2	3	4	4	4	4	4	21	100
		Expanding forest through capacity building on techniques for planting trees (fast growing) and studies on the best adaptive species	●	3	4	5	4	5	3	24	100	
		Expanding forest through Afforestation and through Community Forestry to provide for construction, cooking, livelihoods	●	2	4	4	5	4	3	22	100	
	ER2 Pakokku has access to affordable, sufficient quality water from a variety of sources for people, agriculture and livestock	Preventing water pollution in the river/ground sources through law enforcement and community awareness	Improving water harvesting and storage techniques/capacities at household and community levels	●	2	3	4	4	5	4	22	75
			Improving the management of water sources/resources through local committees and establishing water utilities (willingness to pay to be assessed)	●	4	4	4	5	5	4	26	75
			Training communities on Water Hygiene and Management	●	4	4	5	5	5	4	27	100
			Establishing a network of water reservoirs for communities (village tracts), strategically located to ensure water availability	●	2	3	4	5	5	3	22	100
			Building a network of water containment/catchment to control runoff water from floods and seasonal streams to avoid soil erosion, destruction of crops and to	●	1	3	5	5	5	3	22	75
ER3 Land in Pakokku continues to support agriculture through sustainable management of soils and adaptive agricultural inputs			Building technical capacities for testing adaptive agricultural techniques	Testing new planting/agriculture techniques	●	3	4	4	4	4	4	23
	Testing short-term cycle crop	●		2	3	4	4	4	4	21	75	
	Building capacities for sustainable soil management (including Plants, Soil Nutrients, Organic Pesticides etc.)	●		3	4	4	5	5	4	25	75	
	Increasing access to climate risk information for farmers, and climate change awareness for communities	●		3	4	4	4	5	4	24	100	

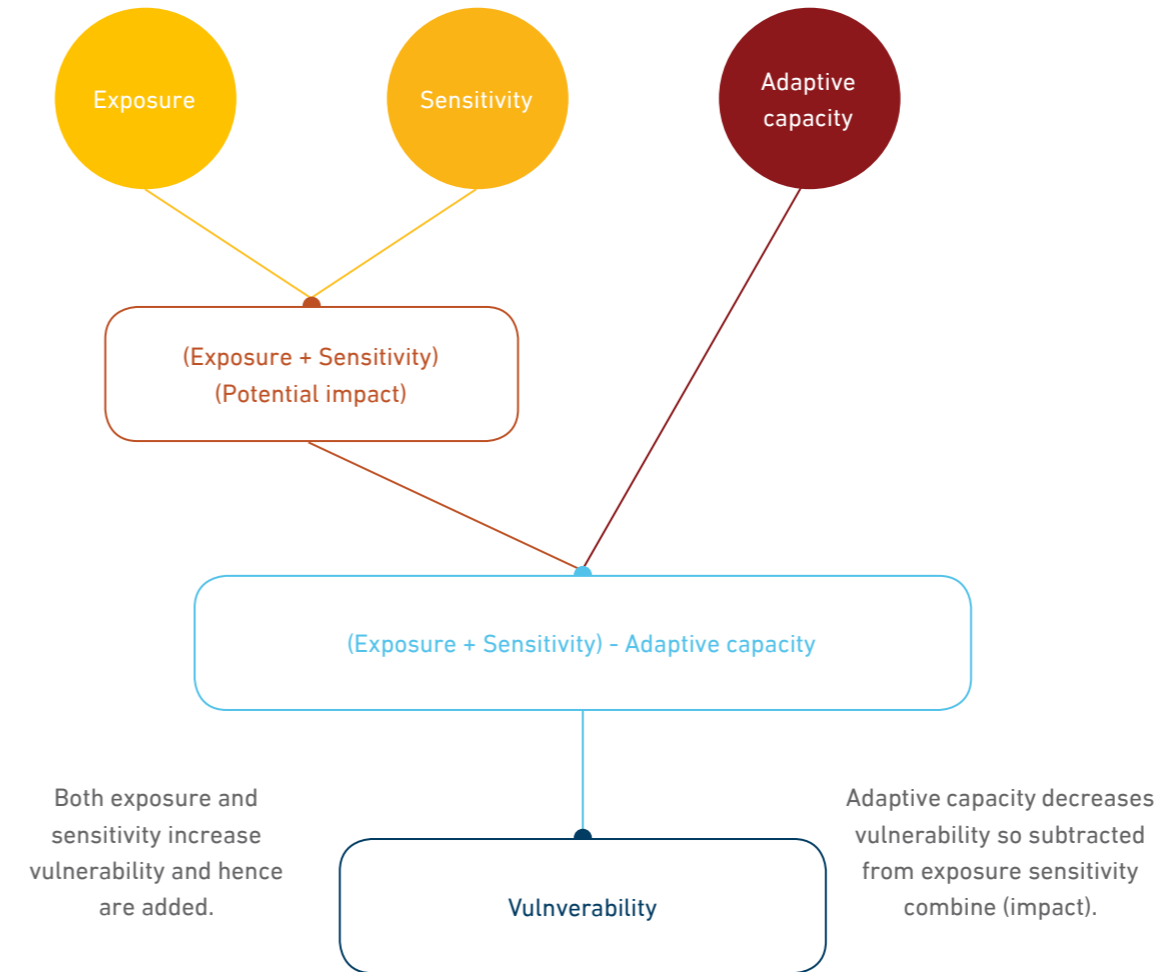
OUTCOME 2: SOCIO-ECONOMIC

STRATEGIC OUTCOME	EXPECTED RESULT	ACTIVITIES	TYPE	COST	FEASABILITY	COMMUNITY ACCEPTANCE	ADAPTATION/EFFECTIVENESS	BENEFIT ANYWAY/NO REGRET	SPEED	SCORE	STRATEGIC VALUE
A diversified, inclusive and resilient economy, to enhance the economic conditions of the township;	ER1 Information, skills, knowledge and technolgy have been improved to combat	Training on climate smart agriculture	Training and capacity building	3	3	5	5	4	3	23	75
		Training on soil fertility management	Training and capacity building	4	3	3	5	4	3	22	75
		Vocational training	Training and capacity building	2	3	4	3	4	4	20	100
		Develop CSOs	Management	5	4	4	4	5	3	25	50
	ER2 Increased investment and access to finance to maintain and improve production in agriculture and livestock	Permanent pastures	Investment	1	3	3	4	4	3	18	50 2e
			Investment	2	3	4	4	3	4	20	50 2f
		Long term loans for agri	Investment	4	4	5	4	4	3	24	100 2b
			Investment	1	3	2	4	5	1	16	25 2a
		Seed production farm (includes livestock species)	Investment	2	3	4	3	3	1	16	50 2d
		Agricultural inputs - drought resistant	Investment	2	4	5	4	4	4	23	75 2c
ER3 Investment in new industries has increased	Loans for micro industry for landless people	Investment	4	4	5	5	4	3	25	100 3b	
		Investment	3	3	4	5	4	3	22	100 3a	
	Value chain analysis	Research and analysis/Investment	5	3	4	5	5	5	17	75 3c	
	Insurance for homes in the urban area	Investment	1	2	2	2	4	3	14	50 3d	

OUTCOME 3: INFRASTRUCTURE

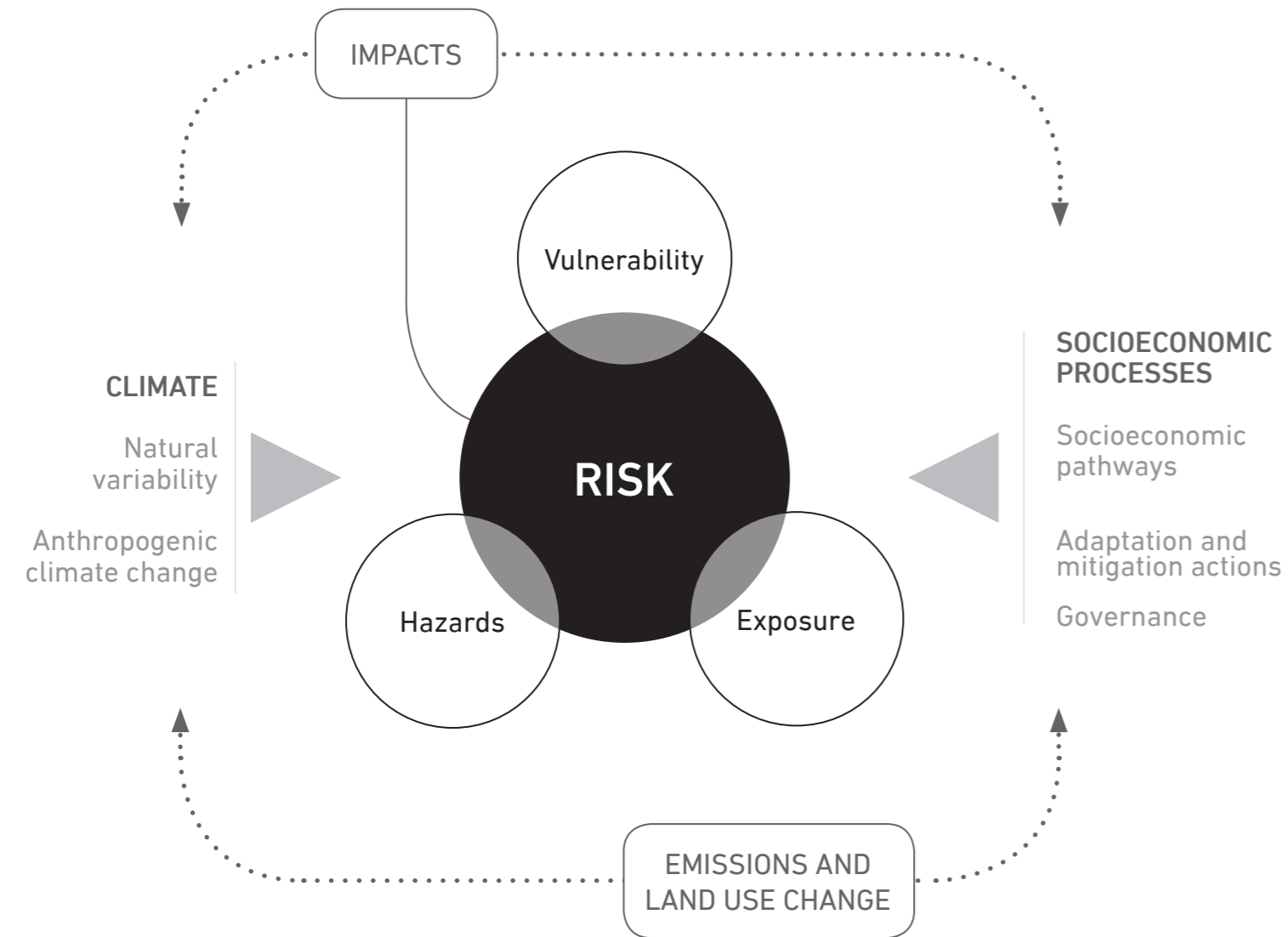
STRATEGIC OUTCOME	EXPECTED RESULT	ACTIVITIES		TYPE	COST	FEASIBILITY	COMMUNITY ACCEPTANCE	ADAPTATION/EFFECTIVENESS	BENEFIT ANYWAY/NO REGRET	SPEED	SCORE	STRATEGIC VALUE
Resilient infrastructure and connectivity, that protects and enables people	ER1 All people Public and private facilities and services are protected in Pakokku against A2 natural hazards	Studies on spatial location risk areas	1.1	●	5	5	5	5	5	5	30	100
		Improve design of housing to protect from floods and heat waves	1.4	●	4	5	5	4	5	4	27	100
		Improve storage to protect food, crops and animals from floods	1.6	●	3	4	5	5	5	4	26	100
		Willingness to pay for retrofiting study	1.9	●	5	4	4	5	5	3	26	100
		Participatory planning	1.10	●	5	4	4	4	5	4	26	100
		Improve management of infrastructure	1.3	●	2	4	5	5	5	3	24	100
		Improve radio access and broadcast	1.5	●	3	4	5	4	5	3	24	100
		Improve design of stables to protect animals from heat waves	1.11	●	3	4	4	4	5	4	24	100
		Building shelters than can also be used as schools/community centres	1.2	●	2	4	5	4	5	3	23	100
		Roads and bridges to improve access	1.7	●	2	3	5	4	5	3	22	100
		Improve construction techniques	1.8	●	3	5	5	5	5	4	27	100 if on the job t
		Improve shelters to protect elder people from heat waves	1.12	●	2	4	4	4	5	3	22	100
ER2 Access to water in Pakokku is ensured		Improve water management at community level	2.3	●	4	5	5	5	5	4	28	100
		Strategic water networking between village tracts (emergency reservoir)	2.5	●	4	4	5	5	5	4	27	100
		Improve Network of water harvesting at household level	2.6	●	4	4	4	4	5	4	25	100
		Participatory planning	2.1	●	5	4	4	4	4	3	24	100
		Improve water capture and storage at community level	2.2	●	3	4	4	4	4	4	23	100
		Improve HHs level water management	2.3	●	5	5	5	5	5	5	30	100 increased-th
		Drip irrigation schemes	2.7	●	3	4	4	4	5	3	23	100
		Improve stream and river catchment areas	2.9	●	3	4	4	4	5	3	23	100
		River basin management	2.10	●	1	2	5	5	5	2	20	100
		Build irrigation channels	2.8	●	1	2	3	3	5	2	16	100
ER3 Land is protected of erosion and floods		Flood and erosion control plans	3.1	●	4	4	4	4	5	3	24	100 ok with all ac
		Studies on river floods (hydrodynamics)	3.4	●	3	4	4	4	5	4	24	100
		Embankments	3.2	●	1	2	4	4	5	2	18	100
		Green infrastructure to protect from river/stream erosion (bamboo embankment)	3.3	●	3	4	4	4	5	3	23	100

ANNEX 2. VULNERABILITY FRAMEWORK



DEFINITIONS OF KEY COMPONENTS OF VULNERABILITY⁵⁰

TERM	IPCC AR5 DEFINITION
HAZARD	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.
EXPOSURE	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.
VULNERABILITY	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.
IMPACTS	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.
RISK	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.



⁵⁰ *ibid.*, p.5
⁵¹ *ibid.*, p.3

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 56. Questionnaire for inventorying the functions in each Village Tract

The figure shows four pages of a questionnaire form. Page 1 (leftmost) contains instructions and a list of 27 functions under categories: 1. Public Utilities and facilities, 2. Road Connection and Transportation Infrastructure, 3. Markets, 4. Industries and Commercial Establishments, and 6. Health Facilities. Page 2 (second from left) is a continuation of the list of functions. Page 3 (third from left) contains instructions in Burmese and a table for recording the presence or absence of functions, with a column for 'Frequency' (ရက်စွဲ). Page 4 (rightmost) contains a table for recording the presence or absence of functions, with a column for 'Frequency' (ရက်စွဲ).

STEP 2: MATRIX OF FUNCTIONS PRODUCTION

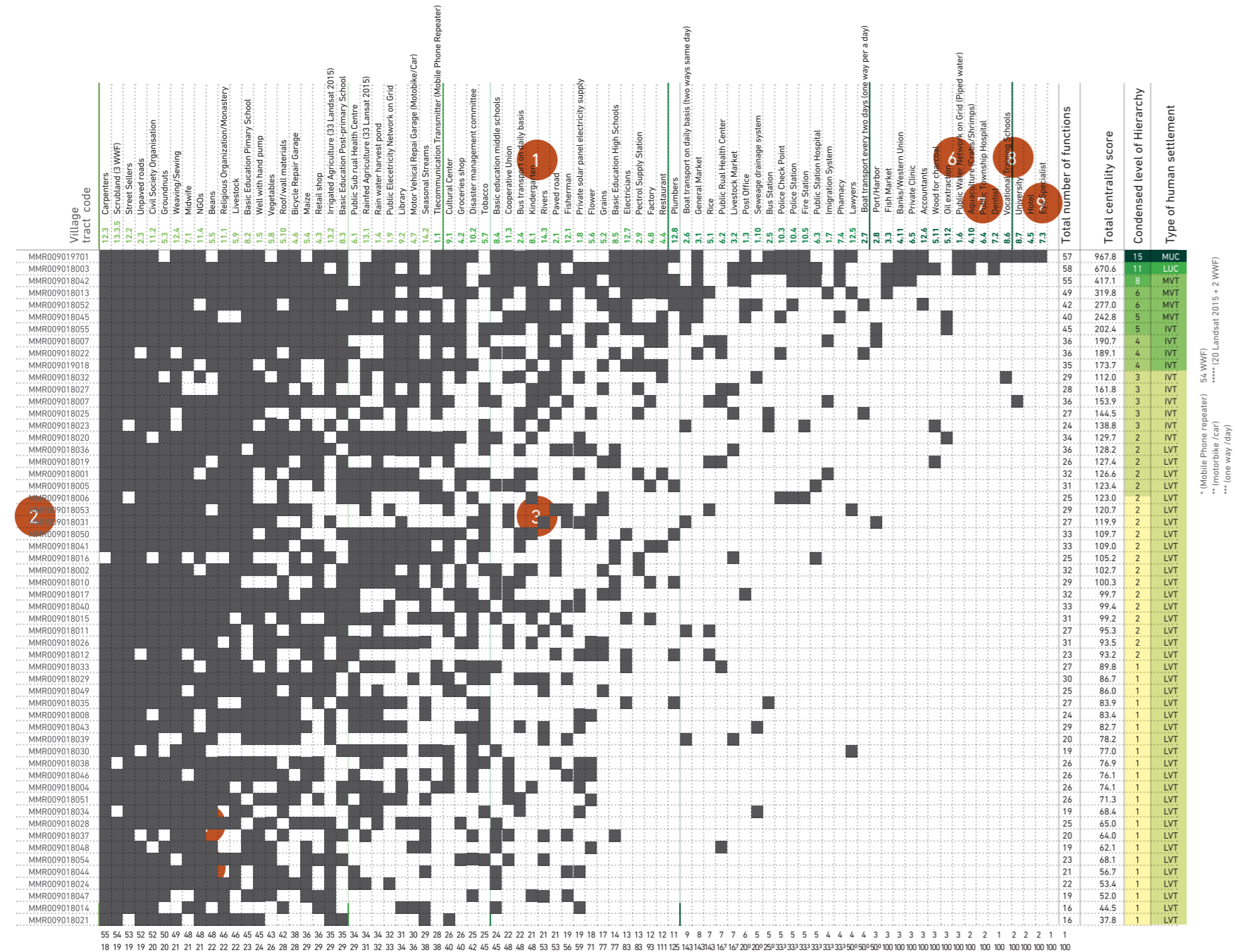
The information collected enables planners and policy-makers to analyse the township's level of physical and socio-economic development.

The data collected is fed into an ordered matrix where:

1. The first row shows the "functions", ordered from left to right according to its frequency of presence;
2. The first column shows the name of Village Tracts (Human Settlements), ordered from top to bottom as per the highest presence of functions in it;
3. In the table (or matrix) itself, a black cell indicates the presence of the function (NB: not how many times the function is present, just if it is present or not – this is a normalised method), while a white cell indicates its absence in the Village Tract concerned;
4. The second-to-last row shows the "functions' frequency", i.e. the number of times that a given function is present in all the Village Tracts;
5. The last row shows the "functions' weighted value", calculated by dividing 100 (the conventional total value of each function) with the frequency: thus, functions are assigned a weight in inverse proportion to the frequency with which they occur.

6. The first column following the matrix itself (i.e. the black and white cells) shows the total number of existing functions for each Village Tract;
7. The third-to-last column shows the "total centrality score" calculated by adding the "weighted values" of the functions in as far as present in the row of the given Village Tract;
8. The second-to-last column shows the "condensed level of hierarchy" obtained by fixing a level whenever a big gap appears between one value of the centrality score and the next value;
9. The last column shows the grouping and classification of the Village Tracts according to the following 6 typologies: Main Village Tracts (MVT), Intermediate Village Tracts (IVT), Local Village Tracts (LVT); Main Urban Centres (MUC), Intermediate Urban Centre (IUC) and Local Urban Centre (LUC)

Figure 57. Organization of the Matrix of Functions



STEP 3: SPATIAL ANALYSIS OF THE MATRIX OF FUNCTIONS

A. Determining a preliminary functional hierarchy of human settlements

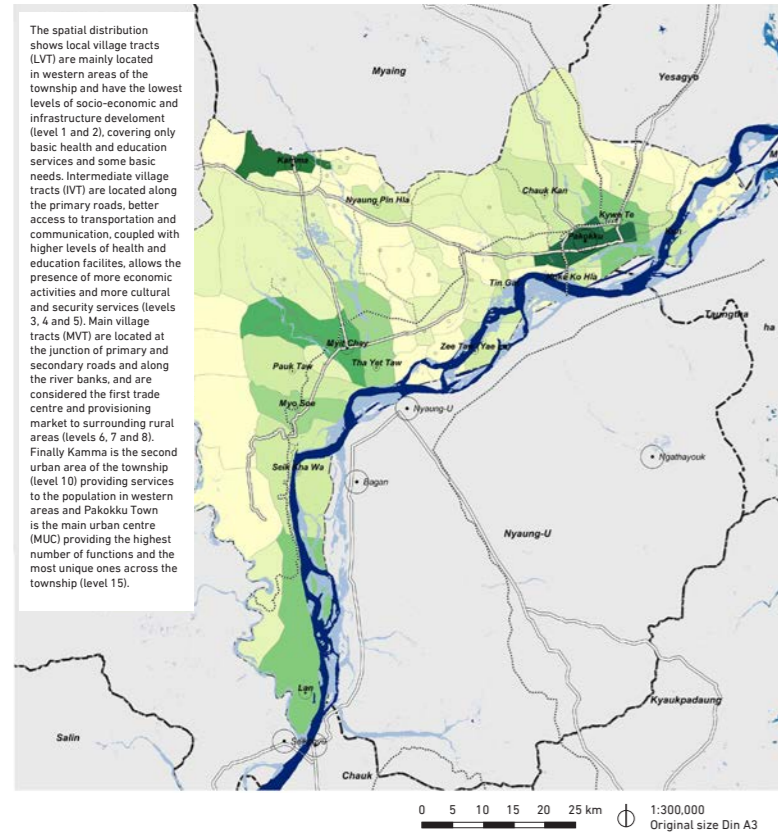
The analysis of the MoF allows to establish a functional hierarchy of settlements based on their "Total Centrality Score". Three types of Rural Village Tracts (local village tracts, intermediate village tracts and main village tracts) and two

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.

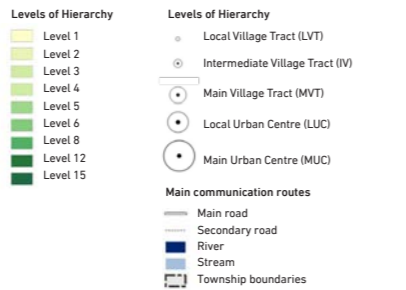
Figure 58. Typologies of Rural Village Tracts & Urban Wards

TYPE	Local village tract (LVT)	Intermediate village tracts (IVT)	Main village tracts (MVT)	Local urban centres (LUC)	Main urban centres (MUC)
CENTRALITY SCORE	37.80- 129.70	138.80 - 242.80	277.00- 417.10	670.60	967.80
LEVEL OF HIERARCHY	1 2	3 4 5	6 7 8	9 10 11	15
LEVEL OF DEVELOPMENT	Is considered the lowest level of infrastructure and socio-economic development. Transportation infrastructure is limited to unpaved roads. Electricity on grid, wells and ponds are the main public utilities and facilities available. Only basic health and education services are covered, while basic needs are provided through small groceries and street sellers. Agriculture and livestock are the main economic activities, together with some small businesses of weaving/sewing and carpenters	Is considered the second to the lowest level of infrastructure and socio-economic development. Access to better transportation and communication facilities coupled with higher levels of health and education facilities, allows the presence of more economic activities and more cultural and security services than the previous typology.	Is considered the highest level of rural settlements. Water and land transportation infrastructure allows the presence of markets, while the strategic location close to the river bank allows irrigation system.	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.
NUMBER AND TYPE OF FUNCTIONS THAT SHOULD BE COVERED	26 functions Eco-system services: Groundnuts, Beans, Livestock, Vegetables, Maize, Roof/wall material, Scrubland, Seasonal streams Infrastructure: Unpaved roads, Well with hand pump, Rain water harvest pond, Public Electricity Network on Grid Socio-economic services: Basic Education Primary Schools, Basic Education Post-Primary Schools, Public Sub-Rural Health Centre, Midwife, NGOs, Religious Organization/Monastery, Civil Society Organisation, Library, Bicycle Repair garage, Retail shop, Motor Vehicle Repair garage (motorbike /car), Carpenters, Street sellers, Weaving/ sewing	46 functions (26 from previous category +20) Eco-system services: Tobacco, Flowers, Grains, Rivers Infrastructure: Telecommunication Transmitter (Mobile Phone repeater), Paved road, Bus transport on daily basis, Petrol Supply Station, Private solar panel electricity supply Socio-economic services: Basic Education Primary Schools, Basic Education Middle Schools, Basic Education High Schools, Cultural Centre, Health Centre, Public Station Hospital, General Market, Livestock Market, Pharmacy, Lawyers	62 functions (46 from previous category +16) Eco-system services: Rice Infrastructure: Bus Station, Boat transport on daily basis (two ways same day), Sewerage drainage system, Irrigation system Socio-economic services: Public Rural Health Centre, Public Station Hospital, Plumbers, Post office, Police Check Point, Police Station, Fire Station, General Market, Livestock Market, Pharmacy, Lawyers	73 functions (62 from previous category +11) Eco-system services: Wood for charcoal, Oil extraction Infrastructure: Port/Harbour, Public Water Network On Grid (piped water) Socio-economic services: Public Township Hospital, Private Clinic, Dentist Banks/ western union, Fish market, Accountants, Aquaculture (Crabs / Shrimps),	777 functions (61 from previous category +4) Socio-economic services: Vocational Training Schools, University, Hotel, Eye specialist

2016 | Spatial distribution of the type of settlements (MOF)



Main cities and towns in Magway and neighbouring regions



Scale: 1:1,000,000, Original size Din A3 PPK09

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 located along the primary roads, better access to transportation and communication coupled with higher levels of health and education facilities, allows the presence of more economic activities and more cultural and security services;
- Main Village Tracts (MVT) are located at the junction of primary and secondary roads and along the river banks, and are considered the first trade centre and provisioning market to surrounding rural areas;
- Kamma is the second urban areas of the township providing crucial socio-economic services to the population in western areas;

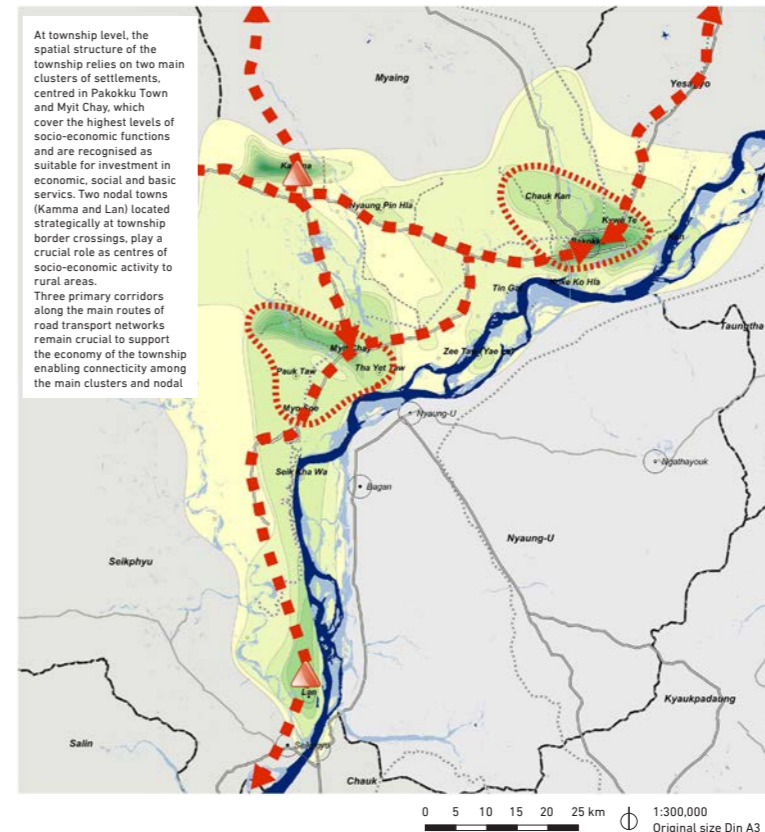
- Pakokku town is the Main Urban Centre (MUC) covering the highest number of functions and the most unique ones across the Township.
 - The assumption, in this assessment, is that human settlements that have fewer functions available are more vulnerable, and their vulnerability would be reduced by providing 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.

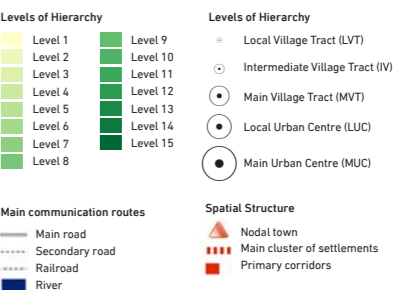
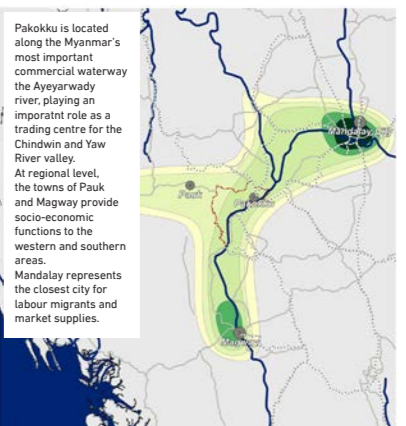
The cartographic representation of the "condensed levels of hierarchy" by using isopleths⁵² allows visualising the level of "territorial influence" (or not) of each Village Tract over its neighbouring Village Tracts at Township and Regional level and, identifying "clusters" of settlements (or areas of

⁵² 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.

2016 | Spatial structure and territorial linkages



Territorial linkages at regional level



Scale: 1:1,000,000, Original size Din A3 PPK10

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, Pauk and Magway providing main socio-economic functions to western areas and southern areas respectively, while Mandalay represents the closest city for labour migrants and market supplies.

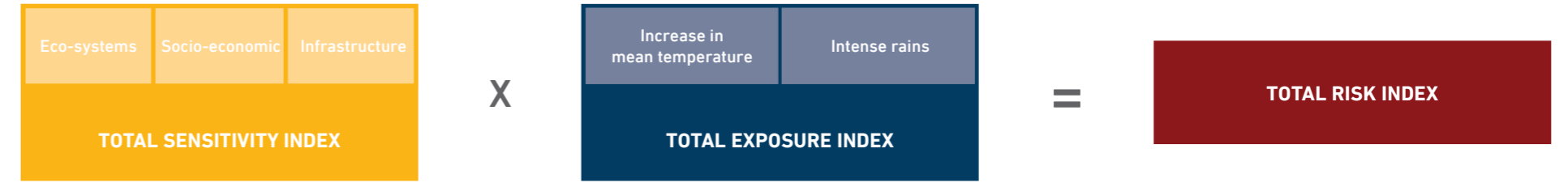
- At township, two main “Clusters” of settlements composed of a network of human settlements which support and complement each other in terms of socio-economic functions and road connectivity and are recognised as suitable for investment in economic, social and basic services.
- Two nodal towns (Kamma and Lan) located strategically at township border crossings, play a crucial role as centres of socio-economic activity to rural areas.

- Three primary corridors along the main routes of road transport networks towns: North-South: Yesagyo – Pakokku – Be - Myit Chay –Lan – Salin, North: Pakokku – Chauk Kan – Myaing Town and East-West: Pakokku – Kan Taw – Kamma – Pauk. These corridors remain crucial to support the economy of the township enabling connectivity among the main clusters and nodal towns.

LOCATION	Eastern area	Central area	North-Central area	Southern area																																																
TERRITORIAL INFLUENCE	The “territorial influence” of Pakokku Town, considered the main urban and trade centre of the township, is observed towards the north and east, along the primary roads to Mandalay City.	The “territorial influence” of Myit Chay, strategically located at the cross junction of primary and secondary roads, spreads along the primary road (paved) to Pakokku and along the secondary road (unpaved) to Kamma.	Located along the main road linking Pakokku Town with Pauk, appears to be rather isolated with weak territorial influence over the neighbouring village tracts	Strategically located at the southernmost part of the township, at the border with Seikphyu and Chauk Township, appears to be rather isolated with weak territorial influence over the neighbouring village tracts																																																
VILLAGE TRACTS	<table border="1"> <thead> <tr> <th>Name</th> <th>Level of hierarchy</th> <th>Typology</th> </tr> </thead> <tbody> <tr> <td>Pakokku Town</td> <td>15</td> <td>MUC</td> </tr> <tr> <td>Kywe Te</td> <td>6</td> <td>MVT</td> </tr> <tr> <td>Chauk Kan</td> <td>4</td> <td>IVT</td> </tr> <tr> <td>Koke Ko Hla.</td> <td>4</td> <td>IVT</td> </tr> <tr> <td>Kun</td> <td>4</td> <td>IVT</td> </tr> <tr> <td>Pakokku Kyun Ku</td> <td>3</td> <td>MUC</td> </tr> </tbody> </table>	Name	Level of hierarchy	Typology	Pakokku Town	15	MUC	Kywe Te	6	MVT	Chauk Kan	4	IVT	Koke Ko Hla.	4	IVT	Kun	4	IVT	Pakokku Kyun Ku	3	MUC	<table border="1"> <thead> <tr> <th>Name</th> <th>Level of hierarchy</th> <th>Typology</th> </tr> </thead> <tbody> <tr> <td>Myit Chay</td> <td>8</td> <td>LUC</td> </tr> <tr> <td>Tha Yet Taw</td> <td>5</td> <td>MVT</td> </tr> <tr> <td>Pauk Taw</td> <td>3</td> <td>IVT</td> </tr> <tr> <td>Nyaung Hla</td> <td>2</td> <td>IVT</td> </tr> </tbody> </table>	Name	Level of hierarchy	Typology	Myit Chay	8	LUC	Tha Yet Taw	5	MVT	Pauk Taw	3	IVT	Nyaung Hla	2	IVT	<table border="1"> <thead> <tr> <th>Name</th> <th>Level of hierarchy</th> <th>Typology</th> </tr> </thead> <tbody> <tr> <td>Kamma</td> <td>11</td> <td>LUC</td> </tr> </tbody> </table>	Name	Level of hierarchy	Typology	Kamma	11	LUC	<table border="1"> <thead> <tr> <th>Name</th> <th>Level of hierarchy</th> <th>Typology</th> </tr> </thead> <tbody> <tr> <td>Lan</td> <td>8</td> <td>MVT</td> </tr> </tbody> </table>	Name	Level of hierarchy	Typology	Lan	8	MVT
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TOTAL POPULATION	127,239 inhabitants (around 45% of the total population of the township)	24,907 inhabitants (8% of the total population of the township)	10,617 inhabitants (around 4% of the total population of the township)	9,910 inhabitants (around 3% of the total population of the township)																																																
FUNCTIONAL COMPLEXITY	This “cluster” has the highest levels of physical development which allows the presence of more types of economic activities.	Well-balanced “cluster” of settlements providing adequate infrastructure and socio-economic services to the population in the central and southern areas	Kamma is considered the second urban centre, providing main socio-economic services to the surrounding rural settlements in the north-western part of the township	Lan represents the main settlements providing main socio-economic services to the surrounding rural settlements in the southernmost part of the township																																																

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 VI	Ranking
	ECO-SYSTEMS			SOCIO-ECONOMIC			INFRASTRUCTURE				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 protection services		Strong winds (1-4)	Flooding	Drought	Heat Waves			
Kan Yat Gyi	1	4	1	4	4	1	4	1	4	24	2	1	3	3	9	216	1
Pa Daing Chon	1	4	2	4	4	1	4	1	4	25	2	1	3	3	9	255	2
Kan Hla	2	4	2	4	4	1	4	1	4	26	2	1	3	3	9	234	3
Chaing	1	4	2	4	3	1	4	1	4	24	2	2	3	3	10	240	4
Saik Ka Wa	1	4	1	3	3	1	4	3	4	24	2	3	2	3	10	240	4
Lan	v	4	3	3	3	1	4	3	4	24	2	3	2	3	10	240	4
Myo Soe	1	4	2	3	4	1	2	3	4	24	2	3	2	3	10	240	4
Nyaung Pin Hla	2	4	3	4	4	1	4	1	4	27	2	1	3	3	9	243	5
Hpa Lan Oh	2	4	3	4	4	1	4	1	4	27	2	1	3	3	9	243	5
Hpaung Kwe	2	4	3	4	4	1	4	1	4	27	2	1	3	3	9	243	5
Yae Lar	2	4	3	4	4	1	4	1	4	27	2	1	3	3	9	243	5
Lel Yar	3	4	3	4	4	1	4	1	4	27	2	2	3	3	9	243	5
Kamma	2	4	3	3	3	1	3	1	4	25	2	2	3	3	10	250	6
Kya Hote	2	4	2	4	3	1	4	1	4	25	2	2	3	3	10	250	6
Sa Bay	1	4	3	4	3	1	4	1	4	25	2	2	3	3	10	250	6
Myit Chay	2	4	3	3	3	1	4	1	4	25	2	3	2	3	10	250	6
Kywe Te	1	4	3	3	2	1	4	1	4	25	2	3	2	3	10	250	6
Kyun Nyo Gyi	3	4	3	4	4	1	4	3	4	28	2	1	3	3	9	252	6
Ga Wun Lay Taing	3	4	3	4	4	1	4	1	4	28	2	1	3	3	9	252	6
Nyaung Pin	3	4	3	4	4	1	4	1	4	28	2	1	3	3	9	252	6
Shin Ma Kan	3	4	3	4	4	1	4	1	4	28	2	1	3	3	9	252	6
Be	3	4	3	4	4	1	4	1	4	28	2	1	3	3	9	252	6
h Nauk Ma Gyi Kan	3	4	3	4	4	1	4	1	4	28	2	1	3	3	9	252	6
Myin Win	3	4	3	4	4	1	4	1	4	28	2	1	3	3	9	252	6
Shar Pin Kaing	3	4	3	4	4	1	4	1	4	28	2	2	3	3	9	252	6
Chauk Kan	2	4	3	4	3	1	4	1	4	26	2	2	3	3	10	260	7
Nyaung Hla	2	4	3	4	3	1	4	1	4	26	2	2	3	3	10	260	7
Myit Hpyar	2	4	3	4	3	1	4	1	4	26	2	3	2	3	10	260	7
Pakokku Town	2	4	3	3	1	1	4	1	4	26	2	1	3	3	10	260	7
Kan Taw	3	4	3	4	4	1	4	3	4	29	2	1	3	3	9	261	8
Ma Gyi Thone Pin	4	4	4	4	4	1	4	2	4	30	2	3	2	3	9	270	9
Koke Ko Hla	3	4	3	3	2	1	4	1	4	27	2	2	3	3	10	270	9
Ku	3	4	3	4	3	1	4	3	4	27	2	3	2	3	10	270	9
Kun	2	4	3	4	2	1	4	1	4	27	2	1	3	3	10	270	9
Kyee	4	4	4	4	4	1	4	3	4	30	2	2	3	3	9	270	9
Sa Nyaung	2	4	3	4	3	1	4	1	4	29	2	2	3	3	10	270	9
Deit Pyar	2	4	3	4	3	1	4	2	4	27	2	2	3	3	10	270	9
Myo Khin Thar	3	4	3	4	3	1	4	2	4	27	2	2	3	3	10	270	9
Shar Du	2	4	3	4	3	1	4	1	4	27	2	2	3	3	10	270	9
Yae Myet	3	4	3	4	3	1	4	2	4	27	2	3	2	3	10	270	9
Nay Kyun	2	4	3	4	2	1	4	1	4	27	2	3	2	3	10	270	9
Pauk Taw	2	4	3	4	2	1	4	3	4	27	2	3	2	3	10	270	9
Ma Gyi Pin Pu	2	4	3	4	2	1	4	3	4	27	2	3	2	3	10	270	9
Myin Kyun	2	4	3	4	2	1	4	3	4	27	2	3	2	3	10	270	9
Pan Kyun (Ku Kyun)	2	4	3	4	2	1	4	3	4	27	2	2	3	3	10	280	10
Kaung	3	4	3	4	4	1	4	3	4	27	2	2	3	3	10	280	10
Ah Shey Kan Hpyu	3	4	3	4	3	1	4	1	4	28	2	2	3	3	10	280	10
Chaik	2	4	3	4	3	1	4	2	4	28	2	1	3	3	10	280	10
Kyun (Kyun Ka Lay)	3	4	3	4	2	1	4	3	4	28	2	3	2	3	10	280	10
Zee Taw (Yae le)	1	4	3	4	2	1	4	3	4	28	2	3	2	3	10	280	10
Tin Gat	3	4	3	4	2	1	4	3	4	28	2	3	2	3	10	280	10
Pakokku Kyun Su	3	4	3	4	2	1	4	3	4	28	2	3	2	3	10	280	10
Mei Ze Li Pin Kone	3	4	3	4	2	1	4	3	4	28	2	3	2	3	10	280	10
Shar Pin	3	4	3	4	2	1	4	3	4	28	2	3	2	3	10	280	10
Shwe Dar	3	4	3	4	2	1	4	3	4	28	2	3	2	3	10	280	10
Tha Yet Taw	3	4	3	4	2	1	4	3	4	28	2	3	2	3	10	280	10

ANNEX 5. DETERMINATION OF COEFFICIENTS OF CHANGE UNDER 'BUSINESS-AS-USUAL' (BAU) SCENARIO

CAPACITY OF THE POPULATION TO BENEFIT FROM AGRICULTURE

The capacity of the population to benefit from agriculture in 2050, is estimated by applying a coefficient of reduction on 2016's baseline given the projected climate changes in temperature and rainfall, which will result in lower soil productivity, lower yields and more frequent damaged crops.

Assumptions

- We assume the percentage of employed people working in agriculture in 2016⁵³ is proportional to the number of people who depend on agriculture
- We assume the percentage of people depending on rain-fed agriculture is proportional to the percentage of land of this type in each VT⁵⁴
- We assume the percentage of people depending on irrigated agriculture is proportional to the percentage of land of this type in each VT⁵⁵

Coefficient of Climate Change (based on current trends)

- CC Agriculture production= 30% decline in rain-fed areas and 15% in irrigated areas
- CC Water shortage= 20% decline in rain-fed areas and 10% in irrigated areas
- CC Flood recurrence= 5% decline in riverbank areas

Calculations

- (i) Population depending on agriculture in 2016 = 46% of the total population in each VT (Census 2014)
- (ii) Population depending on rain-fed agriculture in 2016 = (i)*percentage of land of this type in each VT
- (iii) Population depending on irrigated agriculture in 2016 = (i)*percentage of land of this type in each VT

- (iv) Population depending on agriculture in 2050 = (i) – [(ii)*0.30 (CC 30% Increase temperature and less rainfall) + (ii)*0.10 (CC 10% water shortage) + (iii)*0.5 (CC 5% inundation recurrence)]

CAPACITY OF THE POPULATION TO HAVE ACCESS TO FRESHWATER SOURCES FOR DRINKING USE

The capacity of the population to have access to freshwater sources for drinking use in 2050, is estimated by applying a coefficient of reduction on 2016's baseline given the projected climate changes in temperature and rainfall, which will result in more evaporation of water from uncovered sources, less time to rain water harvesting, limited groundwater recharge and more frequent water facilities damaged.

Assumptions

- We assume the percentage of people having access to drinking water from census 2014 remains the same in 2016

53 Breakdown of economic activity in Pakokku 2014-2015. Township Planning Department

54 Area calculated based on custom classification of 2015 Landsat Imagery using Google Earth Engine

55 Area calculated based on custom classification of 2015 Landsat Imagery using Google Earth Engine

- We assume the observed impacts and trends will continue and no adaptive measure has been considered

Coefficient of Climate Change (based on current trends)

The following coefficients are spatially based considering the observed impacts and trends to estimate the worst future scenario to identify the most vulnerable areas of the township to maintain and support current living standards assessed in 2016.

CCC Temperature = 50% decline in surface water sources

Higher temperatures result in more evaporation of water from uncovered sources, hence half (0.50) of the current number of households will be able to access uncovered drinking water facilities (ponds, rivers, streams) in all areas across the whole township

CCC Drought =50% decline in groundwater water sources in rain-fed areas and 25% in irrigated areas

Less rainy days and shorter rainy season result in limited groundwater recharge which reduces the quality of water for drinking use and the number of households being able to dig deeper wells to access freshwater by half (0.50) in all areas across the township

CCC Floods recurrence= 25% in irrigated areas and 10% in rain-fed areas all sources

More intense rains result in damaged water facilities (ponds and wells) for longer periods by 2050, hence the estimated population having access to freshwater sources will be reduced by a quarter (0.25) in river banks areas and 10 per cent (0.10) in rain-fed areas.

Calculations

- (i) Households having access to drinking water in 2016 in irrigated areas = total number of HHs having access to “protected and unprotected wells and boreholes” and to “ponds, river, streams and waterfalls” per census 2014 in VT in irrigated areas

- (ii) Households having access to drinking water in 2016 in rain-fed areas = total number of HHs having access to “protected and unprotected wells and boreholes” and to “ponds, river, streams and waterfalls” per census 2014 in VT in rain-fed areas

- (iii) Households having access to freshwater sources in 2050 in irrigated areas = (i) - [(i)*0.50 (CCC rainfall+temp)⁵⁶ + (i)*0.25 (CCC drought)⁵⁷ + (i)*0.25 (CCC floods)]

- (iv) Households having access to freshwater sources in 2050 in rain-fed areas = (ii) - [(ii)*0.50 (CCC rainfall+temp)⁵⁸ + (ii)*0.25(CCC drought)⁵⁹ + (ii)*0.10 (CCC floods)]

- (v) Total number of households having access to freshwater sources for drinking use in 2016= (i) + (ii)

- (vi) Total number of households having access to freshwater sources for drinking use in 2050= (iv) + (v)

⁵⁶ This coefficient is applied to households using surface water sources

⁵⁷ This coefficient is applied to households using groundwater sources

⁵⁸ Climate change coefficients (CCC) are applied only to VT located in riverbank areas

⁵⁹ Climate change coefficients (CCC) are applied only to VT located near seasonal streams areas

⁶⁰ Climate change coefficients (CCC) are applied only to VT located in mountain areas

Village Tract Code	AREA COVERED BY TYPE OF AGRICULTURE		POPULATION DEPENDING ON AGRICULTURE 2016 (v and vi)	COEFFICIENTS OF CLIMATE CHANGE			POPULATION DEPENDING ON AGRICULTURE 2050 (vii)
	Type of Irrigation	Percentage of land in 2016 (ii and iii)		Agriculture production	Water shortage	Floods	
MMR009018001	Rainfed Agriculture	100.00%	1477	0.3	0.2		739
MMR009018002	Rainfed Agriculture	100.00%	807	0.3	0.2		403
MMR009018003	Rainfed Agriculture	100.00%	4884	0.3	0.2		2442
MMR009018004	Rainfed Agriculture	100.00%	973	0.3	0.2		486
MMR009018005	Rainfed Agriculture	100.00%	1397	0.3	0.2		698
MMR009018006	Rainfed Agriculture	100.00%	1081	0.3	0.2		540
MMR009018007	Irrigated Agriculture	91.67%	2646	0.15	0.1	0.1	1720
MMR009018007	Rainfed Agriculture	8.33%	241	0.3	0.2		120
MMR009018008	Irrigated Agriculture	4.65%	42	0.15	0.1	0.1	27
MMR009018008	Rainfed Agriculture	95.35%	866	0.3	0.2		433
MMR009018009	Irrigated Agriculture	79.89%	2416	0.15	0.1	0.1	1571
MMR009018009	Rainfed Agriculture	20.11%	608	0.3	0.2		304
MMR009018010	Irrigated Agriculture	2.92%	34	0.15	0.1	0.05	24
MMR009018010	Rainfed Agriculture	97.08%	1124	0.3	0.2		562
MMR009018011	Irrigated Agriculture	100.00%	136	0.15	0.1	0.05	95
MMR009018012	Irrigated Agriculture	93.54%	1286	0.15	0.1	0.05	900
MMR009018012	Rainfed Agriculture	6.46%	89	0.3	0.2		44
MMR009018013	Irrigated Agriculture	24.70%	1890	0.15	0.1	0.05	1323
MMR009018013	Rainfed Agriculture	75.30%	5763	0.3	0.2		2881
MMR009018014	Irrigated Agriculture	10.80%	85	0.15	0.1	0.05	59
MMR009018014	Rainfed Agriculture	89.20%	700	0.3	0.2		350
MMR009018015	Rainfed Agriculture	100.00%	1611	0.3	0.2		806
MMR009018016	Rainfed Agriculture	100.00%	2050	0.3	0.2		1025
MMR009018017	Irrigated Agriculture	14.23%	261	0.15	0.1	0.05	183
MMR009018017	Rainfed Agriculture	85.77%	1574	0.3	0.2		787
MMR009018018	Irrigated Agriculture	2.26%	57	0.15	0.1	0.05	40
MMR009018018	Rainfed Agriculture	97.74%	2695	0.3	0.2		1347
MMR009018019	Rainfed Agriculture	100.00%	950	0.3	0.2		475
MMR009018020	Irrigated Agriculture	0.64%	15	0.15	0.1	0.05	11
MMR009018020	Rainfed Agriculture	99.36%	2351	0.3	0.2		1175
MMR009018021	Rainfed Agriculture	100.00%	419	0.3	0.2		209
MMR009018022	Irrigated Agriculture	94.07%	4922	0.15	0.1	0.05	3446
MMR009018022	Rainfed Agriculture	5.93%	310	0.3	0.2		155
MMR009018023	Irrigated Agriculture	100.00%	546	0.15	0.1	0.05	382
MMR009018024	Irrigated Agriculture	17.26%	170	0.15	0.1	0.05	119
MMR009018024	Rainfed Agriculture	82.74%	816	0.3	0.2		408
MMR009018025	Rainfed Agriculture	100.00%	1336	0.3	0.2		668
MMR009018026	Irrigated Agriculture	35.42%	368	0.15	0.1	0.05	257
MMR009018026	Rainfed Agriculture	64.58%	670	0.3	0.2		335
MMR009018027	Irrigated Agriculture	55.83%	575	0.15	0.1	0.05	403
MMR009018027	Rainfed Agriculture	44.17%	455	0.3	0.2		228
MMR009018028	Rainfed Agriculture	100.00%	540	0.3	0.2		270
MMR009018029	Irrigated Agriculture	100.00%	695	0.15	0.1	0.05	487
MMR009018030	Rainfed Agriculture	100.00%	2404	0.3	0.2		1202
MMR009018031	Irrigated Agriculture	100.00%	424	0.15	0.1	0.05	299
MMR009018032	Irrigated Agriculture	39.01%	972	0.15	0.1	0.05	680
MMR009018032	Rainfed Agriculture	60.99%	1519	0.3	0.2		760
MMR009018033	Irrigated Agriculture	0.96%	10	0.15	0.1	0.05	7
MMR009018033	Rainfed Agriculture	99.04%	1065	0.3	0.2		532
MMR009018034	Rainfed Agriculture	100.00%	668	0.3	0.2		334
MMR009018035	Rainfed Agriculture	100.00%	2022	0.3	0.2		1011
MMR009018036	Irrigated Agriculture	18.18%	239	0.15	0.1	0.05	168
MMR009018036	Rainfed Agriculture	81.82%	1077	0.3	0.2		539
MMR009018037	Irrigated Agriculture	41.98%	643	0.15	0.1	0.05	450
MMR009018037	Rainfed Agriculture	58.02%	889	0.3	0.2		445
MMR009018038	Rainfed Agriculture	100.00%	327	0.3	0.2		163
MMR009018039	Irrigated Agriculture	100.00%	513	0.15	0.1	0.05	359
MMR009018040	Irrigated Agriculture	100.00%	889	0.15	0.1	0.05	622
MMR009018041	Irrigated Agriculture	26.88%	256	0.15	0.1	0.05	180
MMR009018041	Rainfed Agriculture	73.12%	698	0.3	0.2		349
MMR009018042	Irrigated Agriculture	18.27%	992	0.15	0.1	0.05	694
MMR009018042	Rainfed Agriculture	81.73%	4306	0.3	0.2		2153
MMR009018043	Irrigated Agriculture	10.86%	155	0.15	0.1	0.05	108
MMR009018043	Rainfed Agriculture	89.14%	1269	0.3	0.2		635
MMR009018044	Rainfed Agriculture	100.00%	719	0.3	0.2		359
MMR009018045	Irrigated Agriculture	80.11%	2292	0.15	0.1	0.05	1604
MMR009018045	Rainfed Agriculture	19.89%	569	0.3	0.2		285
MMR009018046	Irrigated Agriculture	77.43%	400	0.15	0.1	0.05	280
MMR009018046	Rainfed Agriculture	22.57%	117	0.3	0.2		58
MMR009018047	Irrigated Agriculture	100.00%	1010	0.15	0.1	0.05	707
MMR009018048	Irrigated Agriculture	17.18%	188	0.15	0.1	0.05	131
MMR009018048	Rainfed Agriculture	82.82%	904	0.3	0.2		452
MMR009018049	Irrigated Agriculture	100.00%	144	0.15	0.1	0.05	101
MMR009018050	Rainfed Agriculture	100.00%	884	0.3	0.2		442
MMR009018051	Rainfed Agriculture	100.00%	965	0.3	0.2		482
MMR009018052	Irrigated Agriculture	51.10%	2330	0.15	0.1	0.05	1631
MMR009018052	Rainfed Agriculture	48.90%	2229	0.3	0.2		1114
MMR009018053	Rainfed Agriculture	100.00%	1783	0.3	0.2		891
MMR009018054	Irrigated Agriculture	100.00%	690	0.15	0.1	0.05	483
MMR009018055	Irrigated Agriculture	23.75%	756	0.15	0.1	0.05	529
MMR009018055	Rainfed Agriculture	76.25%	2428	0.3	0.2		1214
MMR009018701	Irrigated Agriculture	100.00%	41787	0.15	0.1	0.05	29251

CAPACITY OF THE POPULATION TO HAVE ACCESS TO TRANSPORTATION SERVICES

The capacity of the population to have to transportation services in 2050, is estimated by applying a coefficient of reduction on 2016's baseline given the projected climate changes in temperature and rainfall, which will impact vegetation cover and soils by increasing landslides in riverbank areas and intense runoff in seasonal streams destroying unpaved roads, bridges and harbour facilities.

Assumptions

- We assume the percentage of people having transportation items from census 2014 remains the same in 2016
- We assume the observed impacts and trends will continue and no adaptive measure has been considered

Coefficient of Climate Change (based on current trends)

The following coefficients are spatially based considering the observed impacts and trends to estimate the worst future scenario to identify the most vulnerable areas of the township to maintain and support current living standards assessed in 2016.

CCC Erosion = 50% decline in riverbank areas, 25 % near seasonal streams and 10% in mountain area

Village Tract Code	TYPE OF AGRICULTURE	NUMBER OF HHs HAVING ACCESS TO DRINKING WATER	COEFFICIENTS OF CLIMATE CHANGE			NUMBER OF HHs HAVING ACCESS TO DRINKING WATER
			Temperture	Drought	Floods	
	Type of Irrigation	2016 (v)				2050 (vi)
MMR009018001	Rainfed area	817	0,5	0,5	0,1	327
MMR009018002	Rainfed area	363	0,5	0,5	0,1	145
MMR009018003	Rainfed area	2349	0,5	0,5	0,1	940
MMR009018004	Rainfed area	508	0,5	0,5	0,1	203
MMR009018005	Rainfed area	724	0,5	0,5	0,1	290
MMR009018006	Rainfed area	554	0,5	0,5	0,1	222
MMR009018007	Irrigated areas	1142	0,5	0,25	0,25	571
MMR009018008	Rainfed area	500	0,5	0,5	0,1	200
MMR009018009	Irrigated areas	1333	0,5	0,25	0,25	620
MMR009018010	Rainfed area	568	0,5	0,5	0,1	227
MMR009018011	Irrigated areas	80	0,5	0,25	0,25	40
MMR009018012	Rainfed area	735	0,5	0,5	0,1	294
MMR009018013	Irrigated areas	2038	0,5	0,25	0,25	820
MMR009018014	Rainfed area	459	0,5	0,5	0,1	184
MMR009018015	Rainfed area	492	0,5	0,5	0,1	197
MMR009018016	Rainfed area	1016	0,5	0,5	0,1	406
MMR009018017	Rainfed area	1025	0,5	0,5	0,1	410
MMR009018018	Rainfed area	917	0,5	0,5	0,1	367
MMR009018019	Rainfed area	515	0,5	0,5	0,1	206
MMR009018020	Rainfed area	1084	0,5	0,5	0,1	434
MMR009018021	Rainfed area	233	0,5	0,25	0,1	151
MMR009018022	Irrigated areas	2237	0,5	0,25	0,25	757
MMR009018023	Irrigated areas	285	0,5	0,25	0,25	143
MMR009018024	Rainfed area	514	0,5	0,5	0,1	206
MMR009018025	Rainfed area	631	0,5	0,5	0,1	252
MMR009018026	Rainfed area	489	0,5	0,5	0,1	196
MMR009018027	Irrigated areas	566	0,5	0,25	0,25	283
MMR009018028	Rainfed area	281	0,5	0,5	0,1	112
MMR009018029	Irrigated areas	345	0,5	0,25	0,25	170
MMR009018030	Rainfed area	1164	0,5	0,5	0,1	466
MMR009018031	Irrigated areas	201	0,5	0,25	0,25	101
MMR009018032	Irrigated areas	1170	0,5	0,25	0,25	584
MMR009018033	Rainfed area	416	0,5	0,5	0,1	166
MMR009018034	Rainfed area	377	0,5	0,5	0,1	151
MMR009018035	Rainfed area	1031	0,5	0,5	0,1	412
MMR009018036	Rainfed area	714	0,5	0,5	0,1	286
MMR009018037	Irrigated areas	807	0,5	0,25	0,25	356
MMR009018038	Rainfed area	174	0,5	0,5	0,1	70
MMR009018039	Irrigated areas	290	0,5	0,25	0,25	131
MMR009018040	Irrigated areas	467	0,5	0,25	0,25	234
MMR009018041	Rainfed area	437	0,5	0,5	0,1	175
MMR009018042	Rainfed area	2738	0,5	0,5	0,1	1095
MMR009018043	Rainfed area	722	0,5	0,5	0,1	289
MMR009018044	Rainfed area	382	0,5	0,5	0,1	153
MMR009018045	Irrigated areas	669	0,5	0,25	0,25	241
MMR009018046	Rainfed area	244	0,5	0,5	0,1	98
MMR009018047	Irrigated areas	499	0,5	0,25	0,1	324
MMR009018048	Rainfed area	536	0,5	0,5	0,1	214
MMR009018049	Irrigated areas	83	0,5	0,25	0,25	42
MMR009018050	Rainfed area	442	0,5	0,5	0,1	177
MMR009018051	Rainfed area	438	0,5	0,5	0,1	175
MMR009018052	Irrigated areas	604	0,5	0,25	0,25	217
MMR009018053	Rainfed area	583	0,5	0,5	0,1	233
MMR009018054	Irrigated areas	331	0,5	0,25	0,25	165
MMR009018055	Irrigated areas	1661	0,5	0,25	0,25	831
MMR009018701	Irrigated areas	12529	0,5	0,25	0,25	6248

More intense rains result in landslides in riverbank areas and intense runoff in seasonal streams damaging unpaved roads, bridges and harbour facilities reducing by half (0,50) the use of transport items in riverbank areas and by a quarter (0.25) in communities near seasonal streams.

CCC Floods recurrence= 25% in riverbank areas

More intense rains result in increased river flooding damaging unpaved roads, bridges and harbour facilities in riverbank areas reducing by a quarter (0,25) the use of transport items.

Calculations

- (i) Total number of households using transportation items in 2016= total number of HHs having transportation items per census 2014 in VT
- (ii) Households using transportation items in 2050 in riverbank areas = (i) – [(i)*0.50 (CCC erosion) + (i)*0.25(CCC floods)]
- (iii) Households using transportation items in 2050 in village tracts near seasonal streams = (i)*0.25 (CCC erosion)
- (iv) Households using transportation items in 2050 in village tracts in mountain areas = (i)*0.105 (CCC erosion)
- (v) Total number of households using transportation items in 2050 = (ii) + (iii)+(iv)

Village Tract Code	LOCATION	NUMBER OF HHs USING TRANSPORT ITEMS	COEFFICIENTS OF CLIMATE CHANGE		NUMBER OF HHs USING TRANSPORT ITEMS
			2016 (i)	2050 (iv)	
	Type	2016 (i)	Erosion	Floods	2050 (iv)
MMR009018001		591			591
MMR009018002		415			415
MMR009018003	Seasonal streams	3690	0,25		2768
MMR009018004	Mountain	748	0,1		673
MMR009018005	Seasonal streams	1030	0,25		773
MMR009018006		590			590
MMR009018007	Riverbank area	1941	0,5	0,25	485
MMR009018008	Seasonal streams	719	0,25		539
MMR009018009	Riverbank area	1858	0,5	0,25	465
MMR009018010		800			800
MMR009018011	Riverbank area	114	0,5	0,25	29
MMR009018012		1259			1259
MMR009018013	Riverbank area	5442	0,5	0,25	1361
MMR009018014	Seasonal streams/Mountain	281	0,35		183
MMR009018015	Seasonal streams	1158	0,25		869
MMR009018016	Seasonal streams	1389	0,25		1042
MMR009018017	Seasonal streams	533	0,25		400
MMR009018018	Seasonal streams/Mountain	1950	0,35		1268
MMR009018019	Mountain	572	0,1		515
MMR009018020	Seasonal streams/Mountain	1358	0,35		883
MMR009018021	Seasonal streams/Mountain	177	0,35		115
MMR009018022	Riverbank area/Mountain	2329	0,6	0,25	349
MMR009018023	Riverbank area	264	0,5	0,25	66
MMR009018024		809			809
MMR009018025		985			985
MMR009018026	Seasonal streams	595	0,25		446
MMR009018027	Riverbank area	672	0,5	0,25	168
MMR009018028	Seasonal streams/Mountain	193	0,35		125
MMR009018029	Riverbank area	577	0,5	0,25	144
MMR009018030		1901			1901
MMR009018031	Riverbank area	424	0,5	0,25	106
MMR009018032	Riverbank area/Mountain	1767	0,6	0,25	265
MMR009018033		802			802
MMR009018034		551			551
MMR009018035		1611			1611
MMR009018036		949			949
MMR009018037	Riverbank area	917	0,5	0,25	229
MMR009018038		262			262
MMR009018039	Riverbank area	576	0,5	0,25	144
MMR009018040	Riverbank area	751	0,5	0,25	188
MMR009018041		491			491
MMR009018042	Seasonal streams/Mountain	3744	0,35		2434
MMR009018043	Seasonal streams	776	0,25		582
MMR009018044	Seasonal streams/Mountain	419	0,35		272
MMR009018045	Riverbank area/Mountain	1521	0,6	0,25	228
MMR009018046		387			387
MMR009018047	Riverbank area	905	0,5	0,25	226
MMR009018048	Seasonal streams/Mountain	458	0,35		298
MMR009018049	Riverbank area	86	0,5	0,25	20
MMR009018050		726			726
MMR009018051	Seasonal streams	712	0,25		534
MMR009018052	Riverbank area/Mountain	3402	0,6	0,25	510
MMR009018053		1076			1076
MMR009018054	Riverbank area	633	0,5	0,25	158
MMR009018055	Riverbank area	2901	0,5	0,25	725
MMR009018701	Riverbank area	26634	0,5	0,25	6659

ANNEX 6. MAPS DESCRIPTION

THE USE OF GEOGRAPHIC INFORMATION SYSTEMS (GIS) IS ESSENTIAL TO CARRY OUT THE VA FOR THE ECO-SYSTEM COMPONENT, THE SOCIO- ECONOMIC COMPONENT, THE SPATIAL AND TERRITORIAL COMPONENT, THE CLIMATE MODELLING COMPONENT AND THE LAND-USE RISK MAPPING. IT PROVIDES THE NECESSARY SPATIAL DATA AND MAPS TO IMPLEMENT THE VA AND HELP VISUALIZING CLIMATE CHANGE SCENARIOS.

SPATIAL DATA SETS USED AND MAIN SOURCES

Myanmar Information Management Unit (MIMU)

The Myanmar Information Management Unit (MIMU) is a service to the UN Country Team and Humanitarian Country Team, under the management of the UN Resident and Humanitarian Coordinator. It maintains a common data and information repository with data from various sources on all sectors, countrywide, at the lowest administrative unit for which it is available.

The data sets have been captured on a national level and used for country and township level maps.

The following baseline data sets were used from the website (www.themimu.info), at national scale:

- Political and administrative boundaries: spatial data sets as of January 2014, the Republic of the Union of Myanmar is constituted of 14 States and

Regions plus 1 Union Territory, 74 districts, 330 townships, 84 sub-townships, 398 towns, 3,065 Wards, 13,619 village tracts and 70,560 villages. Place of codes (Pcodes) provide unique reference codes for the different levels of administrative units, they constitute the basis for linking the tabular information available to spatial features.

- Infrastructure: include spatial data sets of transportation networks (roads, railroads) and utility networks (electricity, gas...).
- Hydrology: spatial data sets of major hydrologic features such as main rivers and streams, inland water bodies, coastal features, etc. including names.

Digital Agricultural Atlas of the Union of Myanmar 20021-2002. Food and Agriculture Organization of the United Nations (FAO)

The atlas contains general data sets from international data providers and agricultural-related data sets generated from 2001–2002 statistics

collected at state/division and district level Tabular information and maps are available to support agricultural resources managers.

The following baseline data sets were used from the atlas:

- Soils: this topic portrays soils of the Union of Myanmar derived from the classification produced by the Ministry of Agriculture and Irrigation, Land Use Division, based on soil data collected in the 1950s. Suntac Technologies Inc. conducted the scanning and digitizing of hardcopy maps to produce the digital layer. Soil classification has generally been based on the distribution of the important land resources for agriculture. According to the modern classification, there are 24 main soil types. The characteristics of these soils are determined by: (i) the physical and mineral composition of the parent material; (ii) the relief (physical features); (iii) the climate under which the soil material has been developed; and (iv) the vegetation.

- Digital Elevation Model (DEM): show shape and elevation of landscape features such as mountains and valleys at national level.

World Wildlife Fund (WWF)

The following baseline data sets were used:

- Watersheds: the Global watershed boundaries and sub-basin delineations derived from HydroSHEDS data at 15 second resolution provides a series of polygon layers that depict watershed boundaries and sub-basin delineations at a global scale. All HydroBASINS layers were derived from World Wildlife Fund's HydroSHEDS data (Lehner et al. 2008; Lehner and Grill 2013) based on a grid resolution of 15 arc-seconds (approximately 500 m at the equator). For more information please refer to the Technical Documentation of HydroSHEDS at <http://www.hydrosheds.org>. It should be noted that the quality of the HydroSHEDS data is significantly lower for regions above 60 degrees northern latitude as there is no underlying SRTM elevation

data available and thus a coarser scale DEM has been inserted (HYDRO1k provided by USGS; see http://gcmd.nasa.gov/records/GCMD_HYDRO1k.html).

- Forest quality: Myanmar 2002-2014 forest cover change dataset. Retrieved from [ftp://glcf.umd.edu/glcf/Myanmar_ForestChange/], Bhagwat, T., A. Hess, N. Horning, T. Khaing, Z.M. Thein, K.M. Aung., K. H. Aung, P. Phyo, Y. L. Tun, A. H. Oo, A. Neil, W. M. Thu, M. Songer, K. LaJeunesse Connette, A. Bernd, G. Connette, P. Leimgruber, 2015. This Myanmar 2002-2014 forest cover change dataset is made available under the Open Data Commons Attribution License: <http://opendatacommons.org/licenses/by/1.0>.

Landsat TM and Landsat 8

Landsat represents the world's longest continuously acquired collection of space-based moderate-resolution land remote sensing data. Landsat images are a major source for mapping and research in agriculture, geology, forestry, regional planning,

education, and global change research. Landsat images are also invaluable for emergency response and disaster relief.

The Landsat Thematic Mapper (TM) sensor was carried on board Landsat 4 and 5 from July 1982 to May 2012 with a 16-day repeat cycle, referenced to the Worldwide Reference System-2. Landsat 4-5 TM image data files consist of seven spectral bands. The resolution is 30 meters for bands 1 to 7. The B&W band has a higher 15m resolution. Images are free and can be downloaded from <http://glovis.usgs.gov/>. Landsat images of the same area are available for different month and years.

The following baseline data sets were produced:

- Land cover at township level: The methodology for classifying the images was based on unsupervised classification (i.e. through an automatic definition of the classes), supported by visual interpretation from available Landsat TM images and by consultation of existing maps.
- Normalized Difference Vegetation Index (NDVI) at township level: the NDVI is a numerical indicator that uses the visible and near-infrared bands of

the electromagnetic spectrum, and is adopted to analyse remote sensing measurements and assess whether the target being observed contains live green vegetation or not. The multispectral bands allow analysis and insights shown in false colour or natural colour images. The near infrared band is very useful in detecting vegetation conditions and NDVI's.

NASA

The Shuttle Radar Topographic Mission (SRTM) digital elevation data, produced by NASA originally, is a breakthrough in digital mapping of the world, and provides a major advance in the accessibility of high quality elevation data for large portions of the tropics and other areas of the developing world.

There are two sources of free DEM data available covering the globe. The SRTM 90m grid and ASTER 30m grid. The accuracy of both data is similar but according to reports comparing the quality SRTM data have some advantages due to enhanced data processing. For data processing of coastal areas and hydrology, SRTM has advantages over ASTER data and is recommended widely.

For simulating sea level rise, these data are limited since the elevation interval of the raster grid is

1m. Nevertheless, severe floods of several meters caused by surge flooding and water level rise of rivers in the delta can be modelled with SRTM data. SRTM data are very suitable for creating elevation maps and contour lines.

The following baseline data sets were produced:

- Digital Elevation Map (DEM) at township level: Jarvis, A., H.I. Reuter, A. Nelson, E. Guevara, 2008, Hole-filled SRTM for the globe Version 4, available from the CGIAR-CSI SRTM 90m Database (<http://srtm.csi.cgiar.org>).
- Contour lines at township level: the original SRTM DEM was used to produce the contour lines spatial data sets.
- Ayeryawaddy river bed changes 2003-2016 in Pakokku: river edges were digitized directly from the processed satellite images Landsat TM and Landsat 8 images depending on the year.

Google earth

Both project areas, Labutta and Pakokku are covered completely by high resolution satellite images of Google earth, building a suitable basis for large

scale city mapping and feature generation. Using Google earth for large areas can be achieved by saving individual screen images and stitching them together to mosaics. In this way mapping is possible in scales 1: 5,000 to 1: 10,000. These images are suitable for visual interpretation or as reference for digitizing vector maps.

The following baseline data sets were produced:

- Transport infrastructure at township level: roads and railways at township level were generated directly in Google earth.
- Town maps: spatial data sets covering the town areas of Pakokku and Labutta.

Irrigation Department, Ministry of Agriculture and Irrigation

Geological map of Myanmar 2014: the topic depicts the geology of the Union of Myanmar compiled by Myanmar Geosciences Society.

Township Planning Department

Several maps from the Planning Department of each Township in PDF format were digitised to produce

the following data sets for each township:

Health facilities: location of health facilities

Water facilities: location of the different type of water facilities (wells, dams, water pumps...)

Transport infrastructure: location of bridges, harbours/ports and airports

Electricity and communication infrastructure: location of power lines and stations, and mobile repeaters

The 2014 Myanmar Population and Housing Census. Department of Population Ministry of Immigration and Population. May, 2015. (2014 MPH)

Disaggregated data at Village Tract level from the 2014 MPH was used to produce the following data sets:

Population: number of inhabitants and households per village tract, data from Table A-3 Population by urban/rural and sex; sex ratio and percent of population urban

Type of housing: number of households by type of housing unit per village tract, data from Table I-1 conventional households by type of housing unit

Source of water for drinking use: number of households by source of water for drinking use per village tract data from Table J-2: Conventional households by source of water for drinking use

Source of water for non-drinking use: number of households by source of water for non-drinking use per village tract data from Table J-3: Conventional households by source of water for non-drinking use

Transport items: number of households by availability of transportation items per village tract, data from Table J-6. Conventional households by availability of transportation items

The following spatial data sets were produced using the participatory natural hazard mapping exercises conducted during the community consultations:

- Hazards: location of main hazards and impacts observed such as, storm surge, main deforested areas, salinity areas, ...

Matrix of functions (MoF)

The following spatial data sets were produced using the information collected in the Matrix of Functions Questionnaire and the spatial analysis carried out:

- Typologies of village tracts: based on the categories derived from the analysis of the MoF
- Isopleths: cartographic representation of the “levels of hierarchy” by using isopleths.⁶¹

Technology used

Software for GIS data generation, data processing and mapping used:

ArcGIS

Commercial high end GIS- software with all necessary tools for data generation and processing. Widely used and compatible with other software. Expensive.

QGIS

Open Source GIS- software. Most popular and applied GIS-software worldwide. The software is user-friendly for basic functions. Advanced data processing can be difficult since there is no clear support of extension tools, help functions and error detection. Knowledge has to be found on the internet, requiring high skills and much time for the GIS staff.

Google Earth Pro

Free software for data generation directly from satellite images. Very helpful and easy to use software to digitize vector data. Data can be converted to shapefile format.

El-ShayalSmart

Free software to generate mosaics of large areas from Google earth images.

Coordinate System

Myanmar is divided into 2 UTM Zones (Zone 46 and Zone 47), Pakokku is situated in Zone 46.

⁶¹ 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.



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