A Socio-Ecological Assessment of Mangrove Areas in Sittwe, Pauktaw, Minbya and Myebon Townships, North Rakhine State

Myanmar

Assessment Report

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Dave Storey, Consultant

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Cover photo:

SUMMARY

Using a combination of remote sensing and data retrieved from the field, this Socio-Ecological Assessment sought to investigate the major trends and drivers of change affecting the current status of mangroves in Sittwe, Pauktaw, Minbya and Myebon townships in northern Rakhine state under the IOM-led consortium project, the "Program for Improved Disaster Management and Resilience against Natural Disaster in Rakhine State, Burma/Myanmar."

In support of this study, a remote sensing analysis of mangrove coverage in 1988, 2000, and 2015 was conducted by UNOSAT. According to this analysis, Myebon and Pauktaw have lost 22 and 43 percent of their mangroves over the course of the reference period, signifying an alarming rate of loss. On the other hand by 1988, Minbya and Sittwe had already lost most of their mangroves and in fact experienced modest gains during the reference period.

In order to understand the drivers and dynamics behind these observed changes, the remote sensing was followed up by a review of secondary data and primary data collection, through participatory assessments, in six villages across the project area. These exercises indicate that the major causes for the losses in mangroves in Myebon and Pauktaw were ambiguities over land tenure and corruption, an overall increase in extensive shrimp and rice farms, as well as ongoing firewood collection for domestic use. Additional factors are the cumulative impact of natural disasters as well as the repercussions of recent conflict.

Those most affected by the mangrove degradation include fishers and shrimp farmers who have experienced a serious decline in their primary means of livelihoods. In addition, partly due to deforestation, villagers in the area are now significantly more exposed to the threat of natural disasters, especially in terms of cyclones and flooding as well as ongoing riverbank and shoreline erosion.

The report concludes by recommending that actors working on mangrove ecosystems in the state, more specifically to:

- Work to raise the knowledge and awareness of local people on the importance of protecting the ecosystem on which they depend.
- Investigate broader social, economic and ecological contexts of mangroves in Rakhine state as well as in Myanmar more generally, with specific focuses on issues such as land tenure, priority areas for protection and the potential of community forestry and ecological mangrove restoration.
- Investigate options for long term financing for mangrove protection, in particular the option of carbon funding.

CONTENTS

List of Acronyms

CBO	Community-based organisation
CCA	Climate change adaptation
CSO	Civil society organisation
CERA	Community Empowerment and Resilience Association
GAD	General Administration Department
DoF	Department of Forests
DoFi	Department of Fisheries
DRR	Disaster Risk Reduction
EMR	Ecological mangrove restoration
FAO	United Nations Food and Agriculture Department
HDDS	Household Dietary Diversity Score
IOM	International Organisation for Migration
LIFT	Livelihoods and Food Security Trust Fund
MOECAF	Ministry of Environment, Conservation and Forestry
NGO	Nongovernmental organisation
PRA	Participatory rural appraisal
RRD	Relief and Resettlement Department
SEA	Socio-Economic Assessment

PRA Villages

ATNKC	Ah Twin Nga Khu Chaung
KT	Kyay Taw
NTK	Nan Tet Kyun
NWS	Nga Wey Sway
PYNKC	Pyin Nga Khu Chuang
TPK	Taung Poke Kay

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1. INTRODUCTION

Myanmar's north-western coastal state of Rakhine is exposed to multiple natural hazards, including cyclones, tropical storms, flooding, earthquakes and their associated tsunamis. Rakhine has been hit by seven cyclones since 1968. Since 2000 alone, strong winds and storm surges from cyclones in 2004, 2006 (Mala) and 2010 (Giri) have caused major damage to infrastructure and livelihoods in the coastal areas of the state, although fortunately without the huge loss of life accompanying cyclone Nargis (2008) in the Ayeyawady delta region. In addition, the region is vulnerable to the lower-frequency but still present threat of earthquakes and tsunamis from the Bay of Bengal, or inland from a local fault system north of Sittwe. Upland regions in the eastern parts of the state also experience occasional exposure to forest fires and landslides, with 46 people being killed by a landslide in Maungdaw Township in 2010.[1]

People's vulnerability to these hazards is exacerbated by weak infrastructure and chronic underdevelopment. Physically, Rakhine is isolated from the rest of the country, largely cut off by inaccessible ranges of mountains and hills. Within the state there are few paved roads, with transport links in several areas being limited to weather-dependent boat routes.[2] The 2009-2010 UNDP Integrated Household Living Condition Survey ranked Rakhine state as second worst countrywide in terms of overall poverty (43.5% compared to the national average of 25.6%) and food poverty (10% against the national average of 4.8%).[3] A subsequent World Bank reestimation using the same data, recently revised overall poverty incidence in Rakhine upwards to 78%—the highest in the country compared to a revised national average of 37.5%.[4] The state also fares poorly on a range of other sectoral indicators. For example, it has the lowest percentage of households with access to improved sanitation in the country (48% compared to a national average of 84%), as well as the lowest primary school enrolment rate (71.4% compared to a national average of 87.7%).[5]

These issues have been further sharpened by sectarian tensions resulting from an outbreak of violence in 2012. As of July 2015, around 145,000 people were living in displacement camps or temporary sites across the north of the state—many of which are built in low-lying coastal areas with few disaster management or mitigation measures in place. Affected populations are found to be especially vulnerable, frequently dependent on external support for food and shelter, cut off from livelihood activities by movement restrictions and a lack of opportunities in situ, and disempowered by lack of clarity over their legal status.[6]

Against this background, the Program for Increased Disaster Management and Resilience Against Natural Disaster (IDM-RAND) was launched in late 2014. IDM-RAND is run by a consortium of organisations comprising IOM, ACTED, the Asian Disaster Preparedness Centre, Swiss Resource Centres and Consultancies for Development, and Swanyee Development Foundation. It focuses on reducing disaster risk in targeted areas through interventions across six key priority areas: 1) improving readiness through improving local government disaster management planning and coordination; 2) improving construction practices to increase resilience; 3) improving the effectiveness of hazard early warning systems; 4) increasing disaster management and preparedness skills among local Disaster Risk Reduction (DRR) actors; 5) increasing awareness and education on DRR; and 6) protection of mangroves as a barrier against coastal hazards. It will run from 2014 to 2017 across the following five townships: Maungdaw, Sittwe, Pauktaw, Minbya and Myebon (see Map 1).

[1] United Nations Development Programme (UNDP) / Asian Disaster Preparedness Center (ADPC) - Multi Hazard Risk Assessment in Rakhine State of Myanmar (Yangon, 2012).
[2] UNDP – Local Governance Mapping: The State of Local Governance: Trends in Rakhine (Yangon, 2015).
[3] UNDP – Integrated Household Living Conditions Survey in Myanmar (2009-2010) (Yangon, 2011).
[4] World Bank Group – Myanmar: Ending poverty and boosting shared prosperity in a time of transition: A systematic country diagnostic (Yangon, 2014).
[5] Ministry of National Planning and Economic Development/Ministry of Health/United Nations Children's Fund (UNICEF) – Multiple Indicator Cluster Survey 2009-2010 (Yangon, 2011).
[6] See Myanmar Information Management Unit's Rakhine emergency page: http://www.themimu.info/emergencies/rakhine (accessed 21 October 2015).

Map 1: IDM-RAND Consortium Target Townships

In a secondary review of available evidence and existing programming conducted at project inception, IDM-RAND found that despite evidence of widespread and accelerating encroachment of Rakhine's mangrove forests, management of this critical resource is only weakly integrated into previous and ongoing DRR programming in the state. It also identified weaknesses and contradictions in the existing evidence base regarding the drivers of mangrove degradation in the state, as well as diverging figures from a variety of sources on both existing levels of mangrove coverage in the state and rates of change over time.

Given that well-managed mangrove areas can both reduce people's exposure to natural hazards and provide a sustainable basis for livelihoods, IDM-RAND will work to advocate for ecosystem-based DRR approaches with the government, civil society and local communities. In order to support this process and fill the evidence gaps mentioned above, REACH was contracted to conduct a Socio-Ecological Assessment (SEA) of mangrove areas in northern Rakhine state, specifically in the townships of Sittwe, Pauktaw, Minbya and Myebon.[7] The assessments objectives were as follows:

- **Overall objective**: to convincingly advocate for the rehabilitation of the coastal mangroves as part of an integrated, ecosystem-based approach to DRR, and thereby reduce the vulnerability of the local population.

[7] While Maungdaw Township was originally selected to be included in this assessment, weather-related barriers to collecting data and incomplete remote sensing data for this part of the state meant that little meaningful data could be collected for the township. Due to the substantially different socio-economic context in Maungdaw compared to the other assessment townships, it was felt that extrapolation of trends from other townships would not be valid in this case, and it was therefore excluded from the assessment.

- **Specific objective:** to raise awareness about the socio-ecological drivers of change affecting the current state of mangroves in Northern Rakhine state, and how these changes influence the vulnerability of the local population.

In order to achieve these objectives, the assessment seeks to answer the following key questions:

- What is the current status of the mangroves in the five townships covered by the project?
- Within the last 30 years, what has been the extent of mangrove coverage in the area and how has this changed over time?
- In which specific ways have human activities affected mangrove distribution and condition over the last 30 years?
- Who are the people which depend on the ecosystem services provided by mangroves?
- In which ways, and to what extent, do / did the mangroves provide ecosystem services to the local population over the last 30 years?
- How have the changes in the status of the mangroves effected those dependant on them vis a vis their capacities and vulnerabilities?
- What can be done to rehabilitate the mangroves?

The results of the assessment are intended as a tool for advocacy. For this reason, the primary target audience chosen were the local leaders and opinion makers from the village, to township and state levels.

The remainder of this report is structured as follows: Section 2 presents details of the study's methodology; Section 3 presents a summary of a secondary data reivew; Section 4 presents evidence from the study's remote sensing exercise; Section 5 presents evidence from the study's field-based participatory rural appraisal component; Section 6 provides a synthesis analysis of study findings; and Section 7 provides a summary conclusion and a set of recommendations.

2. METHODOLOGY

The assessment used three complementary approaches to achieve its objectives: a secondary review of existing data conducted in order to understand the overall context of ecosystem use and degradation in the state; a review of remote sensing data on land coverage in order to obtain objective data on the extent and rates of mangrove degradation; and primary data collection through a participatory rural appraisal (PRA) approach in order to examine the causes and dynamics of mangrove degradation.

Desk review

Prior to and in parallel with other research activities, a comprehensive desk review was conducted on two complementary thematic areas of existing secondary data:

- Secondary data directly related to the socio-economic and ecological context of Rakhine state
- Secondary data on wider evidence and best practice related to Disaster Risk Reduction (DRR), coastal livelihoods and eco-system management

Remote Sensing

The remote sensing aspect of the SEA took the form of a whole-state land cover classification analysis conducted by UNOSAT using Landsat imagery. Data were captured for the following three years: 1988, 2000, and 2015. These years were selected in order to provide a picture of shifting trends in landcover over the course of the study's 30-year reference period, within the constraints of the available budget. The analysis used a variety of methods including principal component analysis and normalised difference vegetation index (NDVI) to produce a 30m-resolution dataset of five different land coverage categories for each year (mangroves; closed canopy forest; open canopy forest/grassland; agricultural/paddy areas; and denuded/barren soil).[8] This exercise was followed by a ground-truthing exercise conducted in Pauktaw Township to validate the results.

In addition to providing data at the state and township level, remote sensing data on land-use change were also used in combination with recent Google Earth imagery to triangulate village-level results emerging from the PRA component of the study.

Participatory rural appraisal

The initial list of villages selected for involvement in the PRA exercise was developed by cross-referencing vulnerability to natural hazards[9] with extent of mangrove loss over the reference period. Mangrove loss was divided into three categories. An initial set of 12 villages were selected for assessment from across all five project townships. However, due to a cyclone and catastrophic flooding during the field data collection period, only six villages were visited, spread across Sittwe, Pauktaw, and Myebon townships (see Table 1 below).

Table 1: Categories of mangrove cover loss

Category	% intact	% degraded or deforested	Number/location of villages assessed
Category 1	80 - 100%	0 – 20%	2 (Pauktaw 1, Sittwe 1)
Category 2	50 – 80%	20 – 50 %	3 (Myebon 2, Pauktaw 1)
Category 3	< 50 %	> 50 %	1 (Pauktaw)

[8] For further technical details of the analysis see United Nations Institute for Training and Research Operational Satellite Applications Programme (UNOSAT) - UNOSAT Concept Note: Myanmar Landcover Classification Methods (Geneva, 2015), available on request from geneva@reach-initiative.org

[9] Vulnerability here defined by height above sea level and population density. Data and approach derived from United Nations Development Programme/ADPC – Multi Hazard Risk, and ADPC/Malteser International - Climate Change Impacts and Vulnerability Assessment in Rakhine State [Draft] (Yangon, 2014).

Data were collected by a team of three staff comprised of an ACTED disaster risk reduction (DRR) specialist and two staff from Community Empowerment and Resilience Association (CERA), an organisation with extensive local knowledge and experience working on mangrove recovery programming.

The team took part in an initial two-day training workshop on overall research approach and research tools (see below). An initial pilot visit was conducted in a rural village in Sittwe before full roll-out across the remaining five villages. For each village, the team conducted an initial visit to explain the research and secure buy-in for community members. This was followed by two days of data collection involving approximately 15 male and 15 female participations from a range of ages and socio-economic backgrounds.

In each site, the team used the following combination of participatory research tools:[10]

- **Historical profile** – to gather data on the history of the community, focusing on key events and changes that may have had an impact on livelihood activities and local ecosystems.
- **Trend lines** – to understand changes over time in the amounts of different non-timber forest products collected from mangrove areas.
- **Money purse exercise** – to understand communities' sources of income and expenditure and how these have changed over the years, as well as how these trends correlate with changing mangrove status.
- **Transect walks and participatory resource mapping** – to better understand dynamics surrounding different types of land use in the village and how these relate to other data collected on livelihoods and income generation.
- **Informal interviews**– conducted on an ad-hoc basis throughout the research process with as many different stakeholders as possible, in order to triangulate and explore gaps or contradictions in the data collected through other exercises, as well as provide a greater level of contextual depth.
- **Photographs and personal observations** – teams were encouraged to take photographs and record their personal reflections throughout the research process in order to provide further triangulation and contextual data.

These tools generated large volumes of data in the form of maps and charts – drawn mainly by community members themselves – as well as photographs, interview transcripts and field notes. At the end of each site visit, the team conducted a thorough debriefing session and translated the data into a standard reporting template for each community.

Limitations

This study does not claim to produce a comprehensive overall picture of the state of mangrove ecosystems in Rakhine, nor does it produce statistically representative data at community level that can be generalised to any particular population. Instead, it has opted to combine objectively verifiable quantitative data on mangrove coverage, in-depth qualitative data on the different factors combining to cause mangrove degradation over time, and a thorough review of existing evidence, in order to provide an overview of **some of the key themes** surrounding mangrove ecosystems in the state. Limitations specific to the study's different approaches are discussed in detail below.

Remote sensing

Due to the limitations of the satellite images available, the northern tip of the State could not be included in the mapping and analysis process. Therefore the conclusions made cannot be regarded as the final word on land use coverage for all of the Rakhine state. In addition, slight differences between the size and shape of images from year to year place some additional limitations on the accuracy of the data. These are clearly flagged in subsequent presentation of results.

Due to extensive flooding across the project's coverage area during the field research period, it was also not possible for the research team to extensively ground-truth findings from the remote sensing data. However, ground observations did indicate that in several cases, areas categorised as mangrove-covered by the remote sensing

[10] All of the above are common tools used in PRA processes. For more information and examples, see International Institute for Rural Reconstruction – Participatory Methods in Community-based Coastal Resource Management (Silang, Philippines, 1998).

analysis, were in fact heavily degraded. **It is therefore important to note that the remote sensing data does not make any distinction between healthy and degraded mangrove**, and therefore may over-state the true extent of mangrove coverage in the state.

In addition, **the assessment was unable to make a distinction—vital in the case of analysing mangrove degradation—between paddy fields and shrimp farms, classifying them both as agricultural land**. Furthermore, variations in the level of inundation of land areas between reference periods mean that changes in the area of mangrove, and paddy/shrimp farms reported may in part be driven by levels of flooding as opposed to actual changes in land use.

While data on land cover change can provide a solid indicative picture of broad trends at the township level, it should be used cautiously in the absence of more detailed data. Where possible, it should also be used in conjunction with field assessments (as below) in order to avoid confusion or misattribution of drivers of any changes observed.

PRA

As discussed above, the reduced number of sample villages means the study was not as comprehensive in its geographical coverage as intended and may therefore have missed important local contextual issues. However, the spread of coverage between the three different mangrove degradation categories together with similarities in the trends observed across the data collected suggest that the data are adequate to make valid general statements about important trends in the four townships covered.

At village level, a number of limitations were also noted by the team:

- Village administrators were contacted before the field visits to assemble a mixed group of people for the participatory exercises. The result was that while participation in the discussions was generally broad-based, there appears to have been a slight bias in favour of literate people.
- Understandably villagers were reluctant to talk about the details of savings and loans and as this was not the priority for this assessment, the topic was largely overlooked. However, this gap is likely to have affected the accuracy of the data on income and expenditure.
- Due to the presence of village administrators in many discussions, as well as collective memory of recent state repression and surveillance, community members may have been somewhat reluctant to discuss issues related to corruption, nepotism, and state involvement in the context of mangrove clearance. However, these issues were discussed on a number of occasions despite the presence of the village administrator, reflecting the importance of this issue for community members.

3. LITERATURE REVIEW

This section is structured thematically in three sections which outline the commonly applied aspects of sustainability, namely: Society, Economy and the Environment. Each section begins by presenting a general overview before focusing on specific issues related to mangroves and finally concluding with a summary.

Society

General overview – Human development

Population

Myanmar's annual population growth rate was 1.98% in 2010 and saw a rapid decline to 0.9% in 2015. In comparison, in Rakhine state the growth rate was at 1.8% in 2010.[11] Unfortunately, hard data for Rakhine state in 2015 are not available, as large parts of the population in the townships of north Rakhine, were not included in the 2014 national census.

In 2010 the total official population of the state was given as 3,222,461.[12] Population densities for Rakhine state as a whole was estimated at 87 persons per square kilometre in 2014, not too dissimilar to the average population density of the country, measured at 82 persons per square kilometre.[13] Within Rakhine however, population densities vary widely between the townships. Among the townships selected for the study, Myebon and Minbya in particular have a much lower population density than other townships.

Table 2: Township population densities compared with state and national average[14]

	Maungdaw	Sittwe	Pauktaw	Minbya	Myebon	Rakhine	Myanmar
Population density (people / Km^2)	303	1245	159	60	53	87	82

Key development indicators

The estimated proportion of the population living below the poverty line in Rakhine state is 44%, second only to Chin State. This is in comparison with the national figure given as 38%.[15] Rakhine state is ranked as the second lowest region for access to sources of improved drinking water as well as for treated water. As far as sanitation, Rakhine state has by far the lowest coverage and as for nutrition, Rakhine state as a whole is ranked the worst region for underweight and wasting prevalence and second worst for stunting prevalence among infants (38%, 50% and 11% respectively).[16]

Table 3: Comparisons of general development indicators for Rakhine State[17]

	Poverty level	Literacy	Access to improved water sources	Access to improved sanitation	Infant mortality	Electricity access	Use of firewood as fuel
Rakhine	44%	75%	58%	48%	65%	13%	89%
Myanmar	38%	90%	82%	85%	62%	32%	69%

[11] Ministry of National Planning and Economic Development / Ministry of Health / UNICEF – Myanmar Multiple Indicator Cluster Survey (MICS) 2009-2010 (Yangon, 2011); Department of Population, Ministry of Immigration and Population – The 2014 Myanmar Population and Housing Census: The Union Report (Nay Pyi Taw, 2015).
[12] UNICEF – Rakhine State: A Snapshot of Child Wellbeing (Yangon, 2013).
[13] Department of Population – The 2014 Myanmar Population and Housing Census.
[14] Ibid.
[15] UNICEF – Rakhine State
[16] Ibid.
[17] Source for poverty level and literacy: UNDP – Integrated Household Living Conditions Survey (IHLCS) in Myanmar (2009-2010): Poverty Profile (Yangon, 2010); source for water and sanitation: UNICEF – A Snapshot of Child Wellbeing; source for firewood: Baseline Data Census Dataset: Township Level Dataset (accessed 21 October 2015); source for electricity access and firewood use: Department of Population - The 2014 Myanmar Population and housing census.

Society in relation to mangroves

Governance

The General Administrative Department

In practical terms, the General Administrative Department (GAD) is the central coordinating body for all other government departments in Myanmar.[18] The GAD plays an essential role in a wide range of activities related to mangroves, from collecting tax to land registration and land use planning. In addition, GAD representatives are present from the state-level down to village-level.

As far as rural areas are concerned, the GAD is in charge of the rural development funds of the Government. At the township level the GAD is seen to have an important role in commercial enterprises that may have social implications, such as the shrimp and prawn value chain, as well as the firewood and charcoal trade. A key challenge as far as determining the status of the mangroves is the relatively short institutional memory in the GAD, as officials are routinely rotated in three-year cycles.[19]

Relief and Resettlement Department

According to the 2013 Natural Disaster Management Law the Relief and Resettlement Department (RRD), under the Ministry of Social Welfare, Relief and Resettlement is designated as the lead agency for implementing disaster management activities, including pre-disaster DRR.[20] However, based on experience in Rakhine state during the recent flooding, RRD does not appear to have fully adopted this role in practice, with the GAD still taking the lead on much of the post-disaster response.[21]

The Myanmar Armed Forces

The Myanmar armed forces, officially known as Tatmadaw, have been accused of using forced labour to extensively clear the mangrove forests in the past.[22] In Rakhine state this situation was reported to be particularly extreme in the case of the Na Sa Ka border guard force which has now been disbanded. Due to the obvious challenges of verifying these claims, it is not clear to what extent these practices actually occurred and how much they have continued up until the present.

Rule of law

Land tenure

Officially all land in Myanmar belongs to the State and land-use rights are granted for specific periods depending on the location, status and proposed use of the land. The uncertainties and power imbalances inherent in this arrangement have led to widespread conflicts surrounding land confiscation or land grabs, especially in the post-2010 context of increased foreign investment and a push from the state for higher agricultural output.[23] This set of factors presents a potentially challenging context in which to pursue the responsible stewardship of natural resources.

Forest resources

Technically speaking, mangroves surveyed in the assessment fall under the responsibility of the Department of Fisheries as part of the Ministry of Livestock, Fisheries and Rural Development. Mangroves are classed either as

[18] K. P. Saw and M. Arnold – Administering the State in Myanmar - An Overview of the General Administration Department (Yangon, 2014).
[19] Ibid.
[20] Natural Disaster Management Law (accessed 21 October, 2015).
[21] Discussions with UN and NGO staff in Sittwe, August 2015.
[22] Burma Environmental Working Group (BEWG) - Cut into the Ground: The Destruction of Mangroves and its Impacts (Bangkok, 2009); K. Duh Wan and K. Ryder - Mangrove Deforestation, Shrimp farming and the survival of the coastal Arakanese. In Natural Light. A Journal for Burmese Social Forces, 5 – 16 (April, 2007); M. Macan-Markar - Mangrove Loss Exacerbated Cyclone Devastation (accessed 21 October, 2015)
[23] United States Agency for International Development (USAID) - USAID Country Profile: Property Rights and Resource Governance, Burma (Washington, D.C., 2014)

"primary" – protected forest reserve under the Ministry of Forestry – or "secondary" – available for aquaculture under the jurisdiction of the Department of Fisheries.[24] According to an interview with the head of the Department of Forestry (DoF) under the Ministry of Environment, Conservation and Forestry (MOECAF) in Sittwe, the only legal authority that the department holds over mangroves in the State is over the Wunbaik Forest Reserve in Ramree Township.

As none of the villages surveyed fall within a forest reserve, it may be concluded that the remaining mangroves in the state are officially classified as "secondary" and technically fall under the jurisdiction of the Department of Fisheries (DoFi). DoFi considers these areas as "degraded unclassed mangrove forests,"[25] and therefore eligible for aquaculture. Myanmar has a large number of legislations regarding the harvesting of wood for commercial or domestic purposes. However, it is unclear how these currently interact in practice, either with each other or with existing statutes on mangrove usage.[26]

Marine resources

DoFi implements a system of issuing fishing licences, at a cost of between 10,000 – 12,000 Myanmar Kyat (MMk) in 2013.[27] However, it currently imposes no seasonal or area-based restrictions on fishing practices. Rakhine is currently in the process of drafting a state-level fisheries law to replace the national 1990 Marine Fisheries Law, including provisions for a two-month closed season for offshore fishing. However, the law is yet to be finalised and implemented, in part due to resistance from the private sector.[28]

A variety of other laws have a bearing on mangrove conservation and management.[29] Of particular note, under the 1990 Marine Fisheries Law, small-scale fishermen are given priority access to fishing resources, and according to the 1991 Freshwater Fisheries Law, leaseholders in coastal fisheries must manage their resources in a sustainable way (through maintenance of habitats and replenishment of fish stocks) in order to renew their leases.[30] In other words, as long as local fishers manage their resources in a sustainable way, in theory, they are given priority when it comes to access to coastal waterways.

Based on the brief review of relevant forestry and fisheries laws given above, it would appear that from a legislative perspective, the key obstacle for mangrove conservation in Rakhine state is not due to a lack of policy or legislation, but rather an issue of government capacity and political will.

Corruption

Myanmar continues to rank amongst the lowest countries in Transparency International's Corruption Perceptions Index.[31] On the other hand, with the ongoing process of democratisation and especially with the November 2015 elections, expectations are high for an improvement in government accountability.[32]

Corruption was cited by PRA participants and research team members as a major issue in the lucrative shrimp farming sector, which competes with mangroves for land in coastal areas. There is reportedly a local perception in Rakhine state that in order to become a successful shrimp farmer, one needs to have good connections in the local government as well as deep pockets, in order to bypass the bureaucratic process for obtaining the necessary permissions as well as access to sufficient land.

[24] United Nations Food and Agriculture Organisation (FAO) - Status and Trends in Mangrove Area Extent Worldwide (Rome, 2003)
[25] See for example M. Pe - National Report of Myanmar on the Sustainable Management of The Bay of Bengal Large Marine Ecosystem (Yangon, Department of Fisheries, 2002), p. 31.
[26] Details of this legislation are summarised in NEPCon – Myanmar Forestry Sector Legality Analysis (Aahrus, Denmark, 2013). They include the Forest Policy (1995); Forest Law (1992); Forest Rules (1995); National code of practice for forest harvesting (2000); Community Forestry Instruction (1995); Protection of wildlife and wild plants and conservation of natural areas law (1994); and Environmental Conservation Law (2012).
[27] Equivalent to approximately USD 7-9, although it should be noted that exchange rates can fluctuate significantly.
[28] Summarised from O. Joffre & M. Aung - Fishery Value Chain Analysis in Rakhine State: Assessment for village level interventions (Sittwe, Oxfam, 2014).
[29] U. T. Win - Use of mangroves for aquaculture: Myanmar, in *Promotion of mangrove-friendly shrimp aquaculture in Southeast Asia* (Tiguaban, Philippines, Southeast Asian Fisheries Development Centre, 2004), pp. 145-150; Pe - National Report of Myanmar.
[30] M. Pe – National Report of Myanmar.
[31] M. Chêne, Overview of corruption in Burma (Myanmar) (Berlin, Transparency International, 2012)
[32] See for example "High Expectations for Myanmar Election," Deutsche Wele, 28 July 2015; International Crisis Group – Myanmar's Electoral Landscape (Brussels, 2015).

Civil Society

In the wake of relaxations on freedom of speech and association after 2010, a wide variety of civil society organisations (CSOs), community-based organisations (CBOs) and civil society networks have emerged in Rakhine state. This heterogeneous collection of groups has not yet been comprehensively mapped, and often revolves around small organisations staffed by volunteers and funded by the public. Many are focused on community welfare activities such as healthcare or support for poor families, with some also vocal on environmental issues (for example in relation to controversial offshore gas projects underway in the state). However, some of these organisations have also been tied to local political parties and appear highly politicised in their activities and outlook.[33]

Overall, the expansion of civil society in the past five years may indicate a potentially source of engagement and advocacy on mangrove issues. However, this needs to be tempered with a clear understanding of their focus and activities, as well as consideration for their position and influence within Rakhine's complex and highly sensitive political context.

By contrast, international nongovernmental organisations (NGOs) and United Nations agencies have seen substantial reductions in their operating space in Rakhine since conflict erupted in the state in 2012. This has been matched with a reported widespread hostility on the part of the local population regarding their perceived bias and partiality, as well as suspicions about their intentions. Details of these issues are covered in extensive detail in other studies.[34]

Summary

- Rakhine state is one of the least developed regions of Myanmar according to most of the standardised indicators for human development.
- The current lack of clarity over land tenure in Myanmar is a key weakness as far as conserving mangroves and leaves plenty of opportunity for corruption.
- Although there exist numerous forms of positive legislation with regards to mangrove conservation, a lack of clarity, capacity and political will have ensured that there is little awareness and impact from these initiatives on the ground.

The implication for this assessment is that the state is in a particularly vulnerable position as far as the overall health and human resource capacities of its population. In addition, the legal and administrative context is currently not conducive to the equitable management of natural resources.

Economy

General overview – Livelihoods and Food Security

A variety of different sources of information on livelihoods and food security exist for Rakhine state as a whole, most notably the 2009/10 Integrated Household Living Conditions Survey and the 2009/10 Multiple Indicator Cluster Survey.[35] In addition, baseline data for a LIFT-funded Tat Lan livelihoods programme covers Pauktaw, Minbya, Myebon and Kyaukpyu townships and therefore overlaps heavily with the current study in terms of the socio-economic contexts it covers. The following section therefore presents summary of state-level data, contrasted where relevant with Tat Lan area data as it is the most relevant to the current study.

Schooling

Primary school attendance averaged around 70% for the Tat Lan area, a little lower than the average for 75.8% for the state as reported in the MICS,[36] and was similar for boys and girls. Poorer families were less likely to send their

[33] UNDP – Local Governance Mapping: The State of Local Governance: Trends in Rakhine (Yangon, 2015); International Crisis Group – Myanmar: The Politics of Rakhine State (Brussels, 2014).
[34] See for example ICG – The Politics of Rakhine State; H. Slim – Expert Opinion on Humanitarian Strategy in Rakhine State, paper prepared for OCHA Myanmar, Oxford, 2014.
[35] IHLCS 2009-10; MMICS 2009-10.
[36] Livelihoods and Food Security Trust Fund (LIFT) – Tat Lan Baseline Survey Results (Yangon, 2012); MICS 2009-10

children to school with enrolment dropping to 52% for children of poor families in the areas affected by cyclone Giri.[37]

Income

43% of the population of Rakhine state rely on fisheries, or a combination of aquaculture/fisheries and agriculture. At 63%, a relatively high proportion of households are involved in casual labour as a source of income and 43% ranked this activity as a first source of income, followed by fisheries at 24%. Casual labour is also especially important for landless households as well as the poorest sectors of society.[38]

As far as livelihoods specific to the assessment area, Tat Lan baseline data reports the following:

- Agriculture, followed by fisheries, comprises the main sectors requiring casual labour.
- A relatively low proportion of households derive their main source of income from their own farms.
- Income from livestock production is relatively low, while income from fisheries is relatively high.
- The sale of fresh, wild-catch fish, prawns, crabs, etc. is the single most important source of income for the landless in the cyclone Giri-affected areas.
- Incomes from this area were among the lowest for any livelihood zone identified in the Tat Lan coverage area, with the highest proportion of the population earning less than 25,000 Myanmar Kyat (MMK) per month. On the other hand, in-kind payments were also the highest for casual labour in these areas.[39]

Assets

Coastal areas as well as Giri-affected areas were found to own the least household assets on average. This was clearly linked with the low levels of land ownership as well as income. In addition, households in the SEA assessment area are most likely to use non-permanent materials for their housing, with 85 to 88% of households using palm fronds or thatch as opposed to metal sheets or other 'permanent' materials. The poorest people were those most likely to report that in their opinion their asset levels were decreasing, while the converse was true of the wealthier households.[40]

Food security

According to Tat Lan baseline data the assessment area was found to have the least diversified diet (as measured by the Household Dietary Diversity Score); the least Months of Adequate Household Food Provisioning (MAHFP); and the highest Household Hunger Scale (HHS) relative to other livelihood zones in the Tat Lan area. These poor levels of access to food are reflected in a range of coping mechanisms, which include reducing the size and number of meals per day, selling assets and borrowing. These indicators are correlated, to some extent, with reduced access to land and low income levels.[41]

According to a Cost of Diet analysis conducted in the Tat Lan area by Save the Children, "food availability, economic constraints and cultural practices could be exacerbating poor dietary diversity" in the area. This is because of the fact that while nutritious foods are in fact available locally, the costs of those foods are generally not affordable. In addition and largely due to cultural practises, current dietary practices are too reliant on high levels of rice consumption in comparison with other foods. However, it should also be noted that the study also found that a nutritious diet costs less in coastal areas than further inland.[42]

[37] LIFT – Tat Lan Baseline Survey Results.
[38] Joffre and Aung – Fishery Value Chain Analysis.
[39] LIFT – Baseline Survey Results.
[40] Ibid.
[41] Ibid.
[42] Save the Children UK - A Cost of the Diet Analysis in three livelihood zones in Rakhine State, Myanmar (London, 2014).

Economy in relation to mangroves

Land ownership

The coastal areas of Rakhine show the biggest inequalities in land holdings, with a few people holding relatively large parcels of land and a high proportion of people with land of very small acreages. In these areas, other means of gaining access to land were common, including renting land and the usage of common land.[43]

Energy

Coastal areas of Rakhine are the least likely to have access to electricity for lighting compared to other parts of the state. In addition they are the most likely to rely on firewood for cooking, even though in many cases firewood was not easily available.[44] In relation to firewood, a 2012 study of energy needs Rakhine states that 98% of rural households in Mrauk U Township rely of firewood for their fuel needs. The report estimates in one year each household invests 17 days in the collection of firewood, adding that "This is extremely burdensome and significantly encroaches into other economic livelihood activities."[45]

Shrimp farming

There are two main ways in which shrimp farming takes place in the state: "extensive" systems covering 20 or more hectares per farm, and "Improved-intensive" systems, covering 2-20 hectares. Both systems are otherwise similar, requiring minimal external inputs to set up. They are established by constructing a dyke around an area of mangrove and trapping incoming tidal waters using a sluice gate. In this way, mangroves gradually die due to a lack of fresh water.[46] In addition, a third system allows alternative rice/prawn cultivation in coastal areas where the land is elevated enough to allow drainage during the rainy season.[47]

After being initially introduced during the 1990s, the expansion of shrimp farming began to accelerate and this trend continued into the early 2000's. Especially after 2005 however, despite a relatively strong market, shrimp production has been in decline due to reduced productivity from the predominantly extensive production system.[48]

Agriculture

Coastal areas of Rakhine state suffer from low agricultural productivity due to relatively saline soils. Rice production in the wet season is reliant on monsoon rainfall, while opportunities for a second winter crop in the dry season are limited due to the lack of access to fresh water. According to Stanley et al:

"[P]addy cultivation is largely practiced in converted mangrove areas as shifting or kari cultivation. Villagers, often in family groups jointly develop karis by building embankments to block tidal flows. Each is named and at times villages join together to create new karis. Karis are usually 200 – 300 acres in size and groups share out the land based on efforts in developing the area… between 70 to 100 percent of farmers work on kari land."[49]

In some coastal areas, increasing levels of salinity have been a problem for a large number of years, made worse by the introduction of prawn farms in paddy farming areas. Saltwater intrusion into paddy fields from rice/ prawn farms has reportedly generated local-level conflicts in Myebon Township in recent years.[50]

Summary

- Most of people living in the assessment area are poor when compared with other areas of Rakhine state.
- The majority of people in the assessment area are engaged in casual labour for at least part of their income and the bulk of this labour arises from agricultural and fishery related activities.
- Despite its scarcity in many places, firewood is the predominant source of domestic fuel.

[43] O. Joffre and U. Aung - Prawn Value Chain Analysis, Rakhine State, Myanmar (Yangon, LIFT, 2012); Joffre and Aung - Fishery Value Chain Analysis.
[44] Ibid.
[45] D. Nicholson – Household Energy Market Assessment. An assessment of household energy use and supply in Mandalay, Chine and Rakhine States, Myanmar (Yangon, Mercy Corps, 2012).
[46] Joffre and Aung, Prawn Value Chain Analysis; C. T. Hoanh et al. – Environment and Livelihoods in Tropical Coastal Zones - Managing Agriculture–Fishery–Aquaculture Conflicts, Comprehensive Assessment of Water Management in Agriculture series, No. 2 (Center for Biosciences and Agriculture International, Wallingford, UK, 2006).
[47] Joffrey and Aung, Prawn Value Chain Analysis, p. 16
[48] M. N. Aye – Rakhine shrimp farmers chase European markets, Myanmar Times, 01 September 2015.
[49] O. Stanley and J. Broadhead - *Integrated Mangrove Management Plan for Wunbaik Reserved Forest* (Yangon, FAO, 2011), p. 15.
[50] Joffre and Aung, Prawn Value Chain Analysis.

- The profitability of shrimp farming, as well as agriculture has been in decline in recent years, largely due to poor productivity.

Overall, the local population is heavily dependent on the natural resource based livelihoods of farming and fisheries. Both of these sectors have experienced decreasing productivity over recent years and have become increasing unreliable sources of income.

Environment

General state of the environment

Overview

Very little hard data about the state of the environment in Rakhine state is available, and the situation available sources portray is a complex one. On the positive side, reports suggest the continued presence of rare and endangered species such as Irrawaddy dolphins or Hawksbill and Leatherback turtles in the coastal areas (although others such as the spoon-billed sandpiper remain critically endangered).[51] In addition, large areas of coral reef and seagrass can be found along and off the coast. Coastal waters were described as in "good condition" as far as pollutants are concerned and, without a substantial increase in coastal development in the intervening period, this statement likely holds true for 2015.[52] With reference to mangroves, Wunbaik Reserve Mangrove Forest in Ramree Township covers almost 33,000 hectares and represents a key focus of mangrove conservation efforts in Myanmar.[53]

On the negative side, Rakhine state is usually reported to be one of the areas in Myanmar where the most deforestation has occurred during recent years.[54] In addition, a number of mega-projects currently under development pose a grave potential threat to the environment on the coastline. Most notably, the proposed Kyaukpyu industrial development complex is set to comprise oil refineries, a deep sea port and transport infrastructure, a coal-fired power plant, as well as offshore oil drilling and pipelines.

Marine fisheries

General opinion among experts in Sittwe is that fish stocks have been shrinking in Rakhine state for many years now. The decline in mangroves is often cited as one of the causes for this, along with over-fishing due to a lack of other livelihood options, the use of illegal fishing gear, and weak enforcement of existing regulations. Fish catch in Rakhine is estimated to have declined 70-80% in the past 15-20 years, compared to a nationwide decline of 65% over the past 30 years.

Disaster Risk

Rakhine is especially prone to cyclones and associated storm surges as well as riverine floods caused by often torrential monsoon rains. In addition, a large proportion of the population live in very low-lying, disaster prone locations.[55] With an overall increase in the population of the state of around 1.8% per year,[56] there is a greater risk of disaster, with a greater number of increasingly vulnerable people living in more exposed circumstances than before.

Climate Change

According to a recent climate change scenario analysis, Rakhine state can expect little overall changes in annual precipitation over the next 30 years. However, in general there will be more rain falling during the rainy season and relatively less rain falling during the dry season in comparison with the present. In other words, the intensity of the monsoon associated with cyclones and flooding, will increase, as will the probability of experiencing droughts during

[51] C. Zöckler, S. Delany and J. Barber - *Scoping Paper: Sustainable Coastal Zone Management in Myanmar* (Cambridge, UK, ArcCona Ecological Consultants, 2013).
[52] Pe – National Report of Myanmar.
[53] Stanley and Broadhead - Integrated Mangrove Management Plan
[54] National Comission for Environmental Affairs / Ministry of Forest / UNEP - Myanmar National Environment Performance Assessment (EPA) Report (Yangon, 2008).
[55] UNDP – Multi-Hazard Risk Assessment.
[56] Department of Population – The 2014 Myanmar Population and Housing Census.

the dry season. In addition, an overall increase in both the maximum and minimum average temperatures can be expected, with a projected increase of between 0.5 to 0.8 °C.[57]

Environmental status of mangroves

Ecological context

The northern part of the Rakhine coast line is "shallow and deltaic,"[58] hemmed in by the Yoma mountain range, from which relatively fast-flowing east-west rivers arise. The mountains climb sharply up to 900 meters and the width of the coastal plain varies between five to 20 kilometres, although extending up to 60 kilometres in places.

In certain locations, annual rainfall figures can be up to 6,000 mm per year. Much of this falls during the state's monsoon, with the wettest months between June and August. During this period, coastal surface waters are mixed with freshwater runoff from rivers, bringing the salinity of the water down from a peak of 34 ppt. in spring, to 18 ppt. during the height of the monsoon.

The largest areas of remaining mangroves in Rakhine state are in the central townships of Myebon, Kyaukpyu and Ramree. Associated mudflats are also found extensively over the deltaic areas. On the other hand, the most extensive seagrass meadows lie off the coast of Gwa and Thandwe Townships to the south.[59]

General description of mangroves in Rakhine state

The Rakhine mangroves are made up primarily of *Rhizophora mucronata, R. candelria, Sonneratia* spp., *Kandelia rheedeii, Bruguiera* spp., *Xylocarpus granatum, X. moluccensis, Nipa fruticans,* and *Phoenix paludosa.*[60] *Avicennia species* are also common as well as *Nipa palm (*Nipa fruticans), which is sometimes purposely cultivated for its many economic uses. In Wunbaik mangrove forest reserve – by far the most extensive and best-preserved stand of mangroves in the state – the following levels of biodiversity has been recorded: 70 flowering plants species, including 34 mangrove species and 36 salt tolerant mangrove associates; 72 fish and crustacean species; and 104 bird species.[61]

Extent and changes in mangrove coverage

While the mangroves of Myanmar are widely regarded as one of the most degraded in the Indo-Pacific region,[62] there have until recently been very few reliable, consistent sources of hard data.[63] Estimates over the years have ranged from between 230 to almost 2,000 square kilometres.[64] While a 2011 remote sensing inventory of the world's mangroves by USGS has substantially improved the accuracy of these figures in terms of static coverage,[65] the lack of accurate longitudinal data on coverage still poses major challenge to analysing changes of mangrove coverage over time.

In addition to the wide range of figures given for mangrove coverage in the State, the primary reasons given for the degradation of the mangroves have varied from shrimp farming, charcoal production and firewood harvesting to

[57] ADPC/Malteser – Climate Change Impacts and Vulnerability Assessment.
[58] Pe, National Report of Myanmar.
[59] Ibid.
[60] World Wildlife Fund – Myanmar Coastal Mangroves 2014.
[61] FAO – The Mangrove Vegetation of Wunbaik Reserved Forest (Yangon, 2011); Stanley and Broadhead, Integrated Mangrove Management Plan.
[62] See for example the Encyclopaedia of Earth's webpage on the Myanmar Coastal Mangroves, and World Resources Institute – A Guide to World Resources 2000-2001 People and ecosystems: The fraying web of life (Washington, D.C., 2000), which states that the estimated loss of mangroves in Myanmar is 75 percent of the original forest cover.
[63] See for example FAO - Status and Trends in Mangrove Area, which in the section for Myanmar very honestly points out the poor quality of data available. The clear exception to this is the data for the Wunbaik forest reserve which has been recently extensively and accurately mapped by FAO.
[64] See for example FAO - Status and Trends in Mangrove Area, which in the section for Myanmar very honestly points out the poor quality of data available. The clear exception to this is the data for the Wunbaik forest reserve which has been recently extensively and accurately mapped by FAO.
[64] Examples include a 1996 figure of 157,992 hectares (FAO – Global Forest Resources Assessment 2010: Country Report Myanmar (Rome, 2010)), a 2000 figure of 173,400 hectares (NASA – Myanmar Ecological Forecasting: Utilizing NASA Earth Observations to Monitor, Map, and Analyze Mangrove Forests in Myanmar for Enhanced Conservation (Greenbelt, MD, 2014), a 2005 figure of 178,158 hectares (FAO, 2010), and a 2013 figure of 147,000 hectares (NASA, 2014). Other sources cite hard-to-find secondary data—for example, a figure of 64,477 hectares for 2005 is cited for 2005 by Duh Wan and Ryder (2007).
[65] See http://marine-portal.unepwcmc-001.vm.brightbox.net/datasets/21 (accessed 18 October, 2015)

brick production. The perpetrators of these practices have been said to be the military, with large-scale commercial operations, as well as the local people themselves.[66]

Public opinion about mangroves

According to anecdotal evidence, based on both reports and discussions with local NGO's, farmers practicing extensive shrimp farming recognise that one of the reasons for the decline in production is related to the depletion of mangroves, amongst other factors, most notably increases in illegal fishing activities and "heating."[67] Results from a recent DRR-focused Knowledge, Attitudes and Practice survey conducted by REACH in the target area also indicate that around one-fifth of people believe mangrove degradation has increased their vulnerability to natural hazards, with around the same numbers suggesting mangrove rehabilitation as a future area of focus for DRR activities.[68]

Summary

- Verifiable, hard data on the state of the environment in Rakhine state is limited at present.
- Although marine fisheries in the state have traditionally been very productive, a general decline in harvests has been recorded in recent years, likely linked to over-fishing and bad practices.
- Rakhine is prone to cyclones and flooding, which have caused a great deal of destruction over the years.
- According to climate change predictions, the State can expect an increase in extreme climate events including torrential rain and drought.
- Existing data about the extent and state of mangroves in the state is largely inconsistent and often unverified.

[66] See for example BEWG – Cut into the Ground.
[67] See for example BEWG – Cut into the Ground.
[68] REACH – A Study on Knowledge, Attitudes and Practices (KAP) for Disaster Risk Reduction in Rakhine State (Sittwe/Geneva, 2015).

4. Remote Sensing Results

This chapter presents the results of the remote sensing component of the study. It first presents current land coverage data for the entire state, before examining changes occurring between 1988 and 2015 with a specific focus on mangroves. It then does the same at township-level for the four study townships, before briefly presenting in the findings of a ground-truthing exercise conducted in order to validate remote sensing data.

State level land coverage

Land coverage in 2015

In 2015, open canopy forest/grassland was the most common land-use in the state, covering almost 50% of the state's surface area. Paddy land and closed canopy forest follow, with 25% and 16 percent of total land coverage respectively. Mangroves covered 2,376 Km^2 of the state's coastal areas, representing 7% of the total land cover, primarily in the townships of Myebon, Ann, Kyaukpyu, Ramree, and Toungup Townships.[69]

Mangrove coverage trends

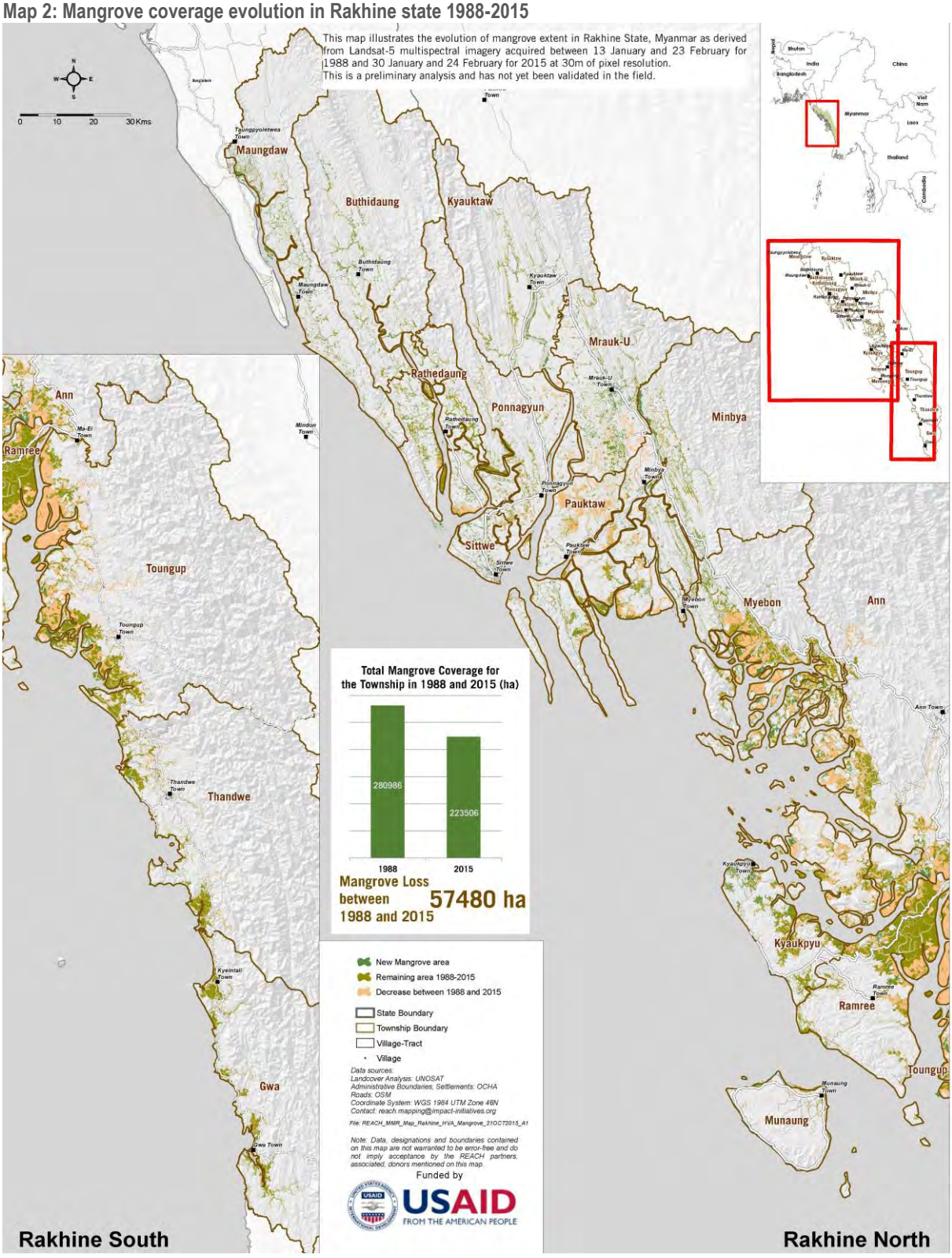
Between 1988 and 2000, the state showed a 3.3% increase in total mangrove coverage area, from 280,986 hectares to 290,282 hectares. In this context, a large drop in mangrove coverage in Pauktaw Township was offset by small gains in other townships, and a large increase in Thandwe. Between 2000 and 2015 however, statewide mangrove coverage shrank by 23% to 223,506 hectares – equivalent to an overall drop in coverage of 57,480 hectares or 20% from 1988 levels. In this period, all major concentrations of mangrove across the state saw a similarly substantial drop in coverage. See map 2 for an overview of the changes in mangrove coverage between 1988 and 2015.

Table 4: State-wide mangrove coverage trends between 1988 and 2015

Year	Coverage (ha)	Change since previous reference period (ha)	Change since previous reference period (%)
1988	280,986	-	-
2000	290,282	+9,296	+3.31%
2015	223,506	-66,776	-23.00%
	Total change 1988-2015	-57,480	-20.45%

[69] Land cover analysis maps produced as part of this assessment for 2015, 2000 and 1988 are available at www.reachresourcecentre.info.

Map 2: Mangrove coverage evolution in Rakhine state 1988-2015



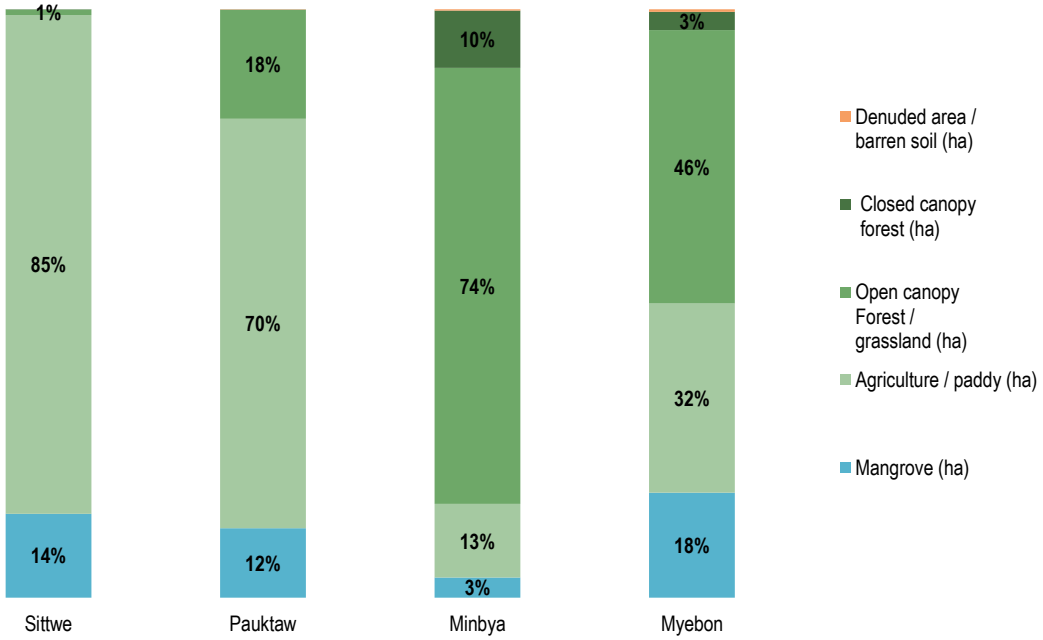
Township level land coverage

This section focuses on changes in land coverage for the study's four selected townships of Sittwe, Pauktaw, Minbya and Myebon. Comprehensive figures for mangrove coverage across all townships in Rakhine can be found in **Annex I.**

Land coverage in 2015

Minbya is by far the largest township in the assessment area, containing a large area of mountainous reserve forest inland, to the northeast. Compared to other townships, it has a much greater proportion of its land covered by open-canopy forest and closed-canopy forest, with relatively small proportions occupied by mangrove and paddy. Myebon represents a more typical coastal township, with larger proportions of land use under mangrove and paddy. Reflecting its low population density and relatively remote character, almost half of the township is still covered by open-canopy forest. Pauktaw, a predominantly low-lying coastal township, is a more intensively-farmed, reflected in the high proportion of its area over given over to paddy land. Sittwe is more heavily urbanised compared to the other townships, with large areas under settlement – which are registered as agricultural land in the remote sensing calculations. See Figure 1 for a breakdown of the proportions of land coverage per township.

Figure 1: Proportion (%) of different types of land coverage in study townships in 2015



The largest concentration of mangroves in the study area is found in Myebon Township, with 32,786 hectares spread across a large and remote area of coastal islands in the township's southeast. Pauktaw and Minbya each have approximately one-third of this mangrove coverage, at 10,173 hectares and 11,860 hectares respectively. Pauktaw's mangroves are largely concentrated in coastal areas in the southeast of the township, while Minbya's mangroves are found mainly along inland waterways, especially around the Lay Myo river. This is followed by Sittwe, which has around one-tenth of this coverage at 2,997 hectares, mainly distributed away from coastal areas along creeks and inland waterways. See Table 5 for a breakdown of mangrove and other land coverage areas per township.

Table 5: Land coverage in study townships in 2015

Township	Open Canopy Forest / Grassland (ha)	Agriculture Paddy Area (ha)	Mangrove coverage (ha)	Closed Canopy Forest (ha)	Denuded Area or Barren Soil (ha)	Total
Sittwe	200	17,806	2,997	3	0.0	21,006
Pauktaw	15,915	59,967	10,173	71	31	86,156
Minbya	257,110	43,445	11,860	33,860	655	346,929
Myebon	85,343	59,006	32,786	5,722	794	183,651

Land coverage trends

Minbya township's overall land coverage make-up has remained relatively static over the study's reference period, characterised by moderate increases in open and closed canopy forest and mangroves, and a moderate decrease in the area under paddy. Mangrove coverage changes over the years have been characterised by a decrease in coverage in the lowland, delta region in the southwest of the township, offset by an increase in coverage in the north-central area of the township along the flood plain of the Lay Myo river.

By contrast, Myebon has experienced substantial changes across different land types. Between 1988 and 2000, the township lost approximately half its closed canopy forest, while expanding its open canopy forest by just over one-tenth. It also experienced a slight increase in mangrove coverage. However between 2000 and 2015, the township lost the equivalent of one-quarter of its 1988 mangrove coverage, while its agricultural area expanded by around one-fifth. Reductions in mangrove coverage have been widespread across the whole of the township, although in some cases decreases on islands the far south-east of the township, have been matched by areas of new growth nearby.

In Pauktaw, substantial mangrove stands across the northern part of the state were significantly damaged between 1988 and 2000, with a corresponding increase in paddy areas. Between 2000 and 2015, mangrove areas recovered substantially, mainly on new growth areas on headlands along the eastern coast of the township near the border with Myebon. During the same time period, the amount of paddy land shrank slightly, as did the land area for the township as a whole, reflecting a larger degree of inundation by water.

Sittwe saw little change between 1988 and 2000, followed by a surprising increase in mangrove coverage and decrease in paddy area along inland waterways between 2000 and 2015.

Overall, it appears that the majority of mangrove degradation has taken place inland, with larger and more contiguous areas of mangroves becoming increasingly fragmented and dispersed, and confined to thinner coastal strips. In terms of gains, recovery of mangroves has occurred both in a patchy way and often along the banks of waterways including tributaries, meandering creeks and small streams (as in Sittwe and Minbya); on headlands (as in Pauktaw); or by in-filling by sediment of previous areas of low-lying paddy land/shrimp ponds (as in south-eastern Myebon).

See Figures 2 and 3 below for a comparison of mangrove coverage across townships over the study period, and Annex I for comprehensive data on all land coverage types across all townships in Rakhine. See Map 3 for mangrove coverage change in Pauktaw Township during the reference period. For reasons of space, further maps are not included in this report and can be downloaded from www.reachresourcecentre.info.

Map 3: Mangrove coverage evolution in Pauktaw Township 1988-2015

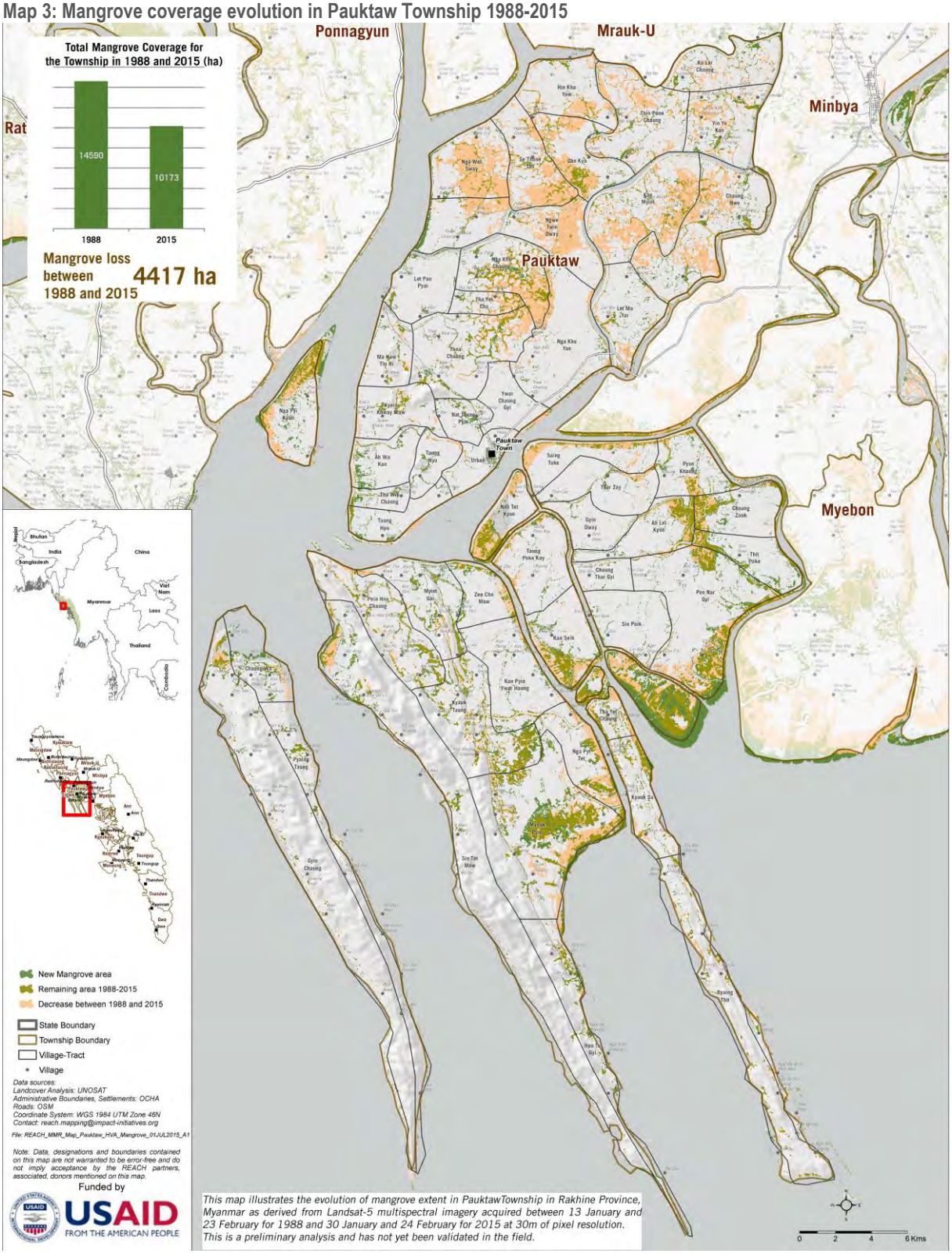


Figure 2: Absolute changes (ha) in mangrove coverage area in study townships over time

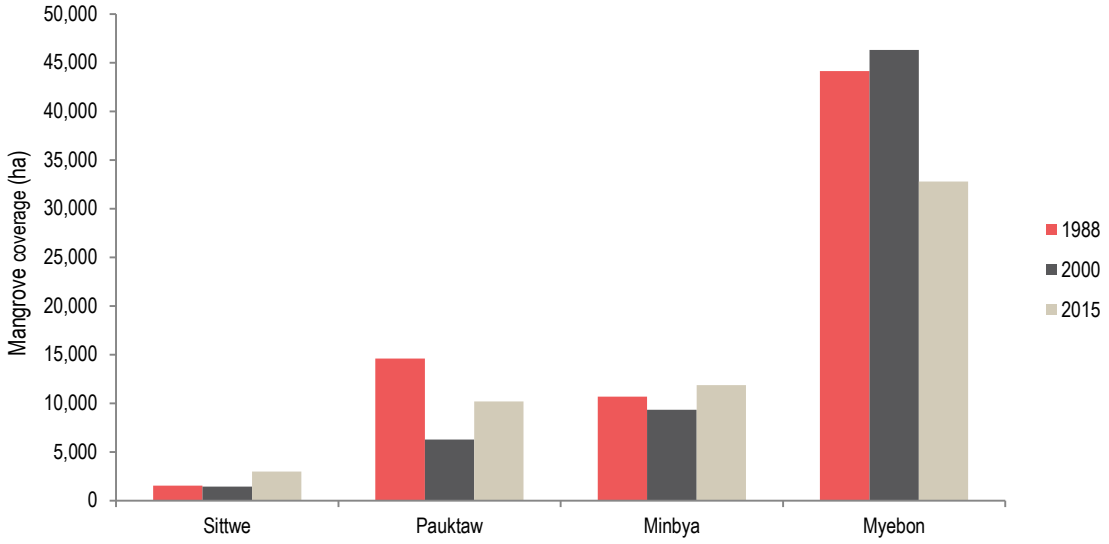
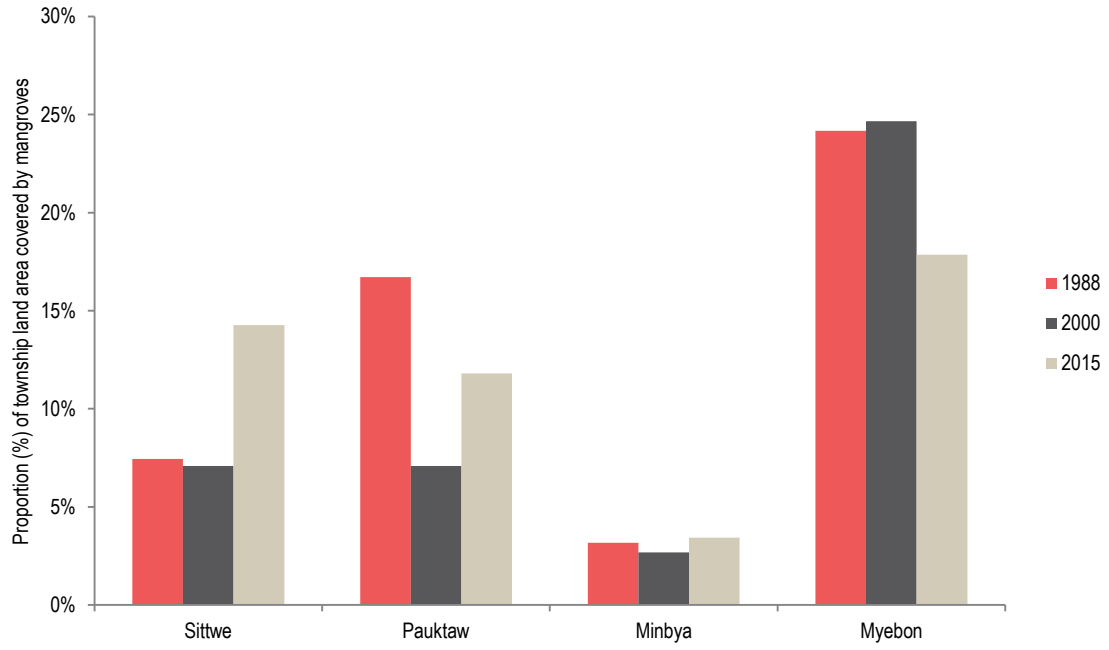


Figure 3: Percentage (%) changes in mangrove coverage area in study townships over time



Ground-truthing

As a supplement to the remote sensing analysis, a ground-truthing exercise was carried out around the current, former and new areas of mangrove growth Sin Paik Ywar Thit in eastern Pauktaw Township (see Map 3) during the period of fieldwork for the assessment. This was in order to assess the sensitivity of the remote sensing results, investigate the general land use and hydrology of the coverage area, and to verify the health of the mangroves in the area, in particular apparent areas of regeneration.

As far as detecting vegetation, the remote sensing imagery was found to be extremely sensitive. For example, in a 30 square meter area representing one pixel in the land use map, the entire pixel is represented as being a

mangrove area even if only one or two stunted mangrove trees or shrubs are present in the midst of ferns and reed beds.

In terms of land use, much of the observed low-lying land in Pauktaw is made up of areas enclosed by earth embankments which have either been permanently reclaimed, temporarily/seasonally reclaimed, or have reverted back to the sea. The earth embankments evidently require constant attention and represent a substantial investment of time and energy.

In terms of hydrology, coastal waters were very brown, turbid and obviously carrying large sediment loads, as would be expected during the monsoon period. In line with this observation, beyond a meandering, informally marked channel, wide and apparently navigable tributaries are in fact very shallow, often less than 50 centimetres deep. In some sections, mangroves formed narrow ribbons along the waterways, where they are subject to river bank erosion as evidenced by exposed roots and toppled trees and shrubs in places. In other sections by contrast, evidence for accretion was common, with newly formed headlands and sand/mud banks often showing the early signs of mangrove colonisation. In further sections, relic creek and stream beds were also common, sometimes with signs of former mangroves. This suggests that in-filling due to deforestation may have contributed to their destruction.

Mangrove-classified areas visited during the ground-truthing exercise were often found to be in a degraded or heavily managed state. Many of the trees are old and the lower branches are heavily pruned, and from a superficial observation the older trees have little or no regrowth appearing below them in the form of seedlings or saplings. The area also has a relatively large number of cows and water buffalo in amongst the mangroves, with clear signs of overgrazed vegetation. Along with firewood collection, overgrazing probably explains the lack of regrowth. However, it should also be noted that areas around Sin Paik Ywar Thit, classified by the remote sensing analysis as new growth between 2000 and 2015, were confirmed to be areas of substantial and healthy mangrove coverage.

5. PRA Results

This section presents the results of the PRA exercise conducted in the six study villages (see Map 4). It first provides an overview of village context, including basic socio-economic factors as well as land use in the surrounding village tracts. It then goes on to provide more detail on livelihood trends in the villages, examining income/expenditure trends currently and over time, as well as the dynamics of different key livelihood activities.

Village context

The section will begin by providing a summary of the general characteristics of each of the communities, before going into further details with regards to livelihoods.

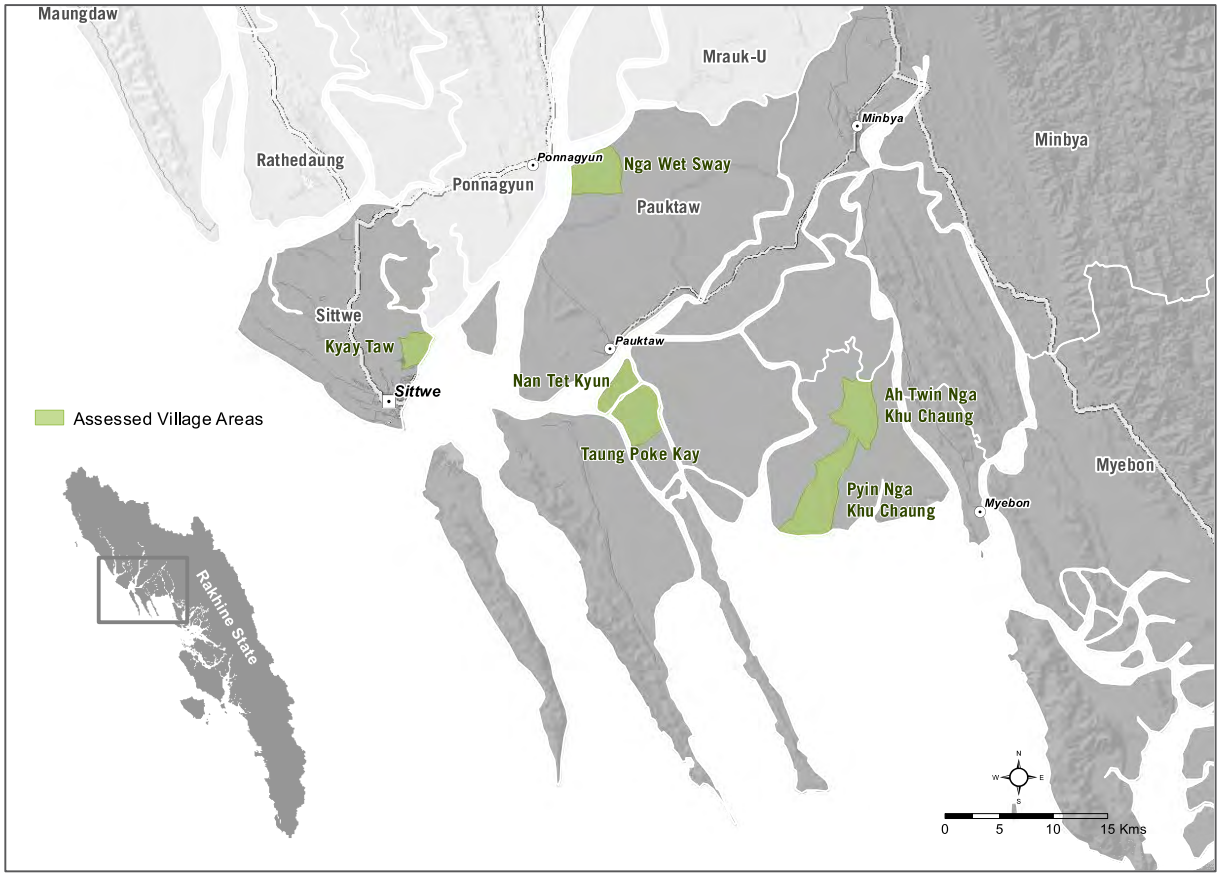
Table 6: Overview of village contexts

Village	Township	Population	Main sources of income	Geography	Notes
Pyin Nga Khu Chaung (PNKC)	**Myebon**	1,203	Fisheries, followed by farming and remittances.	Low lying flood plain area; very isolated with no road access.	Relatively poor village where seasonal migration for work is common; appears especially prone to cyclones.
Ah Twin Nga Khu Chaung (ATNKC)	**Myebon**	1,450	Previously rice farming but shifted to shrimps and seafood processing in recent years.	Low-lying inland area, quite close to a major river.	Relatively poor village; over the years, quite a number of people have emigrated.
Taung Poke Kay (TPK)	**Pauktaw**	2,678	Mixed paddy and self-owned shrimp. Timber traders and remittances.	Set back from the main river on slightly higher ground.	A relatively well-off village, with many people commuting to Pauktaw town.
Nan Tet Kyun (NTK)	**Pauktaw**	1,105	Farming and casual labour on large prawn farms, leased to outsiders.	Flat, extremely low-lying, flood prone area opposite Pauktaw town.	The most flood-prone village of the six surveyed.
Nga Wet Sway (NWS)	**Pauktaw**	2,000	Farming, fisheries and casual labour	Flood prone area with some higher ground. Somewhat exposed on a main tributary.	Relatively well-established farming village with very few remaining mangroves.
Kyay Taw (KT)	**Sittwe**	1,900	Casual labour, small businesses and farming.	Seafront; serious issues with coastal erosion	Generally a poor village, though very close to Sittwe town.

Population

According to PRA participants, all village populations have more than doubled in the last 30 years. KT experienced the biggest increase, presumably as a consequence of its proximity to Sittwe town. On the other hand NTK has experienced a much more modest increase in population, which is likely to be related to its extremely vulnerable geographical position.

Map 4: Village areas covered by the PRA process



Health

Access to health services is a key concern for villagers, both in terms of emergencies as well as minor ailments, which can cost relatively substantial amount of time and money to address due to long travel times to the nearest facility. There are some mobile health services but villagers do not generally perceive these as reliable.

Water and sanitation

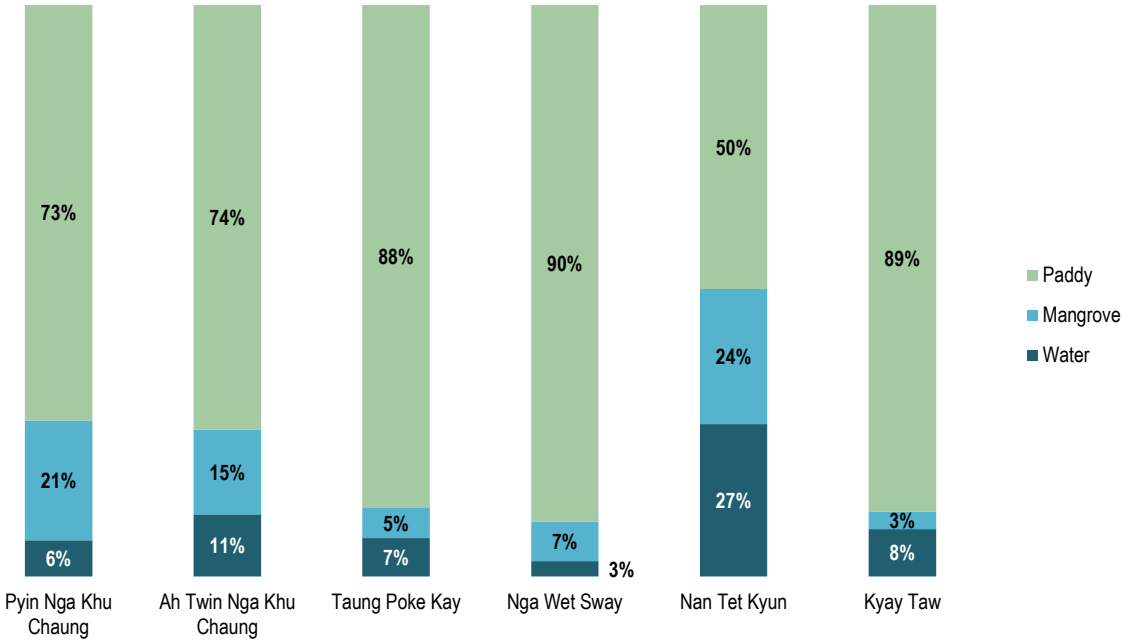
Most of the villages have serious problems with access to adequate safe drinking water and are preoccupied with creating or improving rainwater-collecting ponds for this purpose. During the dry season, villagers are occasionally left with no option but to purchase water from outside the village. Many villagers are also especially concerned about water quality due to open defecation and non-existent water management, especially during the monsoon, along with high levels of salinity during the dry season.

While many of the villagers see latrines as a desirable thing, practically speaking their presence can become a real problem in areas with high water tables and regular flooding; a norm in the assessment area. Despite this, ATNK and NWS were seen to have a remarkably high proportion of households with latrines. In these cases, those without latrines are stigmatised, at least to some extent.

Land coverage and mangroves

In order to better understand changes in land coverage taking place at the village level, a supplementary remote analysis of land coverage for each of the PRA communities was conducted. All assessed villages have only 3 major land coverage classes, namely paddy, mangrove and water. All six villages are in very low-lying locations and are regularly flooded, which explains the entire absence of forest or grassland area. TPK, NWS and KT have a low percentage of mangroves. Conversely these same villages have a relatively high proportion of paddy compared to the other three villages.

Figure 4: Land coverage in PRA village tracts



Over time, all study villages appear to have experienced a similar trend in mangrove evolution since 1988 (with the exception of Kyay Taw, where mangrove coverage has been minimal throughout the reference period). Mangrove coverage declined between 1988-2000—substantially in the case of Pyin Nga Khu Chaung and Nga Wet Sway (by 45% and 19% respectively)—before recovering somewhat between 2000 and 2015, although not to 1988 levels. In all villages, mangrove loss appears directly correlated with gains in agricultural land (including both paddies and shrimp farms). Table 7 provides a breakdown of the different mangrove species recorded across the study villages as reported by PRA participants and observed by the research team.

Figure 5: Mangrove species reported/observed in PRA villages

Species	Type	Notes
Acanthus species	Shrubs, sometimes armed	Common near the top of the inter-tidal zone and along riverbanks and requiring a high freshwater input. These species are often found in disturbed mangrove areas.
Avicennia species	Trees, sometimes with a bushy habit	Often found growing on dry riverbanks or muddy parts of the seashore. *A. alba* and *A. marina* are pioneers, while *A. officinalis* in this case are probably remnants.
Acrostichum aureum	Ferns	Can tolerate very saline conditions, for instance those in reclaimed land, and are an indicator species of degradation or hydrology disruption
Dalbergia spinosa	Twining stiff shrub or small tree, woody spines	Found mainly in slightly higher reaches.
Nypa fruitcans	Palm	Often observed near settlements and either planted or preferentially weeded; has a large number of uses locally including for thatch, juice and sugar.
Sonneratia species	Tree or shrub	Observed especially in the areas of rapidly regenerating mangrove; grow in a variety of locations; likely the most common species on newly-formed mudflats e.g. in southeast Pauktaw, northwest Myebon

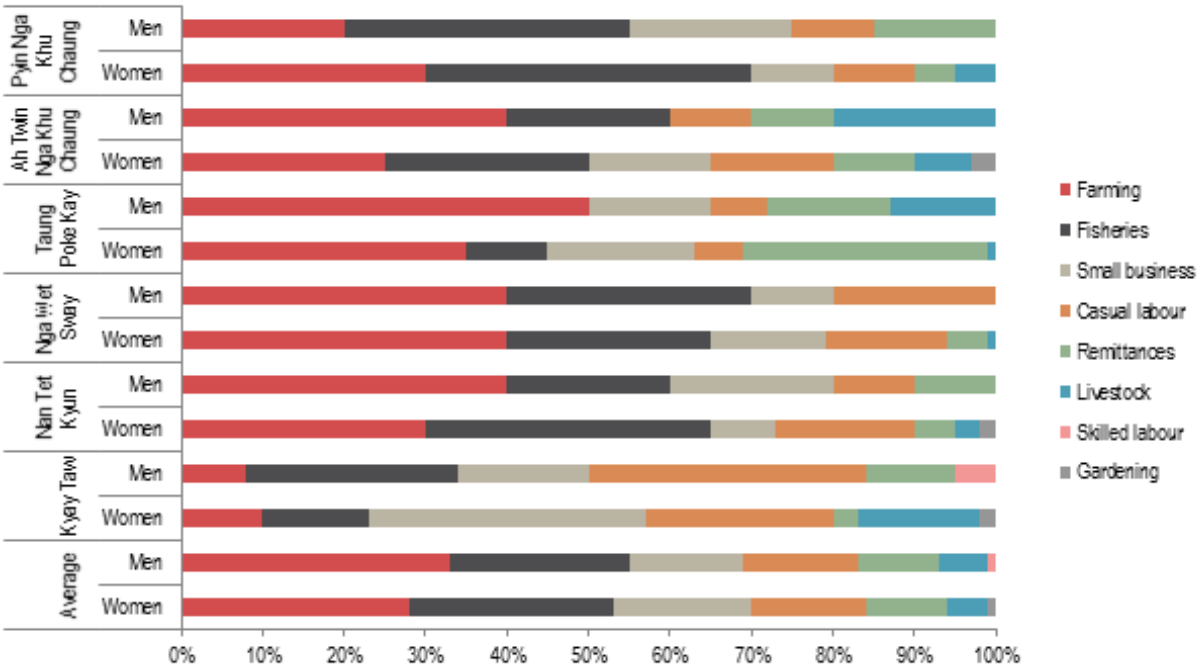
Rhizophora mucronata	Tall evergreen tree	Currently rare in study area although common in the past; grows in places with daily flooding; tends to represent vestiges of old growth in Rakhine; much in demand for firewood and for making charcoal.
Excoecaria agallocha	Deciduous tree	Currently rare in study area although common in the past; grows at the high tide mark, more inland. Can be a pioneer species given those conditions. Adapted to stony as well as muddy soil

Income and expenditure

Using the "money purse" exercise described in the methodology, PRA participants were asked to provide a breakdown of the average proportions of income households in each village derived from different sources during a normal year, as well as the average proportions of expenditure occupied by different types of expense. The exercise was run separately with men and women, leading to some differences in perception in both cases.

On average, farming and fisheries (including shrimp farming) are the biggest source of income, together accounting for more than 50% of reported income among PRA participants. A significant proportion of income is also met through small businesses, at 18%, casual labour at 14% and remittances at 10%. Residual amounts of income come from livestock and skilled labour. Generally men have the same observations as for women except that men consider farming as a more important source of income and find fisheries less important than women.

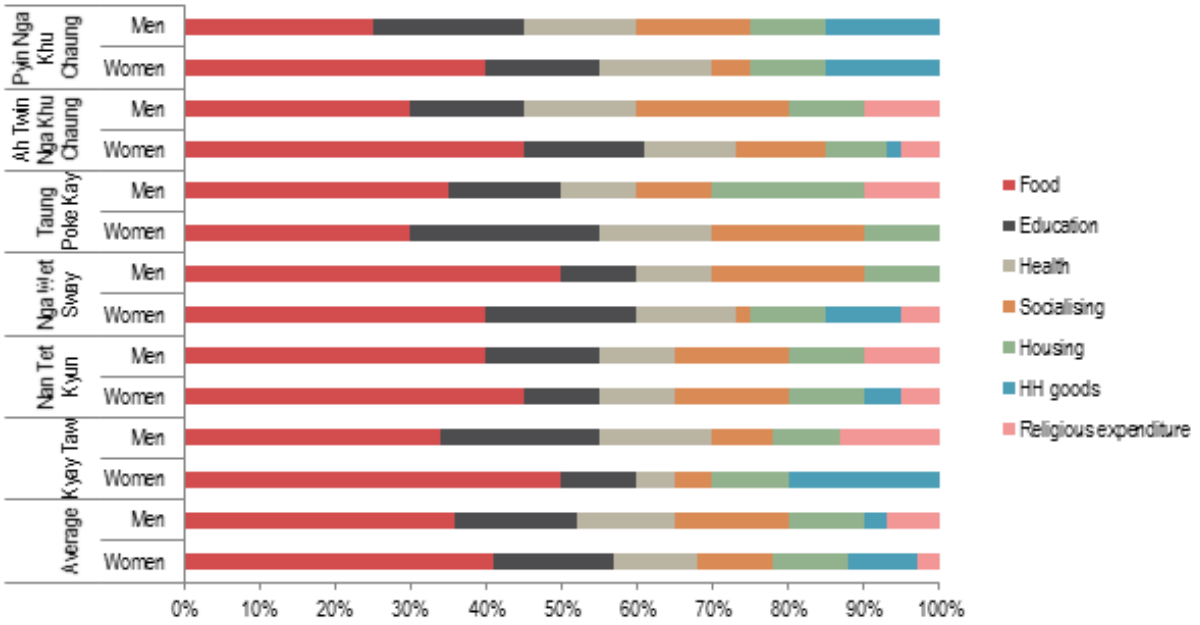
Figure 6: Proportion (%) of income from different sources for a typical household in a normal year as reported by male and female PRA participants



At the village level, NWS and TPK are the only villages where farming is the main source of income. PYKNC and NTK are predominantly fishery/shrimp farming based villages, while ATNK is an even split between the two activities. Meanwhile, the income activities of KT, namely small businesses and casual labour, are a reflection of its status within the economic sphere of influence of nearby Sittwe.

On average, food is the single largest item of expenditure, with women reporting it as a larger portion of expenditure relative to men. This is followed by education and health, all reported as roughly equally large expenses by both genders. Together, these three items account for around 70% of all expenditures. Other sources of expenditure include socialising and religious expenditure (both ranked as larger expenditures by men), spending on housing (ranked equally) and household goods (ranked as larger expenditures by women). Differences between the villages in terms of expenditure are relatively small when compared to income, as would be expected of a population that is lives at a largely subsistence level.

Figure 7: Proportion (%) of household expenditures on different expenses for a typical household in a normal year as reported by male and female PRA participants

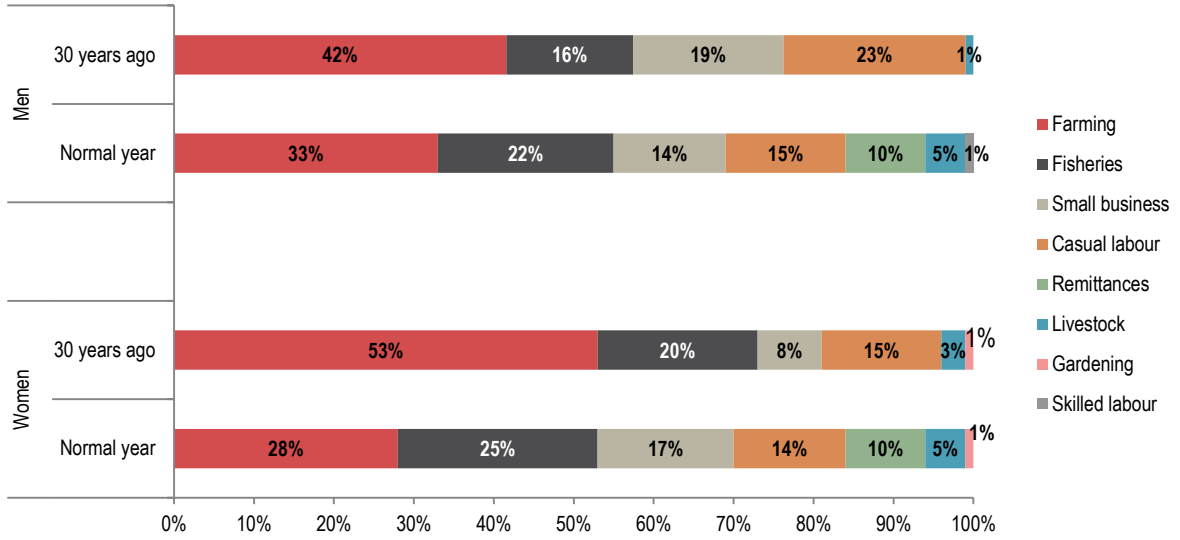


Trends in income and expenditure

Following the "money purse" exercise, men and women were asked to compare the make-up of their income and expenditure in a normal year at present with a normal year 20-30 years ago. The results presented here represent the average for men and women across different study sites.

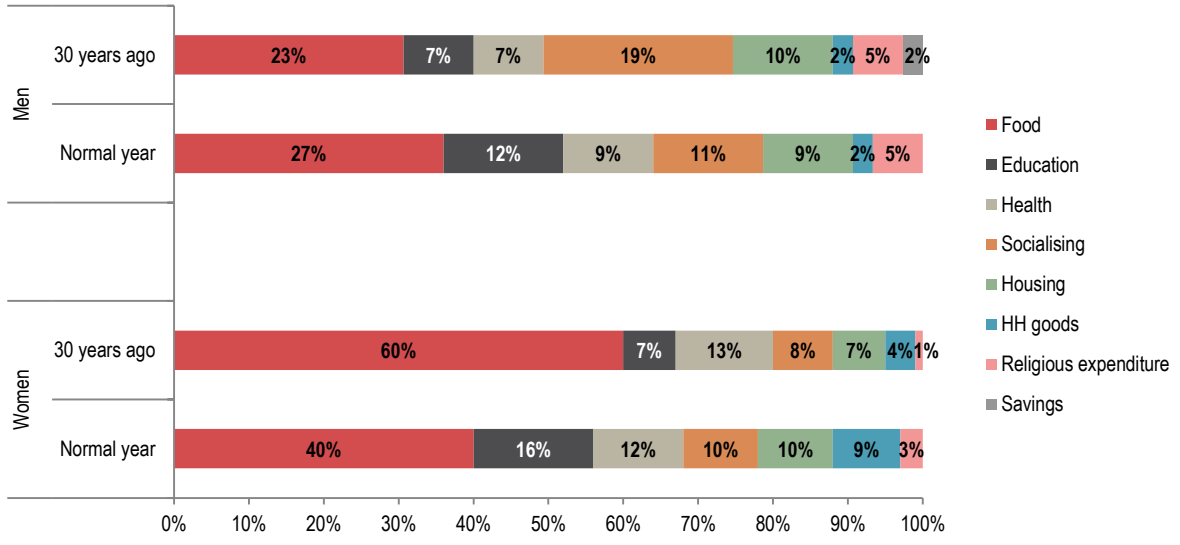
For women, the biggest change in income has been a sharp reduction in farming activities, with income increasingly coming from a greater number of sources, most notably fisheries/shrimp farming. Casual labour as a whole has not significantly changed at between 14-15% of total income. Small businesses have seen a significant increase as a source of income from 9% to 17%. Remittances were not a source of income at all 30 years ago and now make up around 10% of income.

Figure 8: Proportion (%) of income from sources for a typical household in a normal year at present and 20-30 years ago as reported by PRA participants



By contrast, men have noted a less drastic decrease in farming than women, from 42% to 33%. On the other hand, income from casual labour has reduced by a higher margin in the opinion of men, from 23% to 15%. While income from fisheries/shrimp farming has increased by one third from 16% to 22%, it still does not represent as big a source of income as it does for women. In comparison to women's perceptions, men felt that small businesses have decreased as a proportion of income from 17% to 8% and women felt that remittances represent a significant new source of income.

Figure 9: Proportion (%) of expenditure on different expenses for a typical household in a normal year now and 20-30 years ago as reported by PRA participants



For women, the proportion of expenditure spent on food has reduced by about a third over the past 30 years from 60% to 42%. On the other hand expenditure on education has more than doubled from 7% to 17%. Health has slipped behind education to become the third highest expense, though its overall proportion of expenditure has only

dropped marginally. Expenditure on housing, household goods and socialising has increased modestly (see Figure 9).

By contrast, men perceive that expenditure on food has increased, but believe it currently occupies roughly the same proportion of expenditure as women do. In addition, men consider that in the past, socialising occupied a much more significant portion of expenditure relative to women, second highest after food. However, they also believe that this proportion has dropped substantially over the years. Men are in agreement with women that expenses for education have increased; however, in opposition to women they believe that housing costs have decreased, and that expenditure on household goods remains minimal.

In summary, both groups agree that there has been a general reduction in farming as a source of income, replaced to a large degree by increases in income from fisheries, specifically shrimp farming. Both also agree that education costs more than before, and that remittances have become a small but important new source of income. However, they disagree on trends regarding food costs, healthcare and socialising. Unsurprisingly, women and men tended to talk more about their own income/expenditure, rather than the total for the household. Nevertheless, the study team observed that women almost always had a better overall knowledge of the household finances than the men. Some men readily admitted to having little understanding of women's income generating activities, especially the financial details of female-run small businesses.

Livelihood Activities

Paddy Rice farming

Paddy's direct impact on mangroves in the study area largely came in the form of large-scale, government-sponsored clearances of mangroves to open up new farmland in the 60s and 70s (see discussion in section 6 below). Currently, however, paddies appear to have a low indirect impact on mangrove areas, since agriculture in the study area tends to be extensive and uses small amounts of inputs such as fertilisers, minimising the potential adverse effects of pollution from run-off. Some farmers with the means to do so have recently begun to use fertilisers, but this is still relatively rare.

Rice farming in the study area has reportedly become more marginal over the years due to relatively low levels of productivity (likely linked with relatively high levels of soil salinity associated with mangrove areas) and competition with cheap rice from elsewhere. In the fishing villages covered by the PRA, rice farming appeared to be largely a subsistence activity. By contrast, the predominantly agricultural villages of TPK and NWS still appeared to be doing reasonably well from farming. Overall, paddy farming appears to be an almost exclusively male-dominated activity.

Aquaculture – Shrimp farming

According to PRA participants, running a shrimp farm is generally a relatively rich person's means of livelihood since one needs to be well-connected politically in order to gain the right to hold land tenure over an extensive area. By contrast, performing casual labour on others' shrimp farms or collecting post-larvae shrimp from the wild for shrimp farms are usually jobs held by poor people.[70] In some cases farmers use their paddy for seasonal shrimp farming. In these cases the shrimp farms are relatively small and often no more than two to three hectares. In other cases, farmers share the responsibility for managing a larger shrimp farm together.

Villagers stated that the significant expansion of shrimp farming began in the southern part of the assessment area including Myebon, Minbya and Pauktaw in 1995, spreading to Sittwe by 1998 and north to Maungdaw by 2000. After an expansion during the mid-90s with government support, the industry contracted somewhat during the late-90s due to the lack of a viable market. However, between 2000 and 2010 the market price was generally good, resulting in a more rapid expansion of production.

Recently, shrimp production yields have declined due to environmental limitations related to the extensive system of shrimp farming that dominates the study area. According to villagers, these include a decline in the availability

[70] In contrast to information from the literature review indicating that shrimp farming in Rakhine can take place using only passive trapping of wild shrimp, local people insist that shrimp farming requires supplementary post-larvae in order to be viable. This is because the quantity of wild shrimp that can be passively trapped is no longer sufficient.

of wild post-larvae shrimp and an increase in the price for both wild and cultivated post-larvae; "high temperatures" resulting in pond evaporation, linked to a lack of shade from mangroves and the shallowness of ponds; and increasing costs related to the maintenance of dykes and ponds. In addition, secondary literature also suggests that acidification of soils often plays a key role in the decline of productivity.[71] The drop in shrimp production is regarded as a serious problem, but as of yet there appear to be few initiatives in motion to overcome the issue. Table 8 provides a summary of the evolution of shrimp farming in the study area over time.

Table 7: Summary of the phases of shrimp farming in the study area according to PRA findings

	1995-2000		2001-2010		2011-2015
Supply	↑ Expansion in production due to encouragement from the government supported by the United Nations Food and Agriculture Organisation	↔	The supply of shrimps was generally good. Shrimp farming was expanding into new areas in some places and already reducing in others due to falling production.	↓	The supply of shrimp is restricted due to decreasing production.
Market	↓ The market was rather new and relatively weak at this time.	↔	The market was strengthening as worldwide demand for shrimps began to increase.	↑	The market for shrimp is very strong and the prices high.
Context	In Rakhine state this period was marked by rapid expansion of shrimp farming area, at the expense of mangroves and paddy farming to some extent.		These were the boom years for shrimp production in Rakhine state.		Unless problems in shrimp production are met, the future of shrimp production is uncertain.

Fisheries

PRA participants report that commercially important fish species tend to be harvested for sale and are rarely used for household consumption, while a wide variety of local fish are in turn harvested mainly for subsistence purposes (for a summary of the key commercially important species harvested in the study area, see Table 9). A certain degree of gendered division of labour was observed in fishing activities in the study villages: In-land, nearshore fishing maybe carried out by both men and women, with differences in gender roles according to the type of equipment used; offshore fishing has always been a man's area; and harvesting crabs is largely a women's activity.

In all of the study villages, negative trends in fish and shell-fish catches were reported. In some cases the drops in catches have resulted in people being forced to drop fishing as a source of livelihood altogether. In particular, inland fishing—common in many of the study villages—is now regarded as a marginal activity and one which involves mostly poor people. A number of species of fish that were previously regarded by community members as "rubbish fish" are now caught for home consumption and local sale.[72] Furthermore, due to their cost and relative scarcity, shrimps and prawns that were previously caught in the wild for direct sale are now collected and sold to replenish the breeding stock of shrimp farms.

As fish stocks decline, over-fishing, fishing out of season and the use of inappropriate nets all remain common practices. This is despite the fact that people recognised that these techniques posed a serious threat to long term fish stocks. Villagers did however report that the fishery department has been encouraging people to stop cutting mangroves in order to improve the conditions for fishing as well as shrimp farming. Nevertheless, while this has definitely raised general awareness, changes in practices have yet to follow.

[71] Hoanh et al. - Environment and Livelihoods in Tropical Coastal Zones.

[72] The following species were reported by PRA participants as being caught mainly for household consumption or for local sale: *Abudefduf saxatilis* (Damsel fish); *Ambassis gymnocephalus* (Bald glassy); *Anodontostoma chacunda.* (Chacunda shad); *Bathygobius fuscus* (Frill goby); *Boleopthalmus boddarti* (Goggle-eyed goby); *Chrysochir aureus* (Reeves croaker); *Coilia dussumieri* (Gold spotted grenadier anchovy); *Coilia ramcariti* (Gold spotted grenadier anchovy); *Congresox talabon* (Yellow pike conger); *Cynoglossus lingua* (Tongue sole); *Eleuthronema tetradactylum* (Four finger thread fin); *Gerres abbreviates* (Deep body silver biddy); *Glossogobius giuris* (Tank goby); *Plotosus canius* (Gray eel catfish); *Pseudapocryptes lameceolatus* (Mudskipper); *Satipinna wheeleri* (Scaly hair fin anchovy); *Scatophagus argus* (Spotted scat); *Tanulosa illisha* (Hilsa, hilsa herring or hilsa shad); *Telescopium telescopium* (Telescope snail); *Terapon jarbua* (Jarbua terapon); and *Toxotes chatareus* (Spotted archer fish).

Table 8: Commercial fish species in the PRA villages

Latin name	Common name	Approximate value	Abundance	Villages reporting
Lates calcarifer	Sea bass	High	Occasional but suffering from over-fishing.	ATNKC, NTK, TPK, NWS
Liza parsia	Gold spot mullet	Average	Common until the mid-90s, now increasingly scarce due to over-fishing.	ATNK, NTK, KT, NWS
Mystus vittatus	Stripped dwarf cat fish	Low	Common.	ATNKC, NWS
Pinaeus indicus	White shrimp	Average	Common until the mid-90s, now increasingly scarce due to over-fishing.	PNKC, NTK, NWS, TPK
Penaeus japonecus	Sand shrimp	Very high	Rare.	TPK
Penaeus monodon	Tiger prawn	Very high	Always rare, but much more common in the 90s than now.	PNKC, ATNKC, NTK, NWS, TPK
Scylla olivacea	Mud crab	Average	Formerly common until a market developed in the 90s; then rapidly over-harvested until numbers declined in 2005	NTKC, ATNKC, KT
Tannusola ilisha	Hilsa shad	Low	Relatively common, but increasingly suffering from over-fishing.	KT
Trisha mystax	Moustached thryssa	Low	Relatively common, but increasingly suffering from over-fishing.	KT

Small scale business and trade

Firewood sales

During the assessment, villagers pointed out that the cost of buying firewood was often prohibitive, with figures given for weekly expenditure from 5,000 kyat per week to 15,000 kyat per week.[73] Sources of firewood for sale are said to mainly come from Ann Township, or more locally from upriver areas. In some cases, villagers had begun a small trade in firewood to supply other villagers. Those people who could not afford to buy firewood had to spend a great deal of time collecting it, sometimes from other villages or from areas where they were not meant to collect it.

Cutting mangroves for firewood is reported to be mainly a man's job, whereas collecting smaller size dead wood is a women's activity. It appears that firewood is currently collected largely by hand. Should chainsaws become more widely available, it is likely that rates of deforestation in more inaccessible areas may increase substantially.

Small animal and livestock

In some villages, notably ATNKC, TPK and KT, a number of village women were raising animals for sale, including pigs, chickens as well as ducks. These activities were all supported in some way by NGOs or government micro-credit and loan schemes. It would seem that for these activities to become increasingly viable, some level of veterinary care will be required as bird flu was said to be a common problem.

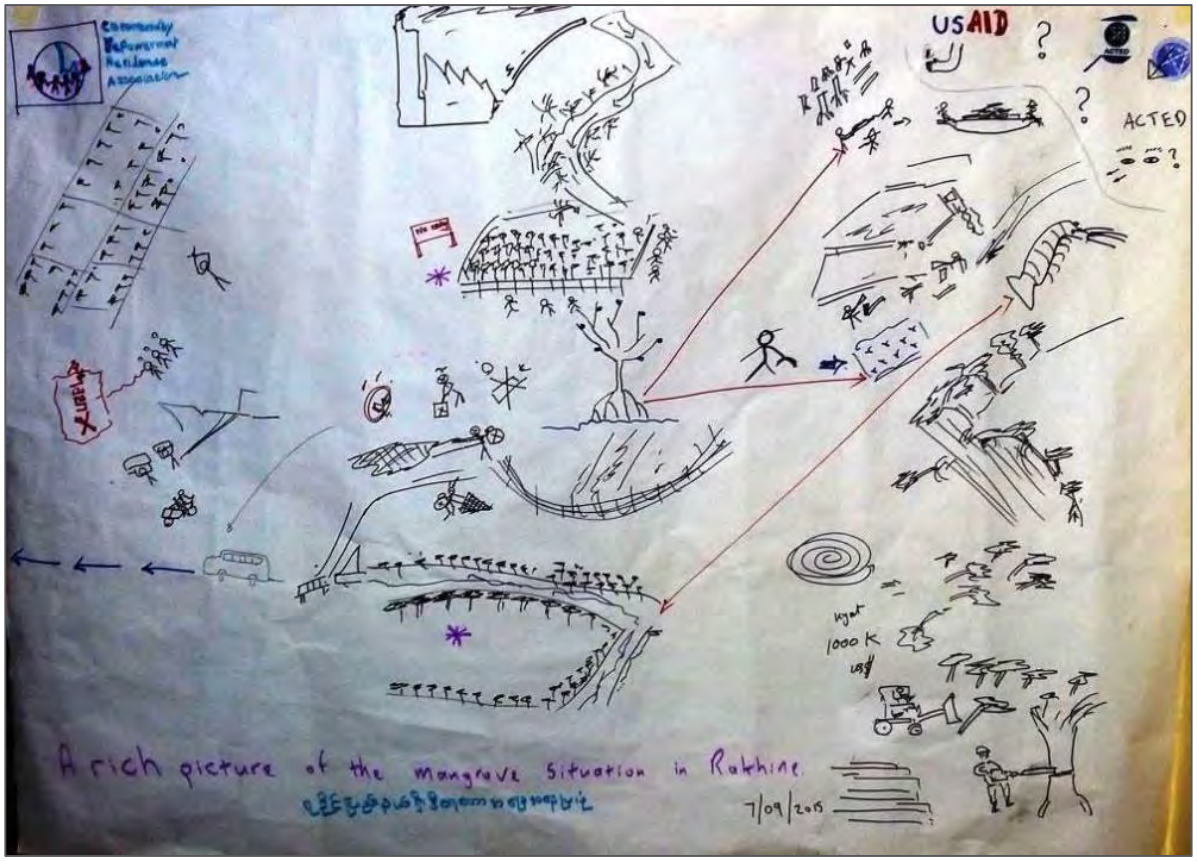
Cows and water-buffalos are relatively common in the area, although it is not clear whether primarily for milk and meat production or for use as animal traction. As above, disease—especially foot and mouth disease—appears to be an issue for livestock keepers in a number of villages. Since a number of mangrove species are attractive to grazing animals for fodder, the role of livestock keepers will need to be borne in mind while devising plans for any improved mangrove management in the future.

[73] The figures do not seem related to the availability of sources of firewood and this would need to be investigated further for clear conclusions to be drawn.

6. ANALYSIS

The SEA is multi-disciplinary in nature and the amount of disparate information that was needed to be brought together was at times complex and over-whelming. In order to facilitate analysis, the research team used a systems thinking technique called Rich Pictures[74] to represent all of the factors on one page. A Rich Picture attempts to capture everything that you know about a "messy situation" without imposing any structure or analysis. Using the Rich Picture as a starting point (see Image 1), the team first identified major trends in mangrove coverage emerging from the data, as well as the key drivers of change influencing these trends. These are presented in turn below.

Image 1: Rich picture analysis of the mangrove situation in Rakhine



Trends in mangrove evolution

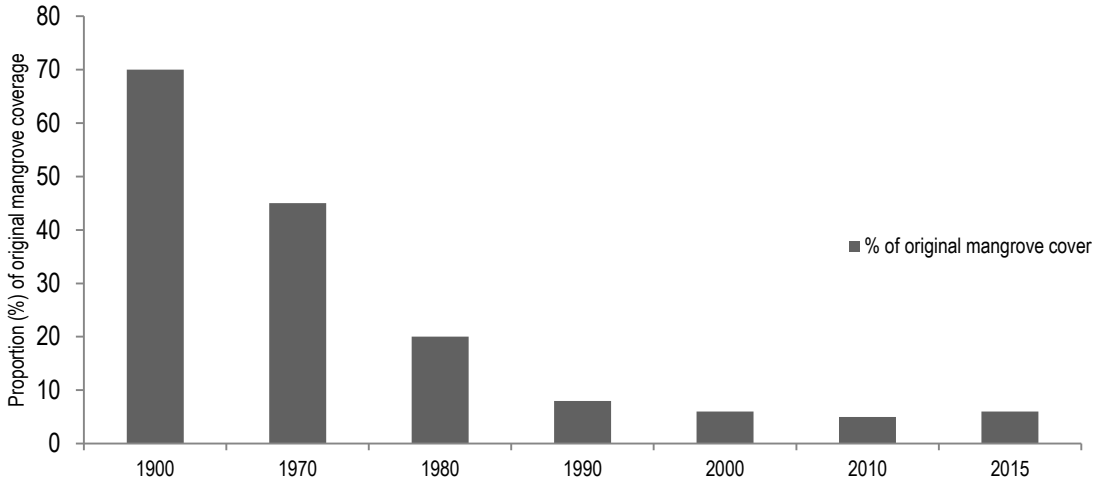
Historical patterns of mangrove clearance

A key point raised by PRA participants is that the majority of mangrove degradation happened before the start of the study's reference period (see Figure 10). This largely coincides with secondary historical accounts, which suggest that mangrove degradation began in earnest in Rakhine state in the 1800s and during the early part of the 1900s, initially driven by the British demands for firewood for steam vessels and the salt industry.[75]

According to PRA participants, however, the most rapid loss in mangrove coverage in the study area occurred during the late 1960s and especially the 1970s. This was reportedly driven mainly by the development policies of the government at the time, which had the stated aim of substantially increasing the area of land under paddy rice production and the unofficial aim of generating income from mangrove timber, charcoal and firewood sales.

[74] R. Armson – Growing Wings Along the Way: Systems thinking for messy situations (Axminster, UK, Triarchy Press, 2011).
[75] Stanley and Broadhead – Integrated Mangrove Management Plan.

Figure 10: Approximate estimates of mangrove change in Rakhine since 1900[76]



More recently, pressure on mangroves for firewood collection has increase as total mangrove areas have decreased. Shrimp farming is also a relatively new driver of mangrove degradation, dating back to the early 1990s and through the 2000s. In the background, a rising population has also remained a constant indirect driver of degradation. In addition, the occurrence of regular and often severe cyclones in recent years has further impacted the already precarious state of the mangroves (either directly or through accelerating the pace of embankment construction, as reportedly occurred after both the 1968 Sittwe cyclone and after Cyclone Giri in 2010).

Amid this picture, it is also important to note that there has been some regeneration of mangroves taking place since the early 2000s. This has mainly occurred in three contexts: in small scattered areas along creeks, streams and in some cases planted alongside shrimp ponds; in larger contiguous area which have colonised newly deposited sediments; and, most commonly, in areas of regrowth in shrimp ponds. It thus appears that declining profitability from the shrimp industry is likely to be one of the major drivers of mangrove regrowth in the study area.

Evolution of mangrove clearance at the village level

In general, mangrove clearance at the village level has tended to happen in a series of more or less predictable steps, as follows:

- **Stage A** – Mangrove clearing around the immediate surroundings of the village settlement. Often this area would also be the highest point in the village and therefore the easiest to drain. The main drivers are a need for building materials, land for rice farming and for reasons of security.
- **Stage B** – Mangrove clearing beyond the main village embankment, on the relatively flat sea/river-facing intertidal zone. This area is more difficult to drain and appears driven largely by extensive shrimp cultivation. Opportunistic harvesting of firewood is a secondary, short-term benefit for villagers.
- **Stage C** – Mangrove clearing along the banks of rivers and creeks. This stage tends to be more piecemeal and gradual, driven by firewood collection and over-grazing, which both gradually degrade the remaining mangroves and restrict regeneration.

Based on the characteristics and mangrove coverage histories of the six PRA assessment villages, it appears that **more densely populated villages which have better access to markets and are less prone to natural disasters clear their mangroves faster and earlier than more remote, more disaster-prone villages.** Table 10 provides a summary of village features in support of this hypothesis.

[76] Note: this chart is based on broad estimates based on primary data for this assessment and secondary sources cited in this section.

Table 9: PRA villages in different stages of mangrove clearance

Stage of mangrove clearance	Village	Mangrove coverage (%)	Access	Disaster risk	Notes
A	PNKC	21%	Less accessible	Very exposed and low-lying and therefore directly and indirectly disaster prone.	
	NTK	24%	Very accessible	In a very low lying and exposed location and is therefore both directly and indirectly disaster prone.	So disaster prone that it is a marginal location for settlement, regardless of its accessibility.
B	ATNKC	15%	Relatively accessible when compared to PNKC but less accessible than villages in C.	Directly and indirectly disaster prone but has some higher ground in the village.	In the medium range as far as accessibility, disaster risk and mangrove cover is concerned.
C	TPK	5%	Very accessible	Protected to some degree by NTK and is situated on slightly higher ground.	Long-established village, mangroves cleared long ago
	KT	3%	Very accessible	Relatively exposed and flood prone, but proximity to Sittwe is a stronger influence.	Long-established village, mangroves cleared long ago
	NWS	7%	Very accessible	Somewhat exposed to cyclones and partly flood prone.	Made the switch between stage B to C recently, between 1988 and 2000.

This observation is only based on a small number of villages and therefore cannot be regarded as comprehensive or valid beyond the SEA area. However, it can nevertheless serve as a working hypothesis for further investigation.

Mangrove coverage versus mangrove quality

It is important to note that the loss of mangroves is not simply about the number of hectares lost but also about the quality of the remaining tree cover. As discussed above, remaining mangroves in the study area were often heavily degraded and subject to regular cutting for day-to-day firewood needs, as well as overgrazing by livestock. Remote sensing for this study was also unable to distinguish between heavily degraded mangroves and patches of healthy growth.

It is thus critical to focus not just on where mangroves have been lost, but on their status in areas where they are still present. Since it is more effective and much more cost beneficial to enable mangroves to regenerate themselves from existing mother trees (rather than reintroducing then from scratch), the state of the remaining mangroves as well as the species composition of these patches requires urgent investigation and action if their capacity to regenerate is to be preserved.

Decline in fisheries as a result of mangrove degradation

PRA participants reported drastic overall reduction in the quantities of commercial species of fish caught over the study's reference period. In addition villagers made it clear that the size and species of fish being caught was changing, to include much smaller fish as well as species which were considered "rubbish" fish in the past. This

study fully concurs with a previous assessment conducted by Joffre and Aung,[77] which blames shrinking fish stocks in the area on overfishing; the loss of mangrove habitats for fish; the lack of enforcement of fishery law and use of illegal fishing gear; widespread collection of post-larvae shrimp; trawling of adult shrimp; and the lack of other livelihood opportunities for coastal communities.

As the loss of mangroves around the world becomes increasingly severe, the quantifiable evidence for the contributions that mangroves in particular can make to the health of fishery stocks becomes progressively more substantial.[78] Among PRA participants, many of these connections are understood on an intuitive level, based on lived experience. In this respect, it was observed that in areas with fewer mangroves, people were most vocal in calls for their protection and regeneration, especially when it comes to ensuring the health of both their fisheries and aquaculture.

Drivers of change

Land tenure and corruption

In some cases, the lack of rights over land tenure and related ample opportunities for corruption can be the deciding factor in the degradation of extensive mangrove areas. For example, in two villages it was reported that mangroves had been cleared by the military in the 1970s with the stated purpose of clearing the area of "robbers." According to villagers, the military had at least in some cases then leased out the land at lucrative rates to outside interests, who had converted it to shrimp farms. As discussed in the literature review above, this has been a claim of activists groups for a number of years now and the findings of this assessment endorse those claims.[79]

Timber, charcoal and firewood

Clearing of mangroves for timber played a relatively minor direct role in the PRA villages, as most trees of larger dimensions had been cut many years ago. However, ongoing felling of timber upstream is still likely to affect mangroves indirectly due to resulting high sediment loads and consequential increases in flooding and general dynamism of rivers in terms of accretion and erosion. The extent of this issue is obviously hard to quantify. From ground observations, it appears that such dynamics can have both positive and negative effects. In positive terms, it can result in substantial areas of accretion of new sediment, which can result in dense areas of new mangrove growth such as in the case of south-east Pauktaw/north-west Myebon. Negatively, it can also lead to severe river bank erosion as observed in KT village, driving back shorelines and reducing land available for mangrove growth.

By contrast, continued degradation of existing mangrove stands as a result of charcoal and firewood collection is ubiquitous in the study area, where all of the villagers surveyed rely on firewood for one hundred percent of their energy needs. Mangrove species with a high calorific value such as *Rhizophora* are often selectively removed for charcoal before other less attractive species are used. In parallel with similar trends around fisheries, "rubbish" species of mangroves (as far as economic uses are concerned) are all that remain of mangrove stands in much of the assessment area.

Shrimp farms

Despite recognition by villagers of the importance of healthy mangroves for sustainable shrimp farming, as well as for fisheries production, shrimp farming has been the major driver of mangrove clearance and degradation in the PRA villages of PNKC, ATNKC and NWS. A great deal of the conversion to shrimp farms in these villages continues to occur and largely coincides with the state of shrimp supply and demand.

In full agreement with other studies, it is clear from this assessment that the extensive or "traditional" system of shrimp cultivation is inherently unsustainable even in the short to medium term, since it requires a constant supply of fresh mangrove land in order to continue as old ponds dry up and acidify. So far, it is unclear whether semi-intensive or intensive systems would prove to be a viable option in the area as there are so few examples to draw

[77] Joffre and Aung – Fishery Value Chain Analysis.
[78] See, for example, J. Hutchison, M. Spalding and P. zu Ermgassen – The Role of Mangroves in Fisheries Enhancement (Cambridge, UK, Nature Conservancy / Wetlands International, 2014).
[79] See BEWG – Cut into the Ground; Duh Wan and Ryder – Mangrove Deforestation.

from. At present, serious constraints exist on a number of points along the supply chain for post-larvae shrimp, with wild shrimp increasingly rare and costs high for both wild and cultivated sources.

Since extensive shrimp farming requires regular replenishment from tidal waters, it regularly overlaps with locations where coastal hazards such as cyclones and storm surges are most prevalent. In this respect, it also maps with marginal areas where some of the poorest and vulnerable members of Rakhine's population currently exist and subsist. These high-risk locations are also the same areas where the remnants of mangroves remain in Rakhine state, and therefore this is where future conservation as well as DRR efforts should focus their attention on in the future.

Rice farms

In line with secondary data on farming in Rakine, as well as field observations of the stages of mangrove clearing described above, there appear to be two distinct kinds of paddy rice farms operating in the study area. First, there are relatively intensive farms, usually nearer to the settlements, managed by individual families. Many of these farms were converted from mangrove decades ago and if any agricultural inputs are used they are directed at these plots. These are more typical in the predominantly rice farming villages such as TPK, NWS and KT.

Second, there is more extensive "*kari*," or shifting rice cultivation, which is usually started by a group of families together. Kari cultivation is developed by building embankments around mangrove areas and restricting the movement of tidal water, sometimes only for one crop at a time. This type of paddy farming is more dominant in the fishing villages where rice farming has a more supplementary role such as PNKC, NTK and ATNKC.

Given *kari* farming's likely importance in the coastal areas of Rakhine, it is striking how little the issue has been studied to date, at least in English. In order to improve understanding of the impact of paddy farming on mangroves, the practice should therefore serve as an important focus for future research.

Natural disasters

In a number of instances villagers stated that mangrove loss could in some instances be accounted for by natural disasters. However, a review of mangrove literature reveals that this statement may be only partly true. With the exception of extreme events such as the 2004 tsunami, mangroves in settings generally undisturbed by human activity are relatively well adapted to surviving natural disasters. Some species may in fact be able to take advantage of these events to gain an advantage during the recovery period when other species are still struggling to re-establish.[80] On the other hand, if a mangrove forest is situated close to human settlements, the removal of large amounts of biomass during a natural disaster, on top of the regular pressures of firewood collection and over-grazing and in some instances, inundation by quantities of solid waste and pollutants, may prove too much and threaten the health and survival of the forest. Ultimately, it appears that the relationship between mangrove health and natural disasters is dependent on a range of different factors, the relationships between which remain poorly understood.

In the context of natural disasters, it is also important to consider the role mangroves can play as an area of "built-in redundancy,"[81] – areas of undeveloped land that serve as buffer zones during flooding or cyclone events. In a disaster-prone context like Rakhine, the continued reinforcement and rising of embankments taking place in some development projects is likely to restrict the possibilities for mangrove regeneration in a role of "built-in redundancy," and may therefore need to be assessed in terms of its potential to contribute to worsening disaster impacts in future.

Industrial development

Industrial development as a driver of change for mangrove degradation is something that villagers in the study area are only vaguely aware of. As discussed in the literature review, it is known that in some parts of Rakhine state small scale oil and gas extraction have had negative impacts on mangroves. Local people are currently nervous of the potential negative environmental impact that the large scale industrial development activities, proposed for

[80] See S. Braatz, . Fortuna, J. Broadhead and R. Leslie – Coastal protection in the aftermath of the Indian Ocean tsunami: What role for forests and trees?, FAO, RAP PUBLICATION 2007/07.
[81] L. Comfort, A. Boin and C. Demchak – Designing Resilience - Preparing for Extreme Events (Pittsburgh, PA, University of Pittsburgh Press, 2010).

Sittwe Port and Kyauk Phyu industrial development complex, may have. In this respect, the effects of these activities on mangrove health will need to be the subject of close monitoring and advocacy moving forward.

Conflict

During the ground truthing exercise and the visit to a relatively large area of new mangroves in Pauktaw Township, it became evident that the legacy of the ongoing conflict between Rakhine and Muslim populations in the state has been in some cases a contributing factor to re-colonisation[82] of degraded mangrove areas. In one observed instance, a Muslim village in a mangrove area was evacuated to a displacement camp in Pauktaw during the outbreaks of violence in 2012. Since that time, apart from brief visits to collect their belongings, the residents have not been actively managing their village tract.

However, from the river it was possible to observe a number of small craft being loaded with firewood in the mangrove area. In addition, it appeared that embankments were in the process of being repaired. Unfortunately the assessment team did not have the opportunity to investigate the situation further, and it remains unclear who is responsible for the ongoing activities given the continued absence of the village's original residents. While confined to one location, this anecdote indicates that, as with other resources, mangroves have the potential to form part of the overall nexus of conflict and inter-community tension in Rakhine. This means that even supposedly "neutral" activity such as DRR or mangrove restoration/conservation need to be undertaken from a conflict-sensitive perspective.

Mangrove planting

In ATNKC, shrimp farmers were making active efforts to plant mangroves around their shrimp ponds, in the hope that they would provide shade and prevent the ponds from becoming "too hot" during the dry season. In addition, with encouragement from Malteser International and CERA, in KT village a small strip of mangrove had been planted between the village and the open sea in an attempt to provide protection from cyclones.

Unfortunately, due to their small scale these efforts are, technically speaking, unlikely to make a great deal of difference, either to extending the life of fundamentally unsustainable shrimp farms, or to protecting villagers from a cyclone. However, the presence of these planted mangroves represents a considerable investment of time and energy by the villagers and can be regarded as a tangible sign of good intentions as far as regenerating mangroves are concerned. As conversations with PRA villagers and the results of a recent REACH survey suggest, there appears to be a strong level of positive sentiment regarding mangroves, as well as interest and initiative in participating in regeneration efforts. This represents a clear resource that can be effectively tapped in future DRR and mangrove-focused activities in the state.

[82] Colonisation is used here as a technical term referring to mangrove establishment

7. Conclusion and Recommendations

This section provides a summary of research findings in line with the study's original research questions. It then goes on to provide a series of recommendations for both programming and future research.

Summary

Current status of mangroves and changes over time

Currently, mangrove coverage appears to be expanding modestly and from an extremely low base in Minbya and Sittwe townships. On the other hand, the status of mangroves in Myebon and Pauktaw has declined rapidly in the last 30 years, where wide spread clearing of mangroves has occurred, particularly in favour of rice paddy and shrimp farms.

Drivers of change

During the last 30 years, a number of inter-linked factors were the main, often closely linked drivers of mangrove degradation. In order of importance, these are:

- Issues of land tenure and corruption
- A rapid increase in shrimp farms
- An increase in area under rice farms
- Firewood collection
- The cumulative impact of natural disasters
- The impact of conflict and the resulting displacement of the local population

In the near to medium future industrial development is also likely to have a negative impact on mangroves in the area. On the other hand, there is also an increasing level of awareness of the importance of mangroves among the local population, and small remedial actions have already begun.

Ecosystem services

Common resource users such as fishermen and shrimp farmers are the most dependent on the ecosystem services that healthy mangroves can provide. Essentially, the mangroves provide them with a means of livelihoods as well as a main source of nutrition. For fishermen, mangroves provide a habitat and means of survival for fish and crustaceans, while for shrimp farmers, mangroves have in the past been important as a source of post-larvae shrimp and feed.

In some areas, given a sufficient area, remaining mangroves appear to provide a means of protection from regular cyclones and flooding. In other areas, especially along the banks of active rivers and the sea, they provide a degree of riverbank/shoreline stabilisation.

Consequences of mangrove degradation

In Myebon and Pauktaw in particular, the decrease in the quantity and quality of mangroves has been a major factor in reducing fish and shell-fish catches, as well as the harvests of shrimp from extensive shrimp farms. Clearly this trend has caused these sources of income to be less reliable, in many cases resulting in a switch to other means of employment including casual labour, minor trade/small business and in certain cases, seasonal or permanent migration.

Whether, how far, and who these trends have increased or decreased vulnerability remains an open question. However, it is clear that due to the increasing ecological vulnerability which has resulted from the degradation of the mangroves, the study area is likely to have become much more vulnerable to the risks posed by natural disasters.

Recommendations

First steps

Based on good practices and experiences to date, the only way for ecosystem conservation to be effective in the long run is to empower those who depend on the services that these same ecosystems provide. Coastal restoration and mangrove conservation for DRR or climate change adaptation (CCA) are no exceptions.

In order to protect the mangroves in Rakhine state, it is therefore critical to work, in a participatory way, directly with the people who are dependent on them. To some degree, this means first meeting their critical needs in order to ensure that they are in a position to address the broader needs of the ecosystem. As a minimum basis for any such efforts, it will be important to:

- Raise the knowledge and awareness of local people on the importance of protecting the ecosystem on which they depend.
- Conduct more research on the broader social, economic and ecological context of mangroves in Rakhine state as well as in Myanmar as a whole
- Investigate long-term climate financing options for mangrove areas.

Future directions

Advocacy

At this stage in Myanmar's move towards increasing democracy, a window of opportunity exists for local people to have a greater voice in their own development. Therefore, it is important that during the next steps, efforts towards advocacy are focused on the local people living in the communities and townships where the assessment took place. Options as far as future steps for advocacy include:

- Developing effective, locally relevant communication materials and methods.
- Effectively reformulating DRR, CCA and livelihood project documents to adequately and effectively mainstream mangrove conservation efforts.
- Forming active partnerships among relevant stakeholders.
- Facilitate hands-on study visits for relevant local CBOs and key community members to Wunbaike forest reserve and other examples of community-managed forestry where.

Further study

While this assessment was a useful first step in beginning to understand the status, trends and drivers of change for mangroves in the region, it largely represents a scoping study identifying key issues for further and more in-depth research. In particular, it identified a number of "black boxes" critical for informing strategies for action:

Land tenure

- Examine opportunities for advocacy on land tenure and legal issues. As this assessment has suggested, the Rakhine coast is characterised by ambiguities of resource ownership and it will be important to investigate these issues further, for example in seeking to understand how these ambiguities affect the value of land in real terms.

Conflict sensitivity and do no harm

- Examine good practices from the wider region and propose effective ways to manage already existing conflict over natural resources. These could include approaches such as participatory land use zoning, incentives for ecologically sensitive methods of production, and institutional capacity building. Such an approach is especially critical in Rakhine given the sensitivity of the context and existing conflict dynamics.

Community forestry

- Explore community forestry as an option for increasing local ownership over mangroves. A number of mangroves have been registered as community forests in the south of Rakhine state – it will be important to examine both the effectiveness of these efforts, and the potential role the DoF can play in this regard.

Energy efficiency

- Examine and assess the viability of available options for improved energy efficiency with existing charcoal and firewood fuels, or the use of alternative energy sources.

Agriculture

- Examine in greater the depth the dynamics of shifting agriculture or "*kari*" practices in order to highlight opportunities for economic as well as ecological improvements, for instance through agro-forestry or green manures and managed fallows.

Shrimp farming

- Investigate viable alternatives to extensive shrimp farming, including "semi-intensive" shrimp practices such as silvo-aquaculture, which have been successfully pioneered elsewhere in the region.

Capacity development

- Explore capacity development gaps and needs for local NGOs/CBOs focusing on mangroves and related areas. These may include strategic planning, administrative support, and methods for participatory project planning and management.

Geographical Information Systems

This assessment identified three stages of mangrove degradation prevalent in the study area. Those villages which can be categorised as Stage A and B offer the best options for future mangrove conservation efforts, as these are places in which substantial areas mangrove remain, and are also areas in which mangroves are under the greatest threat.

Using GIS technologies matched with rapid field studies and ground-truthing it should be possible to identify "hot spots" for action, and ensure that in the future, efforts towards mangrove conservation are made in those places where they can conserve the most mangroves with the least effort, offer the most protection in terms of DRR and CCA, and have the most potential to reduce vulnerability among people whose livelihoods are dependent on access to healthy common resources.

Capacity development for Ecological Mangrove Restoration

Unfortunately standard approaches to mangrove regeneration through re-planting have been largely unsuccessful in Rakhine.[83] Over recent years, an alternative approach of ecological mangrove restoration (EMR)[84] has also been piloted in the state. It is therefore important to assess how effective these efforts have been, and what options exist for increasing their scope. EMR would appear to offer the most cost-effective way of not only restoring mangroves from the technical point of view, but also providing a potential framework for engaging with local communities specifically on the issue of sustainable mangrove management.

Sources of alternative funding

In recent years there has been excitement over the possibility of sourcing "blue carbon" funding as a way to kick-start conservation efforts for mangrove forests.[85] On the other hand, much scepticism exists regarding its real impact.[86] It is therefore important to examine these conflicting points of view in more depth, with a view to assessing how far pursuing such funding is a viable option in the case of Rakhine.

[83] Field observations, discussions with CERA and Malteser staff involved in re-planting efforts.
[84] Mangrove Action Project – MAP Ecological Mangrove Restoration Method (accessed 21 October 2015).
[85] Blue carbon is defined as the carbon captured by the world's oceans and coastal ecosystems. The carbon captured by living organisms in oceans is stored in the form of biomass and sediments from mangroves, salt marshes and seagrasses. For more detail, see The Blue Carbon Initiative - Coastal Blue Carbon: Methods for assessing carbon stocks and emissions factors in mangroves, tidal salt marshes, and seagrass meadows (Arlington, VA, 2014).
[86] J. Broadhead - Reality check on the potential to generate income from mangroves through carbon credit sales and payments for environmental services, FAO, vol. Regional Fisheries Livelihoods Programme for South and South East Asia (GCP/RAS/237/SPA), 2011.

Conclusion

The point of departure for this assessment was to investigate the options for reducing the vulnerability of people in Rakhine to natural disasters by advocating for the preservation of the mangroves that have served to protect and provide for them in the past.

However, it is commonly known that reducing vulnerability to disaster or adapting to climate change, or more positively, increasing the resilience of a local population, is about much more than introducing “hard” measures such as physical barriers to threats or improving early warning systems and ensuring access to evacuation centres.

It is hoped that this assessment has been able to demonstrate that although mangroves serve to physically protect the coastal communities to some degree, they also have critically important ecological, economic as well as social functions in coastal communities. These include the provision of diversified sources of livelihoods, a nutritious source of food, fuel for cooking, materials for building, as well as a form of insurance through firewood sales, and a healthy environment, to name a few examples.

Resilience is often understood as being the opposite side of the coin to vulnerability. However if the ecological foundations of a community have been secured, resilience can also be about an improved capacity to learn, improve, adapt and thrive, despite major changes in circumstances. It is hoped this assessment can serve as a spring board to ensure more concerted action to increase the resilience of the mangrove-dependant coastal communities of Rakhine state.

ANNEXES

Annex I: Mangrove coverage trends in Rakhine state between 1988 and 2015, by township

Note: * indicates townships for which complete Landsat imagery was not available for all reference periods. For this reason, full land cover figures have not been calculated since they represent an incomplete picture of township land cover. Since image gaps do not affect lowland areas, only mangrove coverage has been calculated.

Township	Year	Denuded area / barren soil		Closed canopy forest		Mangrove		Agriculture / paddy		Open canopy forest / grassland		Total	
		ha	%	*ha*	%	*ha*	%	*ha*	%	*ha*	%	*ha*	%
	1988	1,390	0%	98,064	16%	34,039	6%	32,347	5%	448,648	73%	614,487	100
Ann	2000	2,281	0%	96,016	15%	38,045	6%	29,057	5%	472,387	74%	637,786	100
	2015	16,823	3%	89,646	14%	19,073	3%	57,497	9%	448,073	71%	631,111	100
Overall change 1988-2015:													
		15,433	**1110%**	**-8,418**	**-9%**	**-14,966**	**-44%**	**25,150**	**78%**	**-575**	**0%**	**16,625**	**3%**
		ha	%	*ha*	%	*ha*	%	*ha*	%	*ha*	%	*ha*	%
	1988	-	-	-	-	4,217	-	-	-	-	-	-	-
*Buthidaung**	2000	-	-	-	-	5,362	-	-	-	-	-	-	-
	2015	-	-	-	-	6,162	-	-	-	-	-	-	-
Overall change 1988-2015:													
		-	**-**	**-**	**-**	**1,945**	**46%**	**-**	**-**	**-**	**-**	**-**	**-**
		ha	%	*ha*	%	*ha*	%	*ha*	%	*ha*	%	*ha*	%
	1988	290	0%	63,139	28%	8,829	4%	16,620	7%	134,139	60%	223,017	100
Gwa	2000	771	0%	55,149	24%	10,648	5%	16,100	7%	147,484	64%	230,151	100
	2015	823	0%	76,823	33%	9,556	4%	16,545	7%	125,678	55%	229,424	100
Overall change 1988-2015:													
		533	**184%**	**13,684**	**22%**	**726**	**8%**	**-75**	**0%**	**-8,461**	**-6%**	**6,407**	**3%**
		ha	%	*ha*	%	*ha*	%	*ha*	%	*ha*	%	*ha*	%
	1988	833	1%	2,359	2%	25,956	24%	56,257	52%	23,286	21%	108,690	100
Kyaukpyu	2000	563	1%	1,664	2%	27,778	27%	43,207	42%	30,136	29%	103,348	100
	2015	2,294	2%	3,979	4%	20,799	19%	66,619	61%	15,788	14%	109,480	100
Overall change 1988-2015:													
		1,461	**175%**	**1,621**	**69%**	**-5,157**	**-20%**	**10,362**	**18%**	**-7,498**	**-32%**	**790**	**1%**
		ha	%	*ha*	%	*ha*	%	*ha*	%	*ha*	%	*ha*	%

Township	Year	Denuded area / barren soil		Closed canopy forest		Mangrove		Agriculture / paddy		Open canopy forest / grassland		Total	
	1988	-	-	-	-	4,592	-	-	-	-	-	-	-
*Kyaukt*aw*	2000	-	-	-	-	4,869	-	-	-	-	-	-	-
	2015	-	-	-	-	6,428	-	-	-	-	-	-	-
Overall change 1988-2015:													
		-	**-**	**-**	**-**	**1,836**	**40%**	**-**	**-**	**-**	**-**	**-**	**-**
		ha	%	*ha*	%	*ha*	%	*ha*	%	*ha*	%	*ha*	%
	1988	-	-	-	-	3,871	-	-	-	-	-	-	-
*Maungdaw**	2000	-	-	-	-	4,301	-	-	-	-	-	-	-
	2015	-	-	-	-	7,447	-	-	-	-	-	-	-
Overall change 1988-2015:													
		-	**-**	**-**	**-**	**3,577**	**92%**	**-**	**-**	**-**	**-**	**-**	**-**
		ha	%	*ha*	%	*ha*	%	*ha*	%	*ha*	%	*ha*	%
	1988	2,267	1%	32,283	10%	10,664	3%	48,464	14%	243,709	72%	337,387	100
Minbya	2000	1,358	0%	34,515	10%	9,343	3%	50,106	14%	253,230	73%	348,552	100
	2015	655	0%	33,860	10%	11,860	3%	43,445	13%	257,110	74%	346,929	100
Overall change 1988-2015:													
		-1,612	**-71%**	**1,577**	**5%**	**1,196**	**11%**	**-5,019**	**-10%**	**13,401**	**5%**	**9,542**	**3%**
		ha	%	*ha*	%	*ha*	%	*ha*	%	*ha*	%	*ha*	%
	1988	473	0%	298	0%	9,157	8%	66,495	56%	43,190	36%	119,613	100
Mrauk-U	2000	305	0%	445	0%	7,076	6%	69,792	57%	45,372	37%	122,989	100
	2015	146	0%	2,796	2%	10,115	8%	65,029	53%	45,381	37%	123,468	100
Overall change 1988-2015:													
		-327	**-69%**	**2,499**	**840%**	**958**	**10%**	**-1,466**	**-2%**	**2,191**	**5%**	**3,855**	**3%**
		ha	%	*ha*	%	*ha*	%	*ha*	%	*ha*	%	*ha*	%
	1988	4,268	9%	370	1%	2,201	5%	29,099	60%	12,224	25%	48,162	100
Munaung	2000	3,602	7%	166	0%	5,254	11%	21,562	44%	18,441	38%	49,025	100
	2015	9,660	19%	506	1%	1,868	4%	34,196	69%	3,397	7%	49,629	100
Overall change 1988-2015:													
		5,391	**126%**	**137**	**37%**	**-333**	**-15%**	**5,097**	**18%**	**-8,827**	**-72%**	**1,466**	**3%**
		ha	%	*ha*	%	*ha*	%	*ha*	%	*ha*	%	*ha*	%

Township	Year	Denuded area / barren soil		Closed canopy forest		Mangrove		Agriculture / paddy		Open canopy forest / grassland		Total	
	1988	1,238	1%	12,370	7%	44,126	24%	49,918	27%	74,879	41%	182,531	100
Myebon	2000	691	0%	6,245	3%	46,311	25%	49,206	26%	85,274	45%	187,726	100
	2015	794	0%	5,722	3%	32,786	18%	59,006	32%	85,343	46%	183,651	100
Overall change 1988-2015:													
		-443	**-36%**	**-6,648**	**-54%**	**-11,340**	**-26%**	**9,087**	**18%**	**10,463**	**14%**	**1,120**	**1%**
		ha	%	*ha*	%	*ha*	%	*ha*	%	*ha*	%	*ha*	%
	1988	381	0%	396	0%	14,590	17%	57,620	66%	14,296	16%	87,282	100
Pauktaw	2000	200	0%	220	0%	6,255	7%	65,938	75%	15,646	18%	88,259	100
	2015	31	0%	71	0%	10,173	12%	59,967	70%	15,915	18%	86,156	100
Overall change 1988-2015:													
		-350	**-92%**	**-324**	**-82%**	**-4,417**	**-30%**	**2,347**	**4%**	**1,619**	**11%**	**-1,126**	**-1%**
		ha	%	*ha*	%	*ha*	%	*ha*	%	*ha*	%	*ha*	%
	1988	1,250	1%	6,514	6%	6,955	6%	38,567	35%	56,652	52%	109,939	100
Ponnagyun	2000	908	1%	6,245	6%	4,387	4%	39,660	35%	60,534	54%	111,734	100
	2015	565	0%	5,911	5%	7,147	6%	39,046	34%	60,753	54%	113,422	100
Overall change 1988-2015:													
		-685	**-55%**	**-604**	**-9%**	**191**	**3%**	**479**	**1%**	**4,102**	**7%**	**3,483**	**3%**
		ha	%	*ha*	%	*ha*	%	*ha*	%	*ha*	%	*ha*	%
	1988	2,448	2%	1,639	1%	37,370	33%	37,782	34%	33,464	30%	112,702	100
Ramree	2000	4,105	4%	1,420	1%	39,892	35%	33,064	29%	36,191	32%	114,672	100
	2015	11,789	10%	3,768	3%	29,500	26%	55,436	49%	12,829	11%	113,322	100
Overall change 1988-2015:													
		9,340	**381%**	**2,129**	**130%**	**-7,870**	**-21%**	**17,655**	**47%**	**-20,635**	**-62%**	**619**	**1%**
		ha	%	*ha*	%	*ha*	%	*ha*	%	*ha*	%	*ha*	%
	1988	359	0%	1,783	2%	10,378	13%	47,488	59%	20,919	26%	80,927	100
Rathedaung	2000	249	0%	1,333	2%	7,270	9%	51,742	62%	22,527	27%	83,120	100
	2015	105	0%	1,793	2%	11,813	14%	47,521	57%	22,155	27%	83,388	100
Overall change 1988-2015:													
		-254	**-71%**	**10**	**1%**	**1,435**	**14%**	**33**	**0%**	**1,236**	**6%**	**2,460**	**3%**
		ha	%	*ha*	%	*ha*	%	*ha*	%	*ha*	%	*ha*	%

Township	Year	Denuded area / barren soil		Closed canopy forest		Mangrove		Agriculture / paddy		Open canopy forest / grassland		Total	
	1988	0	0%	0	0%	1,534	7%	18,978	92%	105	1%	20,618	100
Sittwe	2000	0	0%	0	0%	1,445	7%	18,824	92%	158	1%	20,427	100
	2015	0	0%	3	0%	2,997	14%	17,806	85%	200	1%	21,006	100
Overall change 1988-2015:													
		0	**0%**	**3**	**3021%**	**1,463**	**95%**	**-1,173**	**-6%**	**95**	**90%**	**388**	**2%**
		ha	%	*ha*	%	*ha*	%	*ha*	%	*ha*	%	*ha*	%
	1988	-	-	-	-	12,014	-	-	-	-	-	-	-
*Thandwe**	2000	-	-	-	-	19,482	-	-	-	-	-	-	-
	2015	-	-	-	-	9,049	-	-	-	-	-	-	-
Overall change 1988-2015:													
		-	**-**	**-**	**-**	**-2,965**	**-25%**	**-**	**-**	**-**	**-**	**-**	**-**
		ha	%	*ha*	%	*ha*	%	*ha*	%	*ha*	%	*ha*	%
	1988	1,137	0%	114,051	24%	50,494	11%	41,347	9%	263,469	56%	470,499	100
Toungup	2000	1,556	0%	118,958	25%	52,565	11%	41,278	9%	269,335	56%	483,691	100
	2015	23,854	5%	129,499	27%	26,733	6%	89,090	18%	214,334	44%	483,510	100
Overall change 1988-2015:													
		22,716	**0%**	**15,448**	**14%**	**-23,762**	**-47%**	**47,744**	**115%**	**-49,135**	**-19%**	**13,011**	**3%**